

# A Simple Nickel Catalyst Enables Broad E-Selective Alkyne Semihydrogenation

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A simple and commercially available nickel catalyst for E-selective alkyne semihydrogenation is presented. The protocol is practical and encompasses a wide variety of internal alkynes, with any and alkyl substituents tolerated alike.

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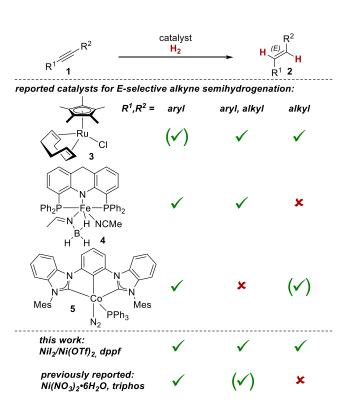
# A Simple Nickel Catalyst Enables Broad *E*-Selective Alkyne Semihydrogenation

Niklas O. Thiel+, Benyapa Kaewmee+, Trung Tran Ngoc, and Johannes F. Teichert\*

**Abstract:** Stereoselective alkyne semihydrogenations are attractive approaches to alkenes, which are key building blocks for synthesis. With regards to the most atom economic reducing agent dihydrogen ( $H_2$ ), only few catalysts for the challenging *E*-selective alkyne semihydrogenation have been disclosed, each with a unique substrate scope profile. Here, we show that a commercially available nickel catalyst facilitates the *E*-selective alkyne semihydrogenation of a wide variety of substituted internal alkynes. This results in a simple and broadly applicable overall protocol to stereoselectively access *E*-alkenes employing  $H_2$  which could serve as a general method for synthesis.

#### Introduction

The stereoselective preparation of alkenes is of prime importance in synthetic chemistry, as the resulting E- or Z-configuration determines the stereochemical outcome for a variety of commonly downstream functionalization reactions halogenations, epoxidations).[1] Catalytic alkvne semihydrogenations based on dihydrogen (H<sub>2</sub>) represent the most atom economic approach to alkenes.[2-4] Hinging on the mechanistic imperative of hydrometallation,[5,6] many Z-selective alkyne semihydrogenations have been developed;[2] the catalyst<sup>[7]</sup> arguably being the most prominent. On the other hand, only a few reports about the more challenging transition metalcatalyzed E-selective alkyne semihydrogenation have been disclosed.[8-11] Whereas for the related E-selective alkyne semireductions other - stoichiometric, and therefore undesirable in terms of waste generation - reducing agents have been reported[3] (such as reduction under Birch-type conditions[12]), only a handful catalysts for the direct E-selective alkyne semihydrogenation with  $H_2(1\rightarrow 2, Scheme 1)$  have been reported: Cationic ruthenium(II) complex 3 is functional group tolerant and gives high E-selectivity.[4,8] However, for diaryl alkynes, longer reaction times are required which led to a significant amount of overreduction to the corresponding alkane. Emanating from this, catalysts based on first row transition metals (attractive due to the availability of the metal precursors)[13] have also been investigated for E-selective alkyne semihydrogenation: In this vein, pincer complexes of iron(II) (4)[9] and cobalt(I) (5)[10] based on sophisticated, not commercially available ligand frameworks were reported for *E*-selective alkyne semihydrogenations (Scheme 1). These catalysts have been mainly successful for diarylsubstituted alkynes. During the course of the present study, also a nickel-based catalyst had been reported,[11] which shares the same limitation in substrate scope. However, as the various catalysts are complementary in the alkyne classes tolerated, there is a clear need for a common, generally applicable protocol. Here, we show that a simple and commercially available nickel catalyst consisting of а Ni(II) salt bis(diphenylphosphino)ferrocene (dppf) can be employed for E-stereoselective alkyne semihydrogenations, encompassing a wide variety of substitution patterns (aryl and alkyl), which had been previously unavailable with a single catalytic protocol.[14] Our results therefore offer a unified approach to *E*-alkenes via stereoselective alkyne semihydrogenations.



**Scheme 1.** Approaches to *E*-selective alkyne semihydrogenations with transition metal catalysts.

[+] These authors contributed equally.

Supporting information for this article is given via a link at the end of the document.

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#### **Results and Discussion**

During the course of our studies aiming at the (complementary) Z-selective alkyne semihydrogenation,  $^{[15]}$  we identified that trace metal impurities based on nickel led to an unexpected E-selectivity. To assess the performance of the catalyst, we first optimized a model reaction (Scheme 2) before studying the substrate scope and functional group tolerance, and analyzed the possible mechanism.

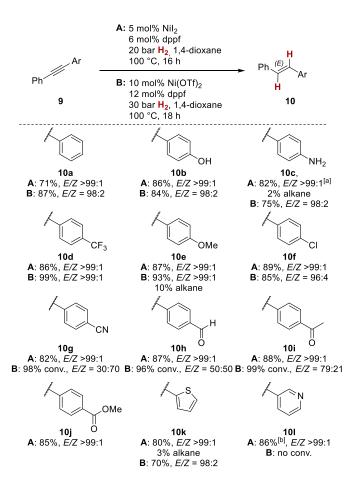
To probe the performance of nickel catalysts in E-selective alkyne semihydrogenation we studied the conversion of homopropargylic pivaloyl ester **6** (Scheme 2). Under optimized conditions, [16] we found that catalytic amounts of nickel(II) iodide and dppf (5 and 6 mol%, respectively) gave the corresponding styrene derivative E-**7** with high stereoselectivity (E/Z = 99:1) at 15 bar H<sub>2</sub> in 1,4-dioxane at 100 °C (55% isolated yield). Along with the desired products, we detected 5% of the overreduced alkane **8** as well as negligible amounts of alkene isomers (<1%). This suggests that the catalyst has a high preference for the hydrogenation of alkynes over the competing reaction with alkenes.

Scheme 2. E-selective alkyne semihydrogenation with a nickel(II) complex.

To optimize the catalyst, we investigated various counterions to nickel and found that the counteranion to nickel is key for high reactivity, as no or little conversion was found with related nickel(II) chloride or bromide complexes. Best results were obtained with either nickel(II) iodide or nickel(II) triflate. In our hands, wide bite-angle bisphosphine ligands ensured high Eselectivity along with little overreduction.[16] Elevated pressure of H<sub>2</sub> was needed, as utilizable turnover was only detected at 10 bar H<sub>2</sub> pressure or higher. We also established that - unlike the pivaloyl ester in 6 - under similar reaction conditions, the related benzyl ether was partially cleaved,[17] which was an early indication for the intermediacy of nickel hydride complexes.<sup>[18]</sup> To explore the substrate scope and functional group tolerance under optimized conditions with both nickel sources (conditions A and B), we investigated the reaction of diaryl alkynes 9 to the corresponding E-alkenes 10 (Scheme 3). We had established in preliminary investigations that when nickel(II) triflate was employed, higher catalyst loadings and higher pressure of H<sub>2</sub> (10 mol% Ni(OTf)<sub>2</sub>, 30 bar H<sub>2</sub>) were necessary.

With nickel(II) iodide (conditions **A**), we found that the reactive functional groups of phenol and aniline derivatives **10b** and **10c**, respectively, did not interfere with the catalyst as these products gave similarly good results in terms of yield and stereoselectivity as the unfunctionalized stilbene **10a** (*E/Z* >99:1, 71–86% yield). For aniline **9c** to be successfully converted, the nickel(II)/dppf complex had to be preformed, since the presence of the aniline inhibited the formation of the active catalyst.<sup>[19,20]</sup> Both electron

poor and electron rich tolane derivatives bearing trifluoromethyl, methoxy, chloro and nitrile substituents 10d to 10g could all be converted with equally good results in terms of yields and stereoselectivity (>82% yield, E/Z >99:1). Noteworthy, with chlorostyrene 10f, no dehalogenation<sup>[21]</sup> was observed under the reaction conditions. A variety of carbonyl and carboxyl functional groups were not affected by the present catalytic protocol, as can be seen from the successful formation of products 10h to 10j, in which aldehydes, ketones and carboxylic esters are present. The successful turnover of aldehyde 10h is noteworthy, as in previous studies, the related nickel-catalyzed alkyne semireductions (with H<sub>2</sub><sup>[11]</sup> or other reducing agents than H<sub>2</sub><sup>[14]</sup>), aldehydes (and ketones) were not shown to be tolerated, underscoring the considerably milder conditions when employing H2 as terminal reductant. In terms of functional group tolerance, these results thus match or outplay the results with diaryl alkynes with the abovementioned catalysts **3-5** reported in literature.<sup>[8-11]</sup>



**Scheme 3.** Nickel-catalyzed semihydrogenation of diaryl alkynes. [a] Preformed Nil<sub>2</sub>/dppf complex<sup>[20]</sup> had to be used. [b] Conditions: 10 mol% Nil<sub>2</sub>, 12 mol% dppf, 40 bar  $H_2$ , 100 °C, 24 h.

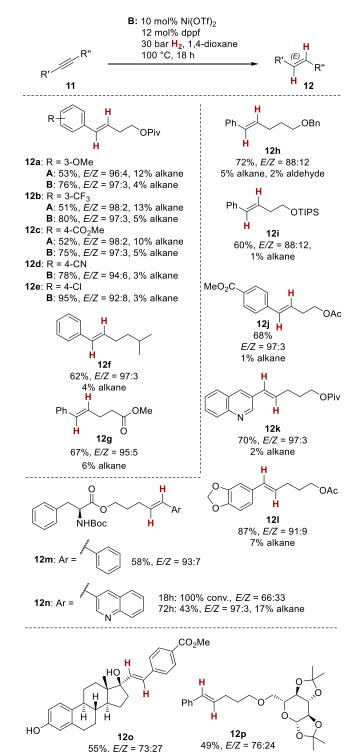
Finally, we turned our attention to heterocyclic systems. Thiophene derivative **10k** could be isolated in good yield and with excellent stereoselectivity (80%, E/Z > 99:1) along with 3% of overreduced alkane. 3-Pyridine derivative **10l** gave the usual good results with respect to stereoselectivity (E/Z > 99:1) and yield

(86%), albeit requiring higher catalyst loading (10 mol%  $Nil_2$ , 12 mol% dppf) and elevated pressure (40 bar  $H_2$ ).

Comparing the two catalytic protocols (**A** and **B**), for diaryl alkynes it can be noticed that on the whole, conditions **A** give better results in terms of yield and stereoselectivity. A drastic case in this vein being pyridine **10I**, for which conditions **B** fail entirely, whereas good results were obtained with conditions **A**. This indicates that the catalyst derived from nickel(II) triflate is more prone to alteration by coordination of substrates. Therefore, for this substrate class, nickel (II) iodide-based catalysts should be employed.

To demonstrate the broad applicability of the present nickel catalyst, we investigated aryl alkyl alkynes 11 next (Scheme 4). Our initial results (formation of *E*-alkenes 12a-12c) unambiguously indicated that for this substrate class, the protocol relying on nickel(II) triflate (conditions **B**) were clearly superior in terms of yield and chemoselectivity.

In this vein, a variety of substituted phenylacetylenes bearing electron donating and electron withdrawing groups 11a-11e delivered the corresponding substituted E-styrenes 12a-12e with very good E-selectivity and little overreduction to the alkane  $(E/Z \ge 92.8. \le 5\%$  alkane). No reduction of ester (12c. see also 12a) or nitrile (12d) groups or dehalogenation (12e) was detected. The investigation of potential alcohol protecting groups in 11h-11i established that for a benzyl or silyl ether (12h and 12i), somewhat diminished stereoselectivity was found, while the acetate 12j was formed with the usual high E-selectivity (E/Z = 97:3). The observation of trace of amounts of the terminal aldehyde in the case of 12h indicates the viability of chain-walking of the alkene by a putative nickel hydride intermediate after ether cleavage. [18] Heterocyclic substrates 12k and 12l could also be converted equally well. Furthermore, the presence of a protected amino acid as in phenylalanine derivatives 12m and 12n was tolerated by the nickel catalyst. Quinoline 12n displayed a dependence of the E-selectivity on the reaction time. Whereas a mediocre E-selectivity of 66:33 was reached after 18 h reaction time, satisfactory stereoselectivity could be achieved after prolonged time (72h, E/Z = 97:3). However, this improved stereoselectivity is accompanied by a drop in yield and an unusual high alkane formation (17%). These data indicate that with extended reaction times, secondary processes leading to overreduction occur. Furthermore, a possible rapid primary formation of the Z-alkene followed by an isomerization process could be present. Therefore, for sophisticated substrates, one has to balance overall yield and stereoselectivity by choice of reaction time. In this vein, ethinylestradiol derivative 12o and glucose derivative 12p were isolated in acceptable yields after the standard 18h reaction time. The formation of 12o indicates that the present nickel-catalyzed alkyne semihydrogenation can successfully also be carried out with highly substituted propargylic alcohols. We therefore investigated the reaction of ortho-phenol and ortho-



Scheme 4. Nickel-catalyzed semihydrogenation of aryl alkyl alkynes.

aniline derivatives **13a** and **13b** to probe a possible disruption of the catalyst by coordination of the functional group to the catalyst (Scheme 5). Whereas phenol **13a** cleanly delivered the desired styrene derivative **14** with the usual results in terms of yield and stereoselectivity (96%, E/Z = 97:3), aniline **13b** on the contrary

led to indole **15** as the major product. In the latter case, a literature-known cyclization<sup>[22]</sup> takes place with higher rates than the respective alkyne semihydrogenation.

**Scheme 5.** Complementary reactions of *ortho*-phenol (13a) and *ortho*-aniline (13b); alkyne semihydrogenation vs. cyclization.

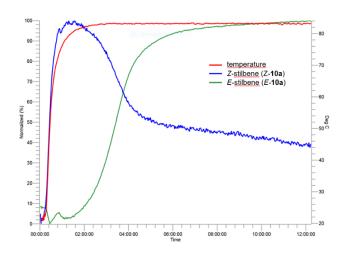
The nickel-catalyzed alkyne semihydrogenation could also be extended to dialkyl alkynes, for which only few catalysts can facilitate an E-selectivity. Therefore, we prepared cyclic bislactone 17 by alkyne ring closing metathesis from diester 16 employing  $W(CCMe_3)(OCMe_3)_3^{[23]}$  as catalyst (Scheme 6). Subsequent nickel-catalyzed semihydrogenation of 17 (under conditions A) gave E-bislactone 18 with complete control of alkene geometry (E/Z>99:1, 45% yield). The stereoselectivity in this transformation is remarkable. E-selective semihydrogenations of cyclic alkynes are highly attractive, as these are accessible through alkyne ring-closing metathesis. [24] The subsequent transformation to E-cycloalkenes is a useful alternative to the challenging E-selective olefin ring-closing metathesis.[25]

**Scheme 6.** Ring-closing alkyne metathesis and nickel-catalyzed semihydrogenation of cycloalkyne **17.** Strategy to access cyclic compounds with *E*-configured alkenes. Conditions: a) 3 mol% W(CCMe<sub>3</sub>)(OCMe<sub>3</sub>)<sub>3</sub>, 4Å MS, toluene, RT, 20 h. b) 5 mol% Nil<sub>2</sub>, 6 mol% dppf, 15 bar H<sub>2</sub>, 100 °C, 24 h.

The investigation of the substrate scope led to the conclusion that the commercially nickel catalyst developed for *E*-selective alkyne semihydrogenation could be widely applied to a variety of substrates, surpassing most of the catalysts previously reported in terms of substrate scope and functional group tolerance.

We carried out further experiments to shed light on the possible reaction mechanism. First, we obtained kinetic data by following the high pressure reaction by IR spectroscopy (Scheme 7). The respective traces indicate that a rapid Z-selective alkyne semihydrogenation takes place even when the reaction vessel is still warming up (blue curve for Z-stilbene (Z-10a)). Only after the

reaction mixture has reached 80 °C after about 90 minutes, the formation of E-stilbene E-10a is observed (green curve). After about 3 h, the rate of the formation of E-10a increases until it becomes the major product. The spectroscopic data therefore suggests two mechanism which are operative: a first Z-selective alkyne semihydrogenation and a second  $Z \rightarrow E$  isomerization process. This type of mechanism had been observed earlier for the other first row transition metal-based catalysts for E-selective alkyne semihydrogenation. [9–11]



**Scheme 7.** Following the nickel-catalyzed alkyne semihydrogenation (conditions **B**) by IR spectroscopy. Horizontal axis: time in h, left vertical axis: normalized percentage, right vertical axis: temperature in °C. (Trace of *Z*-10a becomes more unclear with larger conversion due to overlap of signals.)

In order to investigate whether a reaction pathway via preliminary Z-selective alkyne semihydrogenation followed by a (necessarily rapid) Z/E-isomerization sequence involving nickel hydride complexes<sup>[18]</sup> is operative, we subjected Z-stilbene (Z-10a) to the standard semihydrogenation conditions (Scheme 8). If an upstream Z-selective alkyne semihydrogenation of tolane (9a) took place, Z-10a would be a competent reaction intermediate in the formation of E-10a. However, we observed only partial isomerization and obtained a 57:43 E/Z mixture of 10a with an unusually high percentage of overreduction to the alkane (7%, compared to <1% in the semihydrogenation of 9a, see Scheme 3). As in the absence of nickel(II) iodide, no change of the E/Z ratio of Z-10a took place, a thermal isomerization process could be ruled out. A faster isomerization to E-10a along with suppressed alkane formation (E/Z = 90:10, 1% alkane) was observed when a catalytic amount of tolane (9a) was added to the isomerization experiment. Even though these results do not match the values found in the alkyne semihydrogenation, they nevertheless give an indication for an involvement of the alkyne in a putative secondary catalytic  $Z \rightarrow E$  isomerization process. The

effect of adding catalytic amounts of E-alkene E-10a to the mixture were found to be negligible, underscoring that the presence of an alkyne and not an alkene seems to be key for the reactivity and selectivity. Even though these results demonstrate that  $Z \rightarrow E$ -isomerization of the alkene products 10 can indeed occur under the standard semihydrogenation conditions, the rate of isomerization is not in agreement with the results of the alkyne semihydrogenation. This data therefore suggests an alternative mechanism which does not involve preliminary Z-selective alkyne semihydrogenation followed by  $Z \rightarrow E$ -isomerization. Alternatively, the nature of the nickel catalyst could be altered by the presence of alkyne and/or alkene, leading to a more sophisticated catalyst.

**Scheme 8.** Experiments probing the reaction mechanism of the alkyne semihydrogenation: Z/E-Isomerization of stillbene Z-10a. Standard conditions A: 5 mol% Nil<sub>2</sub>, 6 mol% dppf, 20 bar H<sub>2</sub>, 1,4-dioxane, 100 °C, 16 h.

In order to probe whether a radical mechanism might be operative, methyl acrylate (19) was added to the semihydrogenation of 9a to intercept any radical intermediates (Scheme 9). However, no disruptive effect on the clean and selective formation of E-10a was observed. When 1,6-enyne 20 was subjected to the semihydrogenation conditions A, full conversion of 20 was observed along with the formation of a mixture of products. Noteworthy is the formation of a small amount of cyclopentane 21 as a mixture of isomers (E/Z = 61:39) in these experiments. $^{[16]}$  The observed cyclization could either be indicative for a radical mechanism, or - more likely - be the result of a cyclization reaction involving a polar carbonickelation mechanism. $^{[26]}$ 

In order to shed light on possible nickel hydride intermediates present in either of the proposed steps of the catalysis (Zselective alkyne semihydrogenation,  $Z \rightarrow E$  isomerization), we investigated the isomerization of 2-allylnaphthalene (22, Scheme 10) under the reaction conditions A. When 22 was subjected to the standard reaction conditions (5 mol% Nil2, 6 mol% dppf, 20 bar H<sub>2</sub>, 1,4-dioxane, 100 °C), we found complete isomerization towards E-propenyl-naphthalene 23 (67% yield). This result is an indication for the presence of nickel hydride intermediates, which could facilitate this isomerization through a hydronickelation/βhydride elimination pathway. It should be noted that in the absence of nickel(II) iodide and also in the absence of dppf, no conversion of 22 was observed, indicating the crucial role of the ligand for H<sub>2</sub> activation and/or isomerization. To exclude that possibly formed HI could permit a Brønsted-acid catalyzed isomerization, [27] we carried out the same isomerization (22→23) in the presence of 10 mol% base (2,6-di-tert-butylpyridine). This additive did not hinder the isomerization, indicating the absence of acid-catalyzed processes (Scheme 10, middle). Finally, application of the standard conditions  $\bf A$  utilizing deuterium gas (D<sub>2</sub>) showed a pattern of partial deuteration at all three side chain carbon atoms (17% to 36% deuterium incorporation, Scheme 10, bottom). Especially the presence of partial deuterium labelling at the quasi-benzylic position (17% D incorporation) hints towards a re-insertion of a putative nickel deuteride into the alkene already in conjugation to the aromatic ring.

**Scheme 9.** Experiments probing the reaction mechanism of the alkyne semihydrogenation: trapping/cyclization experiments. Standard conditions **A**: 5 mol% Nil<sub>2</sub>, 6 mol% dppf, 20 bar  $H_2$ , 1,4-dioxane, 100 °C, 16 h.

**Scheme 10.** Isomerization studies. Indication for the presence of nickel hydride intermediates.

The mechanistic investigations for the present nickel-catalyzed alkyne semihydrogenation thus suggest a mechanism similar to the *E*-selective alkyne semihydrogenation with earlier reported Fe, Co and Ni complexes (Scheme 1),<sup>[9-11]</sup> namely a primary *Z*-selective alkene formation followed by an efficient  $Z \rightarrow E$ -isomerization by hydronickelation and  $\beta$ -hydride elimination. From

the results of the isomerization experiments, the involvement of nickel hydride intermediates is highly probable. However, as the presence of alkynes for an efficient  $Z \rightarrow E$ -isomerization is important, the exact structure of the catalyst is not known at presence.

To demonstrate the applicability of the nickel catalyst, we carried out a stereoselective synthesis of a naturally occurring compound, resveratrol (26, Scheme 11). The synthesis emanates from internal alkyne 24, which is the key precursor for the alkyne semihydrogenation. To highlight the orthogonal stereoselectivity of the nickel catalyst to "classic" hydrometalation chemistry, we first carried out a *Z*-selective copper(I)-catalyzed alkyne semihydrogenation with [IPrCuOH] as catalyst. [15b] In this manner, *Z*-25 could be obtained with excellent stereoselectivity (E/Z = 1:99, 88% yield). On the other hand, the nickel catalyst gave the opposite isomer *E*-25 in 79% yield (E/Z > 99:1). The latter was demethylated [28] to give resveratrol (26) in 83% yield.

**Scheme 11.** Complementary stereoselective alkyne semihydrogenations and synthesis of resveratrol (**26**). a) 5 mol% [IPrCuOH], 100 bar H<sub>2</sub>, THF, 60 °C. b) 5 mol% Nil<sub>2</sub>, 6 mol% dppf, 1,4-dioxane, 20 bar H<sub>2</sub>, 100 °C.

#### **Conclusions**

Stereoselective alkyne semihydrogenations with  $H_2$  are among the most efficient access to alkenes. Only few catalysts are available which offer high E-selectivity in this process. Furthermore, these catalyst have been shown to be limited in their substrate scope, with either aryl or alkyl substituents not tolerated. Here, we have presented a simple and commercially available nickel catalyst, which sustains all of the abovementioned substitution patterns, thus offering a unified approach to E-selective alkyne semihydrogenation. Next to a broad substrate scope, mechanistic investigations have been carried out which indicate a two-step overall process of primary Z-selective alkyne semihydrogenation and subsequent  $Z \rightarrow E$  isomerization, with the involvement of nickel hydride intermediates. Our study therefore

puts forward a generally applicable catalyst with a simple protocol for the catalytic and atom economic access of *E*-alkenes from internal alkynes. These results have implications for synthetic chemistry, as the catalyst presented here is widely applicable.

### **Experimental Section**

E-selective alkyne semihydrogenation, general procedure: A glass vial was charged with Nil<sub>2</sub> (5 mol%), and dppf (6 mol%) or Ni(OTf)<sub>2</sub> (10 mol%) and dppf (12 mol%), the corresponding substrate (if solid, 1.0 equiv), a magnetic stirrer and a septum. The charged vial was evacuated and repressurized with N2 gas using a Schlenk line. Then, the corresponding amount of solvent (7.7 mL/mmol substrate) was added. Substrates (1.0 equiv) which are liquid at room temperature were added dropwise via syringe after the solvent was added. After addition of all components the reactions were stirred at room temperature for 2 min. The autoclave was purged with N2 (1 x 1 bar, 3 x 10 bar) before the reaction vessels were placed in an autoclave under a counterflow of N2. Afterwards the autoclave was purged with N2 (3 x 10 bar) and H2 (3 x 10 bar) before the appropriate H2 pressure was applied (pressure is given as initial pressure before heating). The heating block was pre-heated to the temperature given before the autoclave was placed inside. After the reported reaction time the autoclave was allowed to cool to room temperature and H2 was released. The autoclave was purged with N2 (3 x 10 bar) before the reaction vessels were taken out. The reaction mixture was concentrated under reduced pressure, diluted with CH2Cl2 and filtered through a small plug of silica (2 cm ø, 2 mL, CH<sub>2</sub>Cl<sub>2</sub> as eluent), and all volatiles were removed under reduced pressure. Reactions were subsequently analyzed either by GC and/or <sup>1</sup>H NMR. The crude mixture was then subjected to purification as indicated with the appropriate substrates.

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**Keywords:** nickel • hydrogenation • alkyne • stereoselectivity • catalysis

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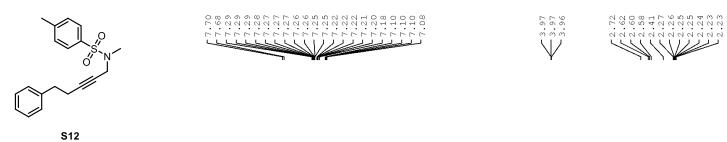
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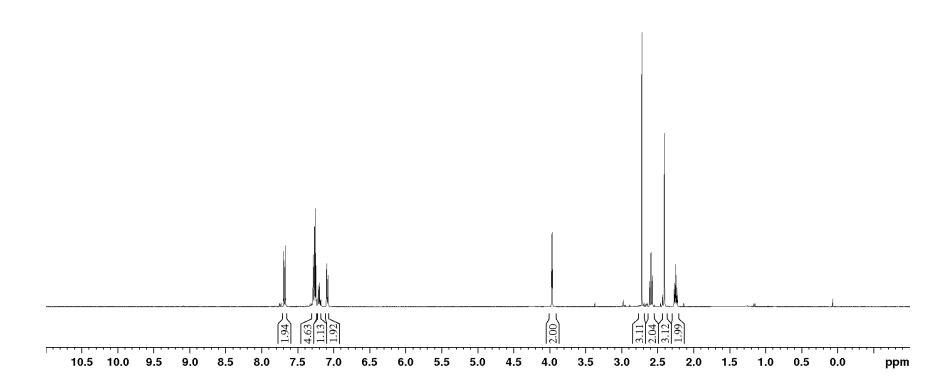
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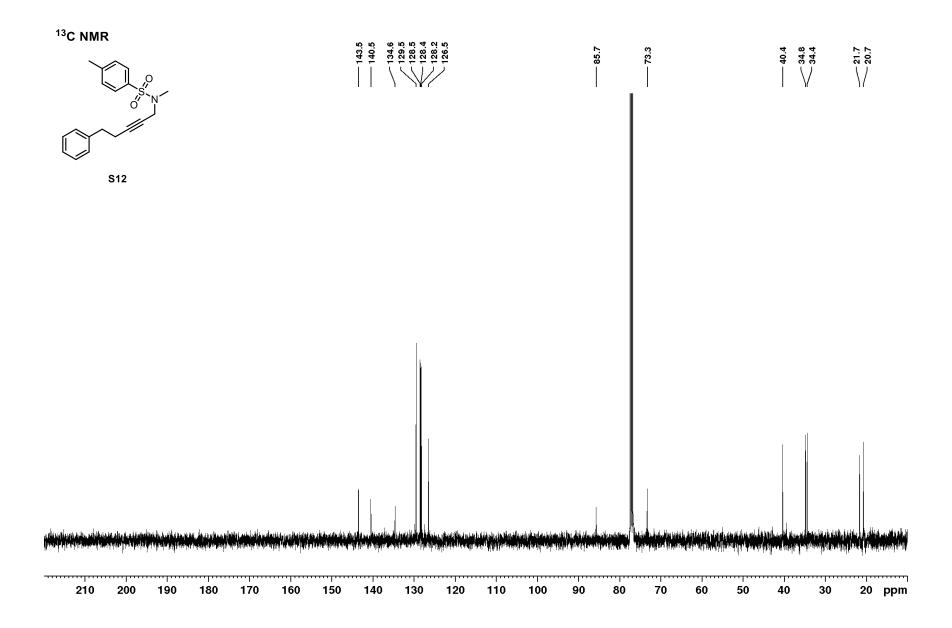
Additional Spectra for N. O. Thiel, B. Kaewmee, T. Tran Ngoc, J. F. Teichert

A Simple Nickel Catalyst Enables Broad E-Selective Alkyne Semihydrogenation

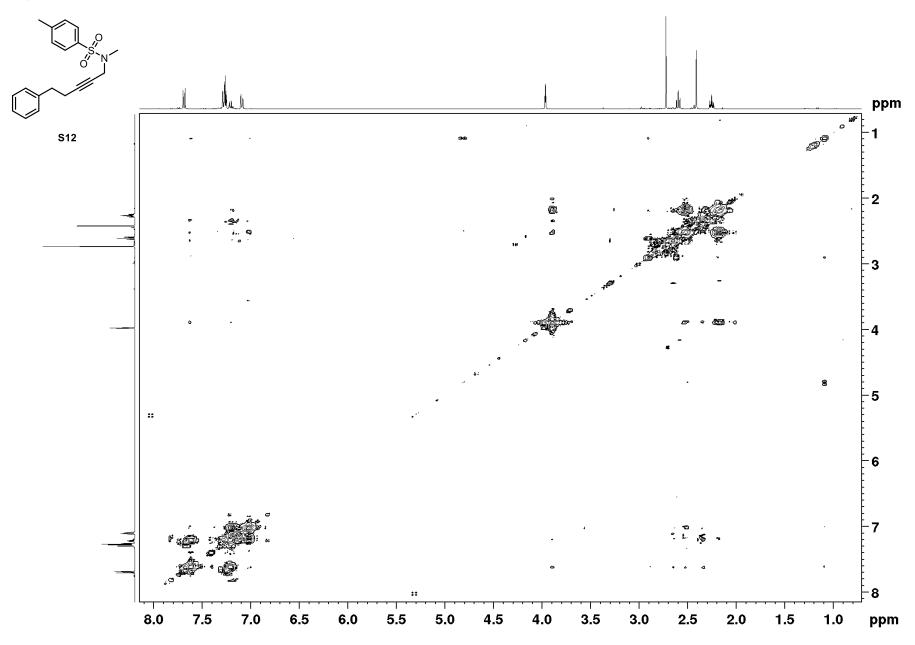
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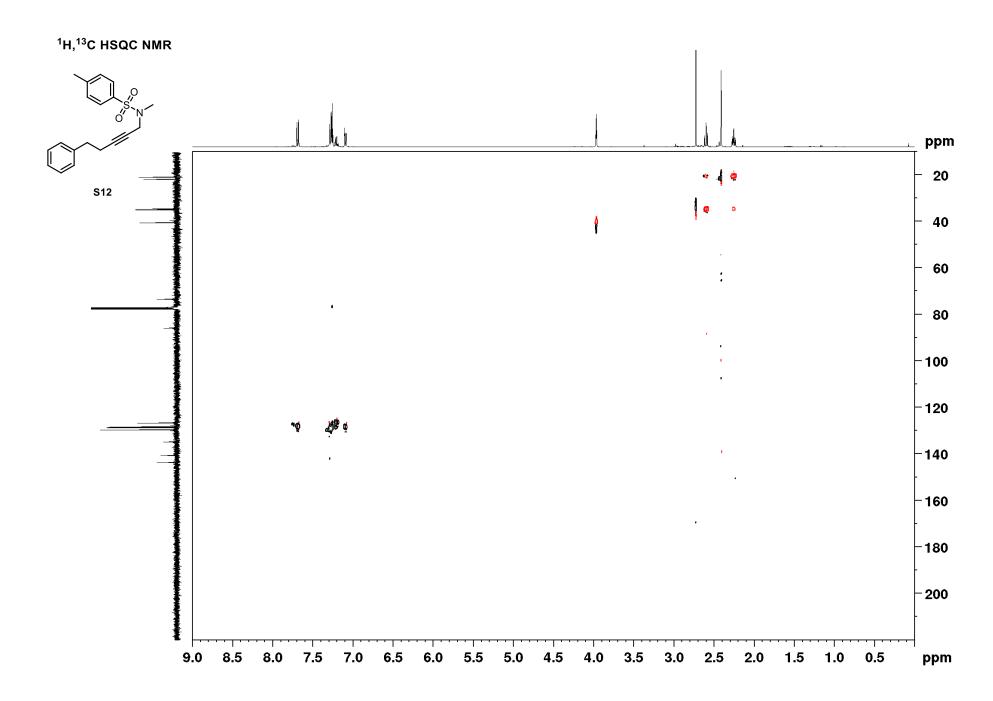




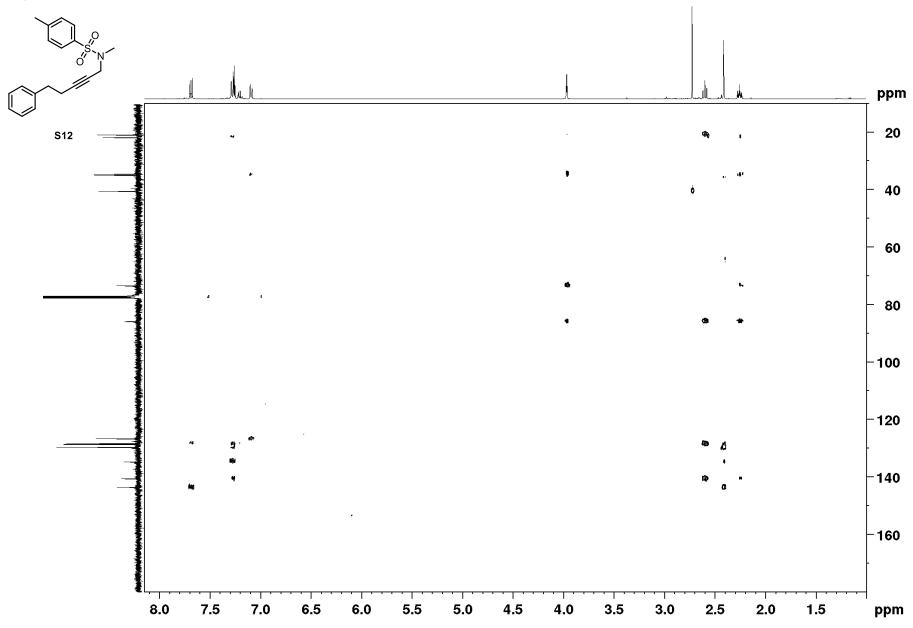


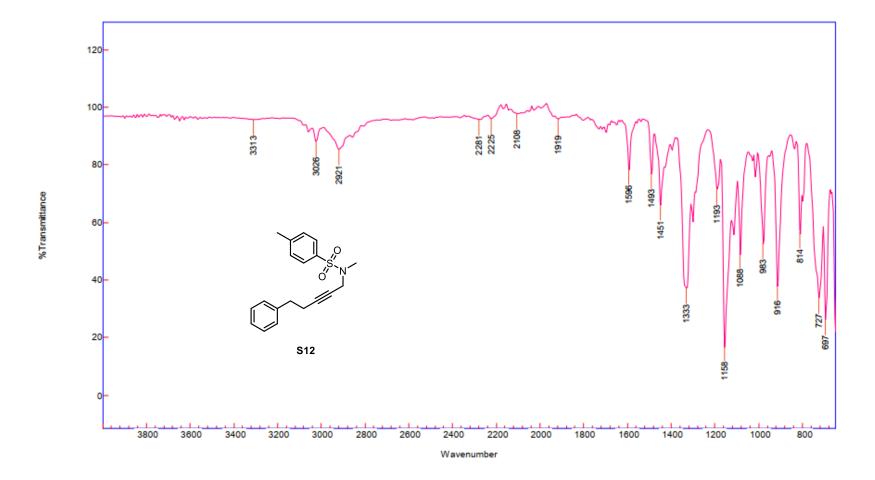


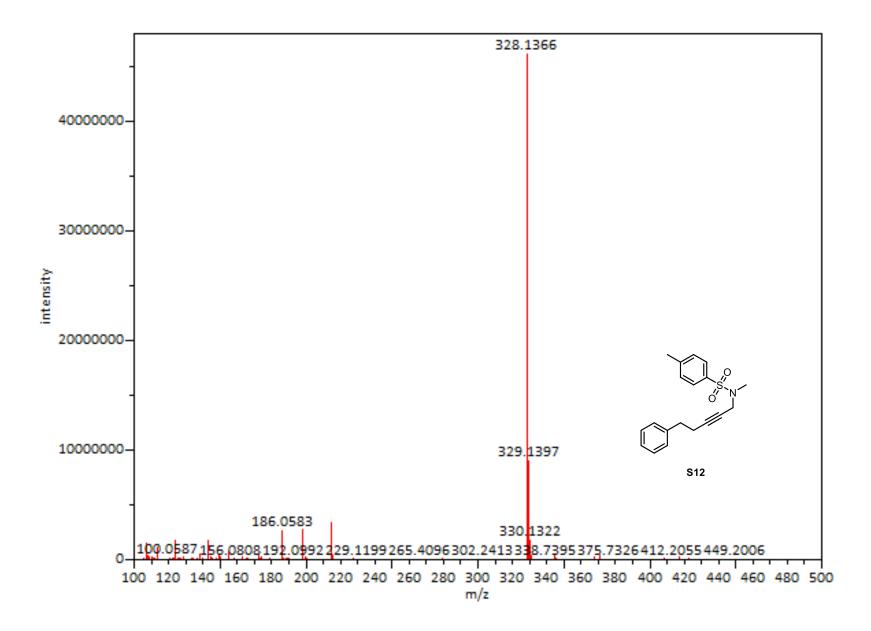


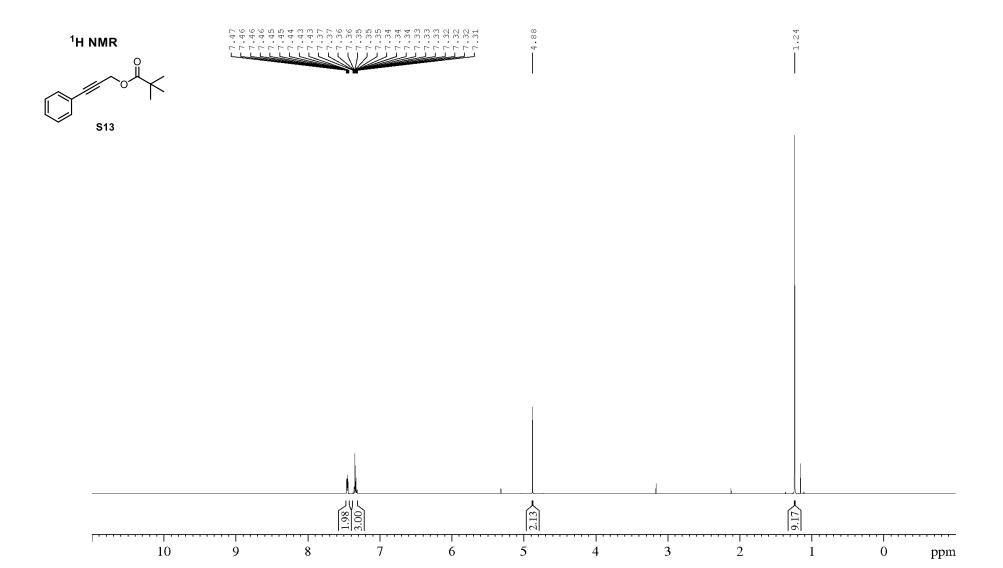


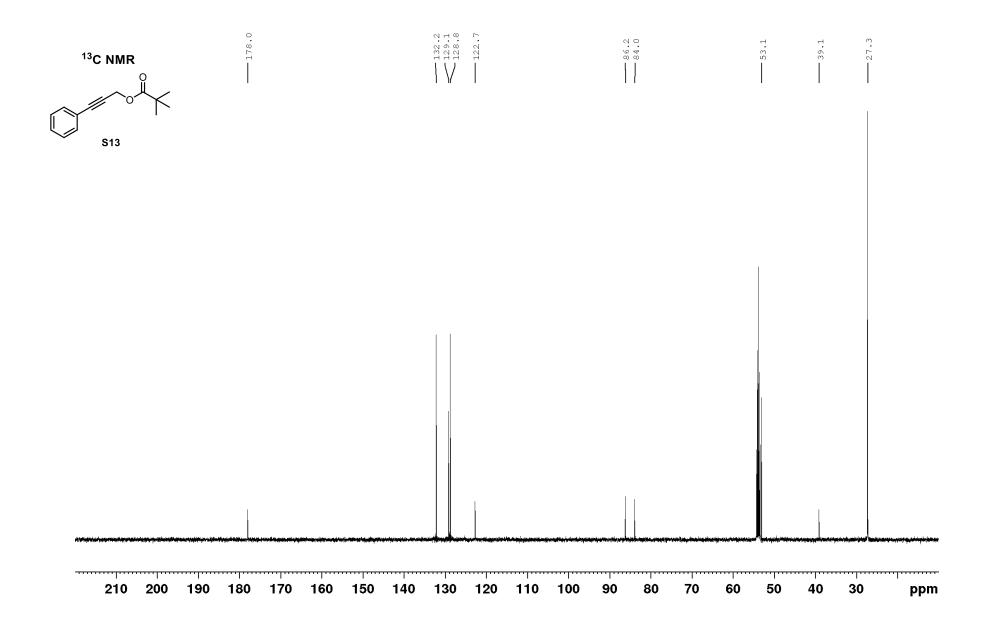




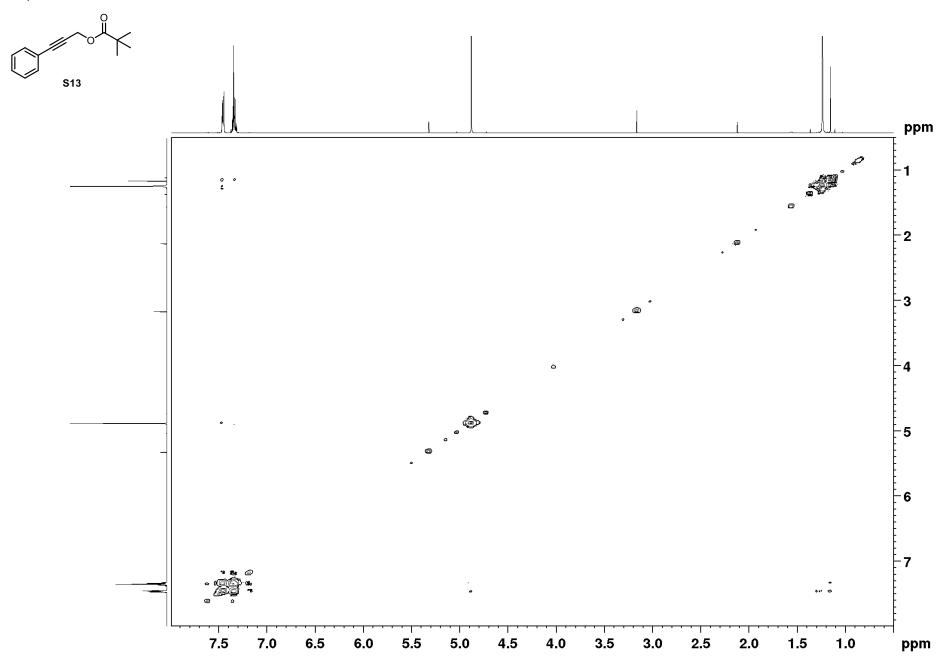




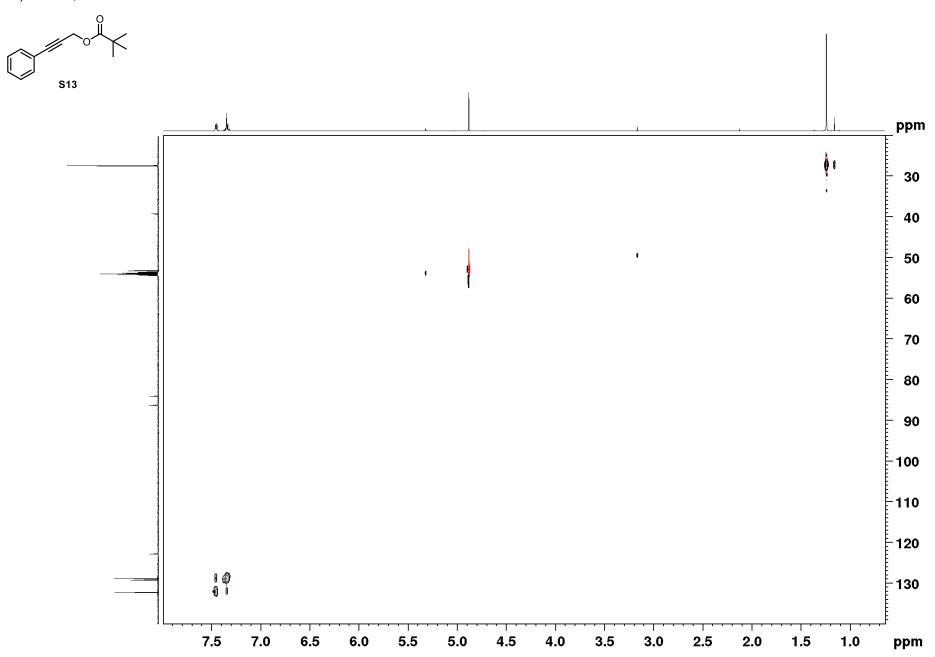




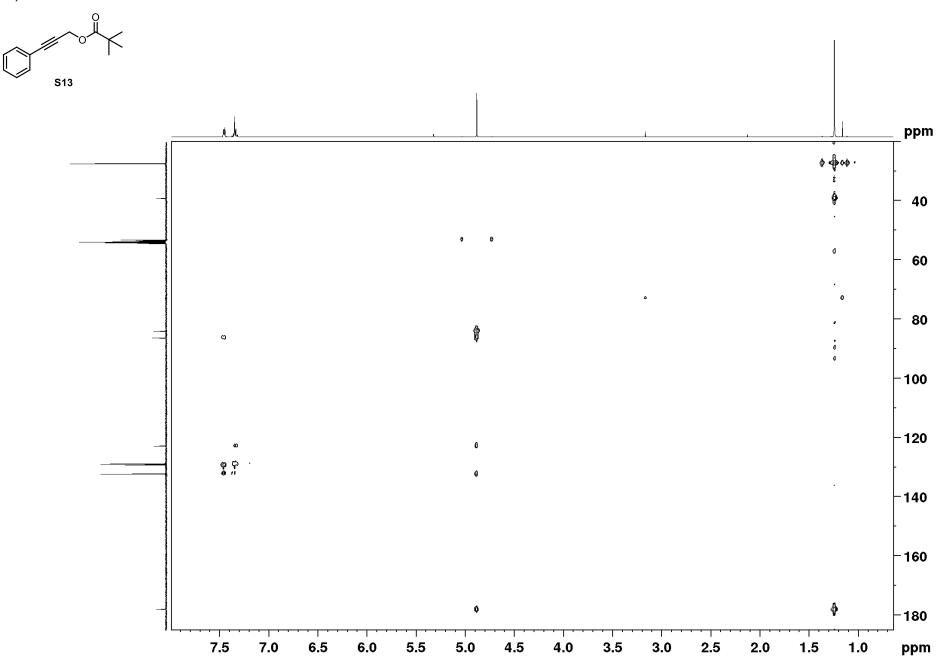


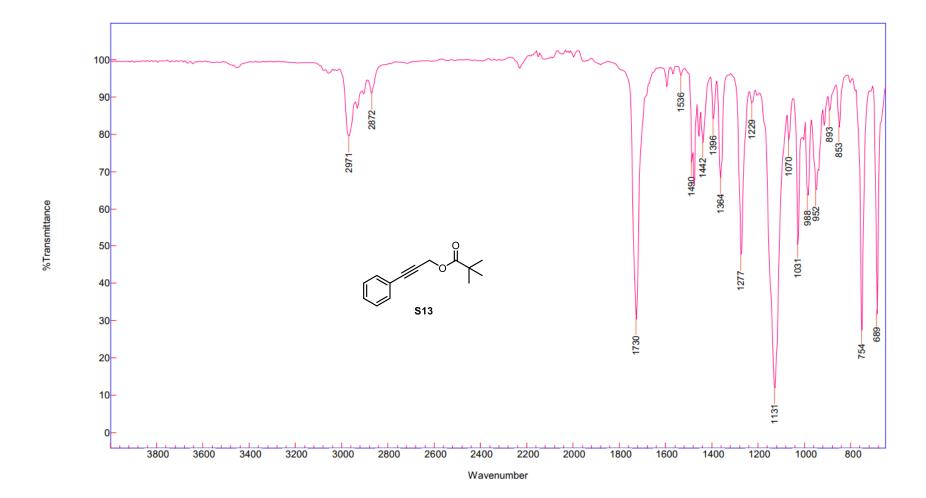


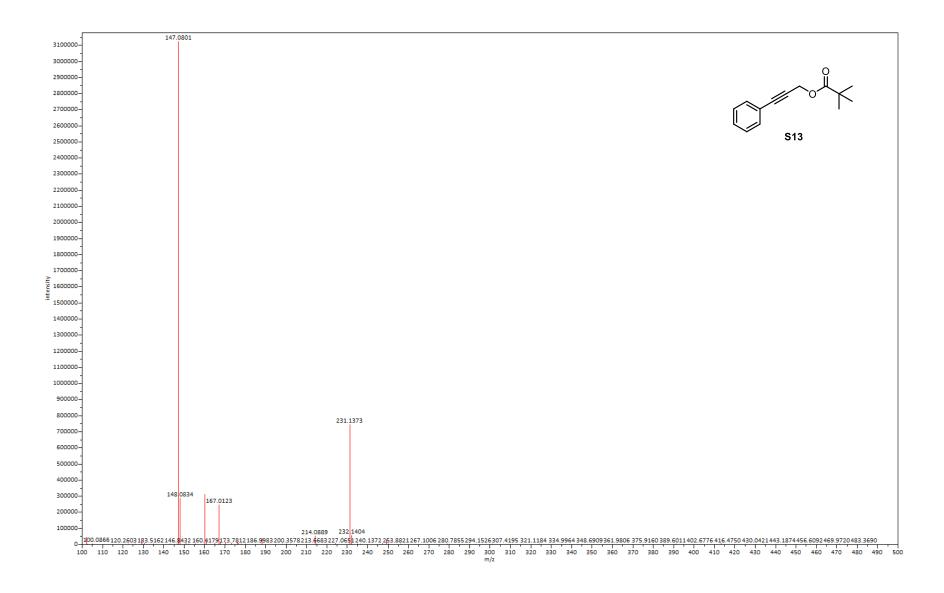


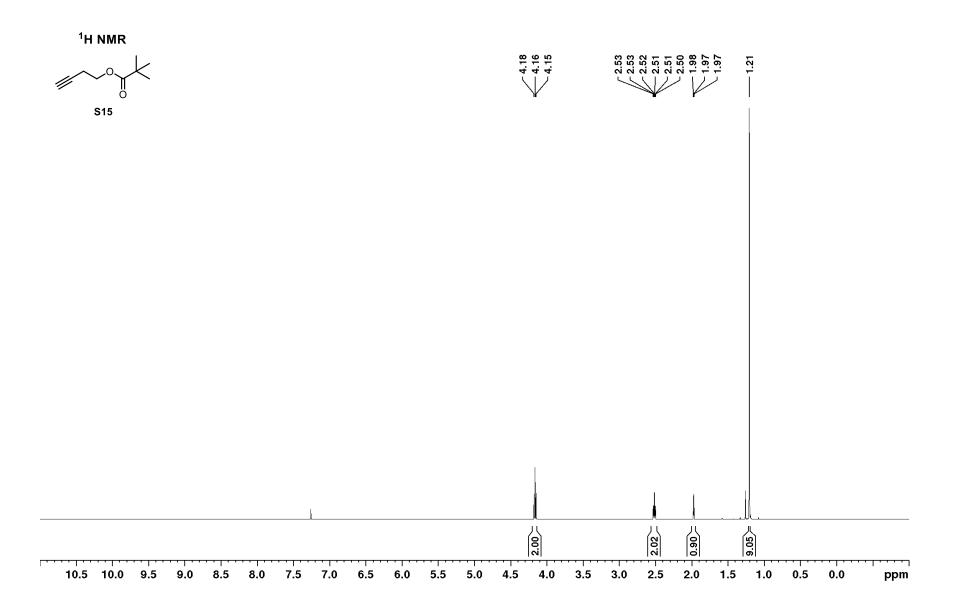


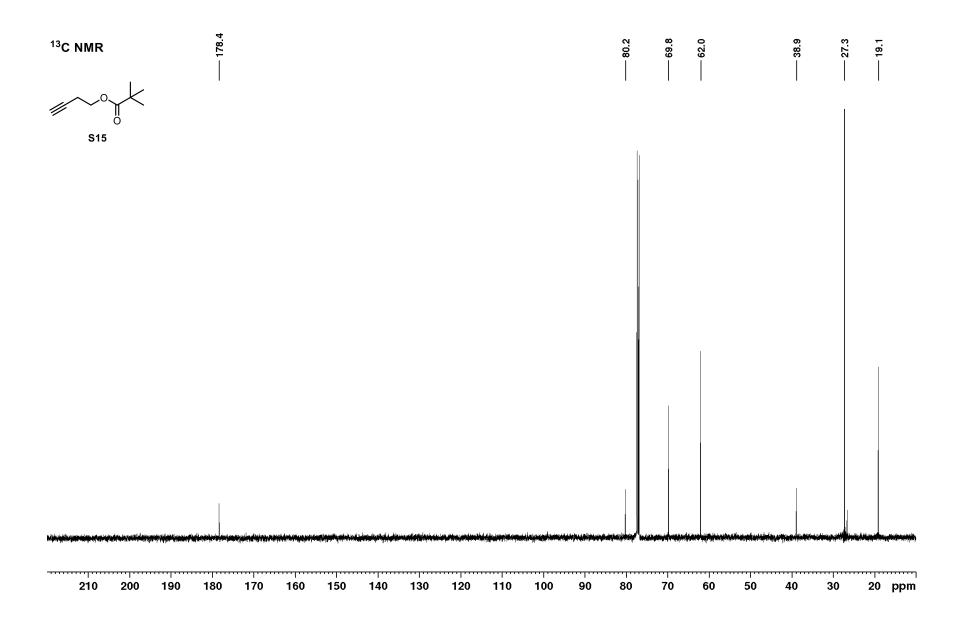




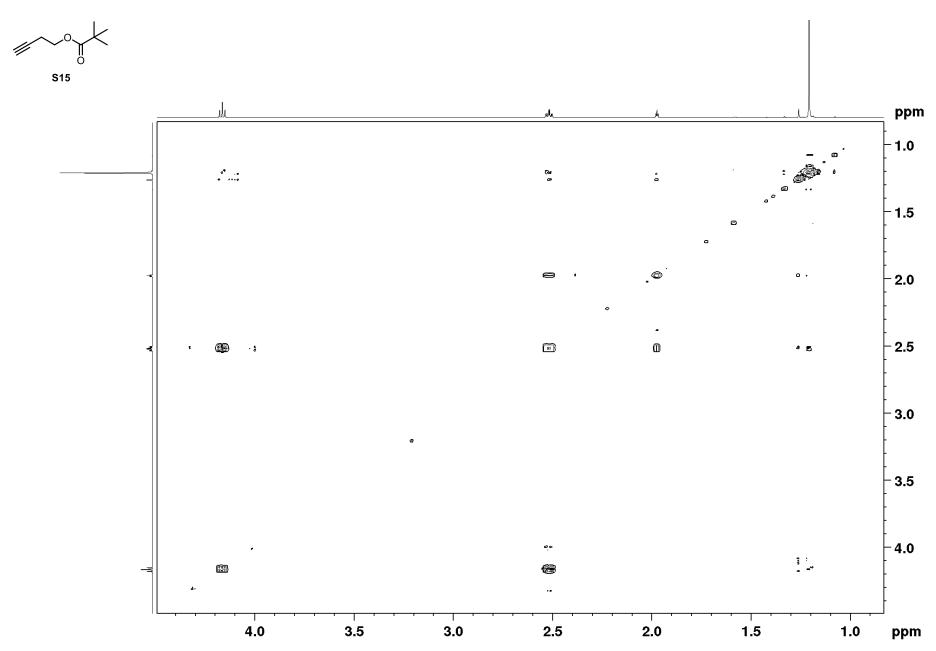




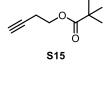


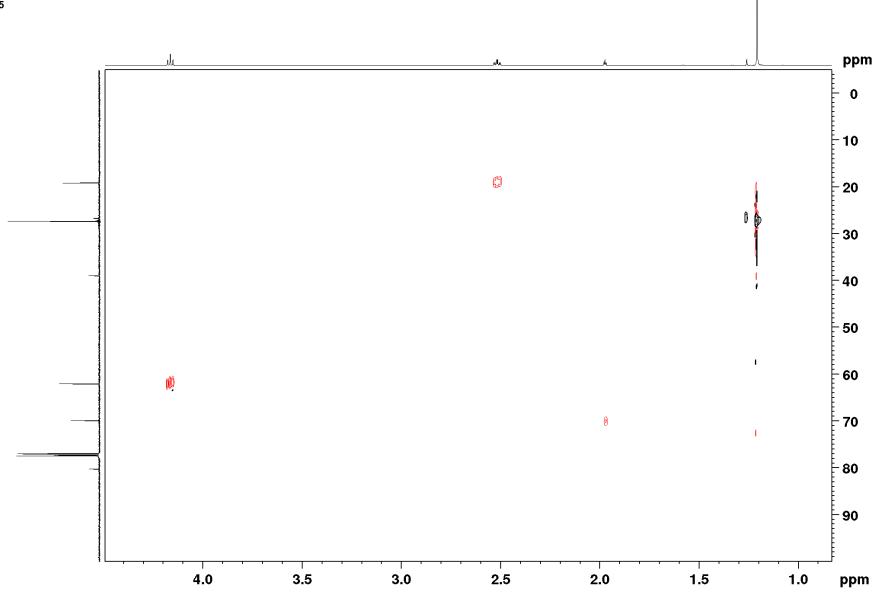




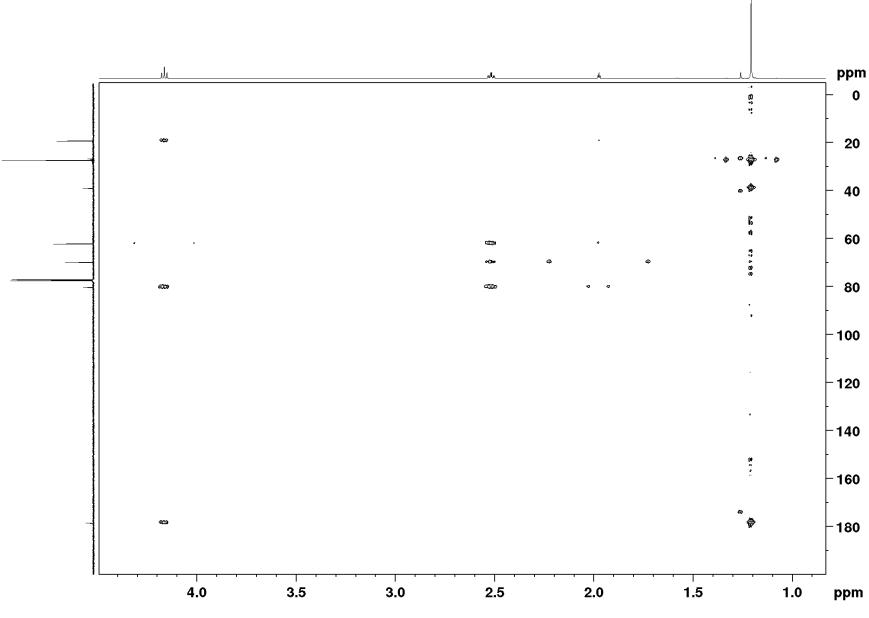


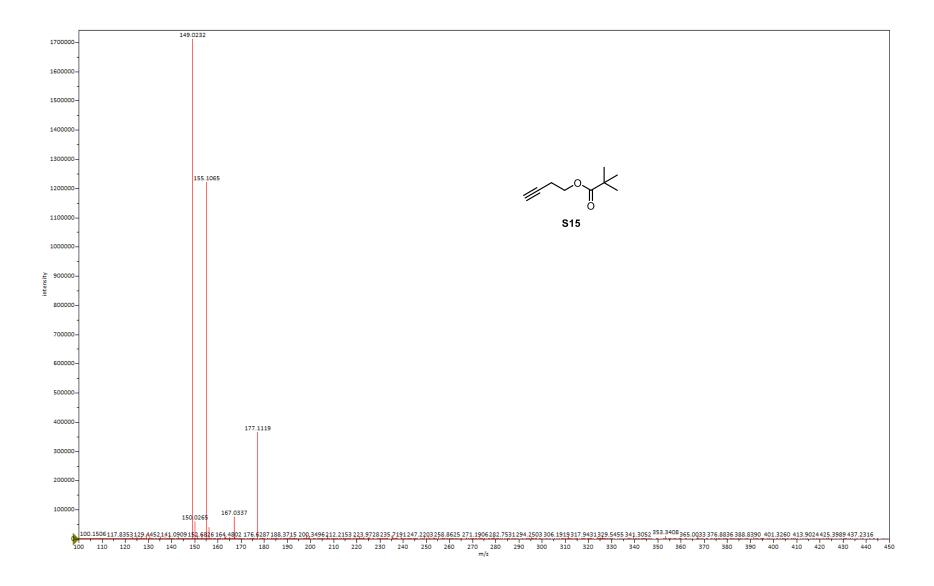


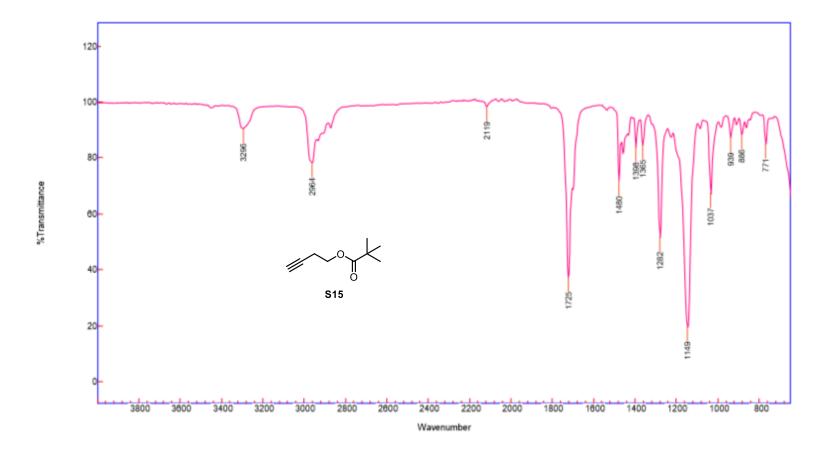


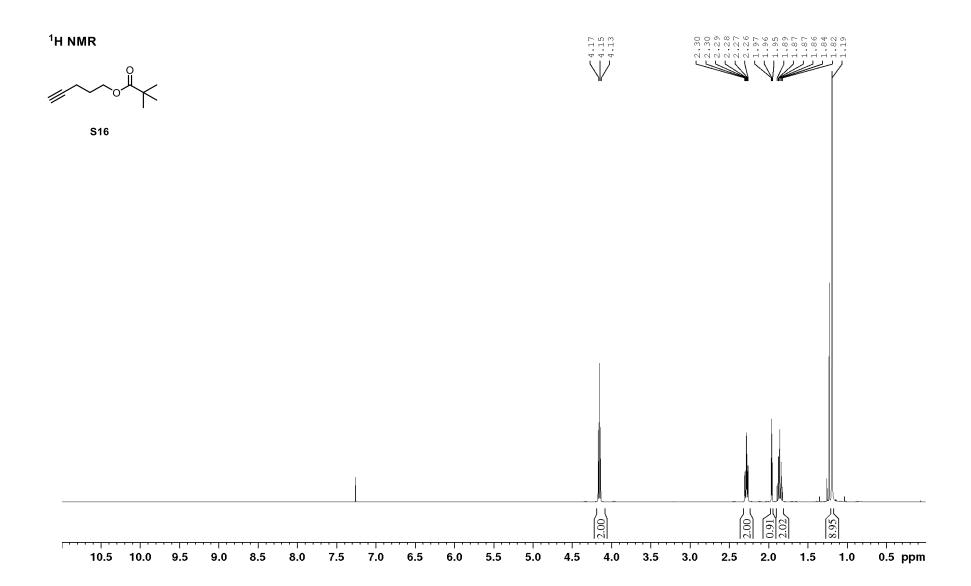


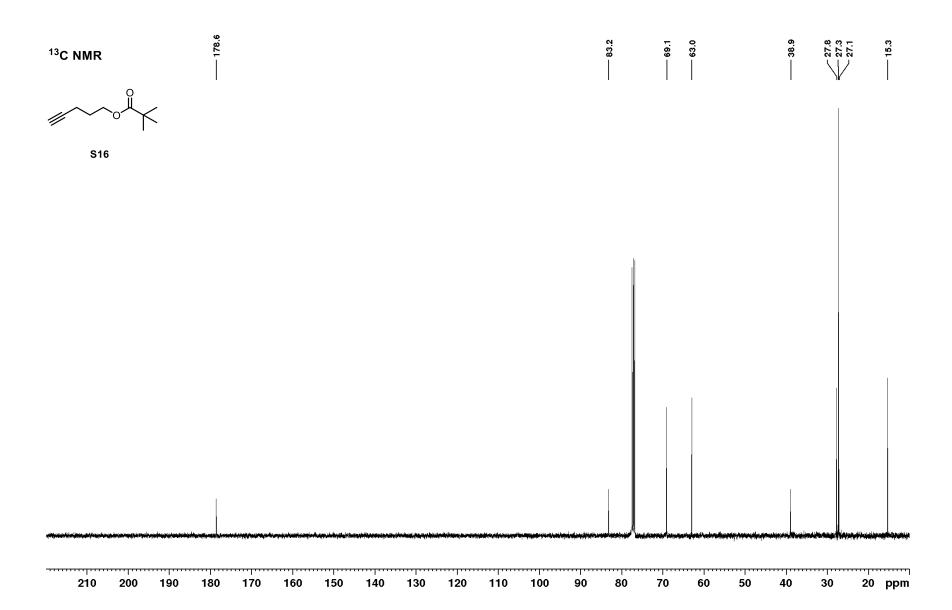


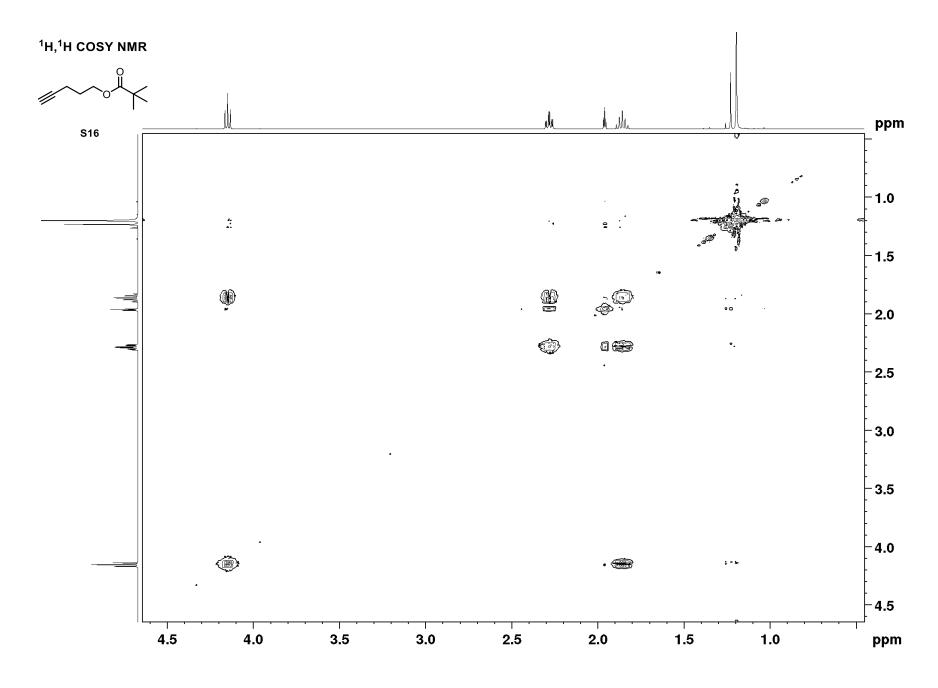


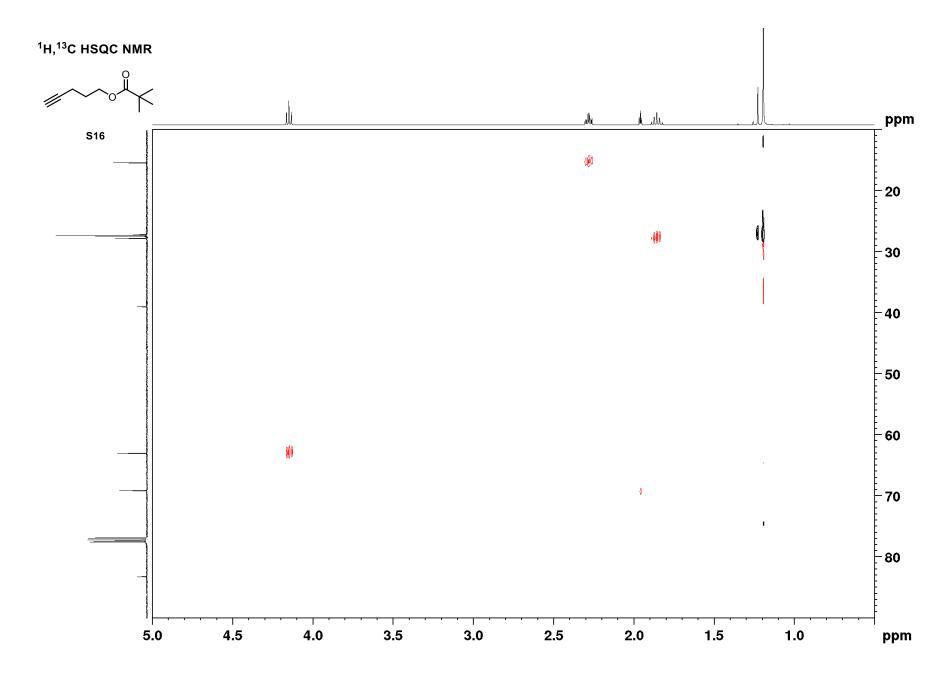


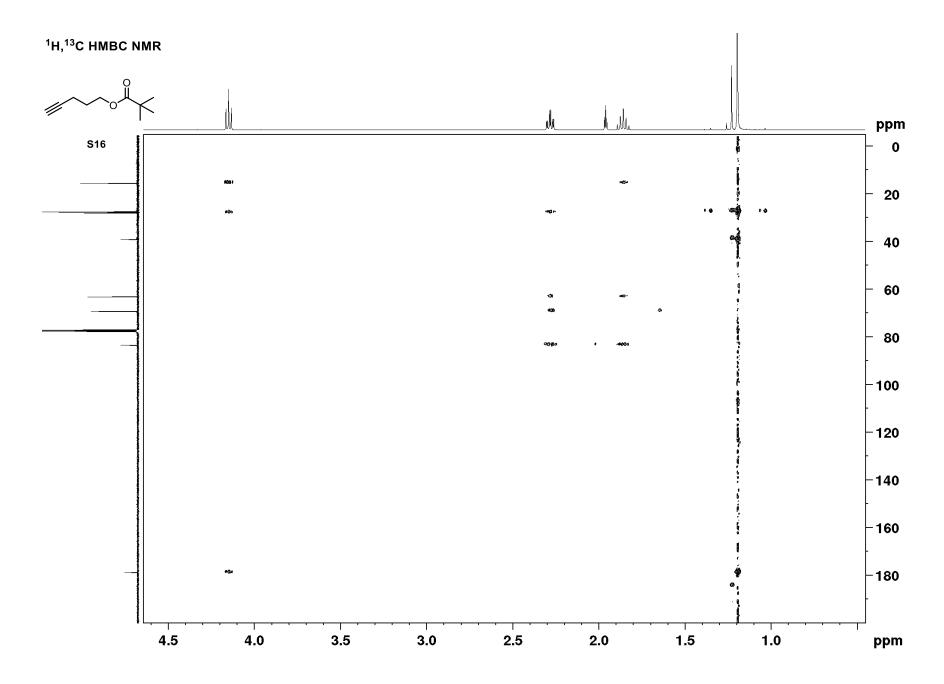


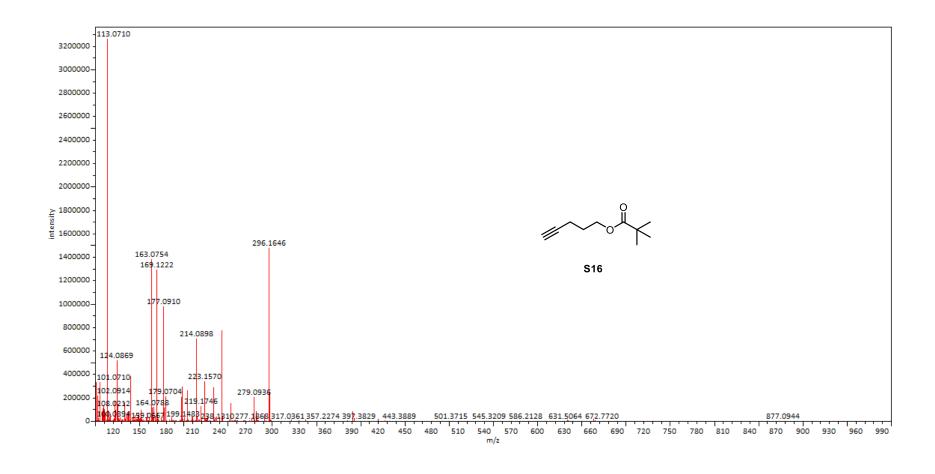


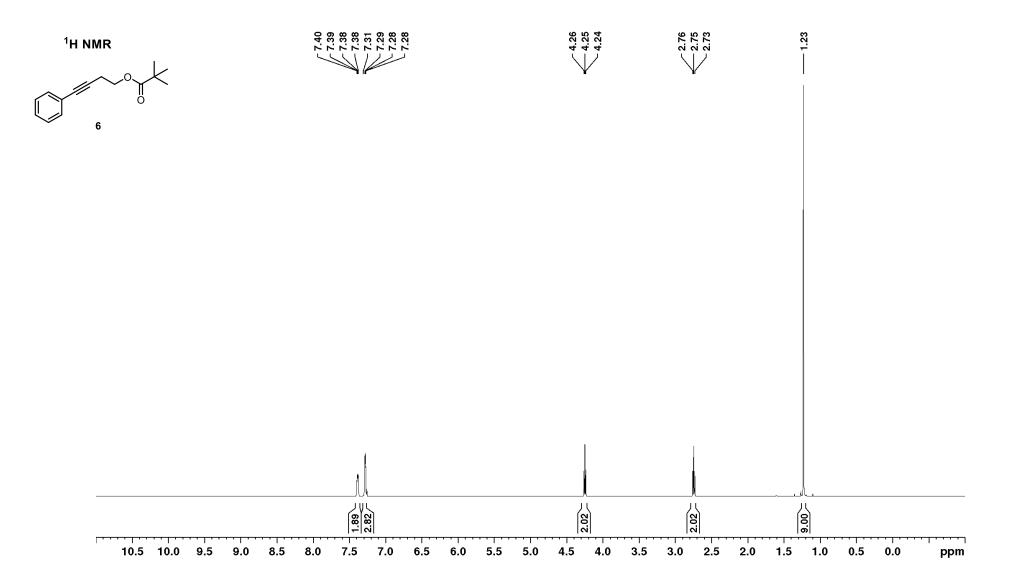


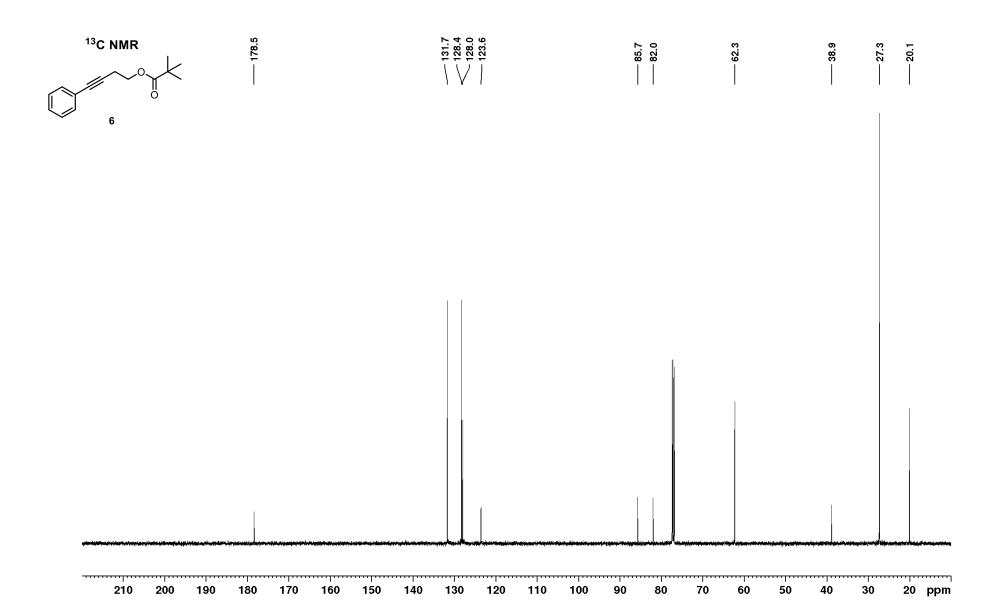


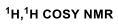












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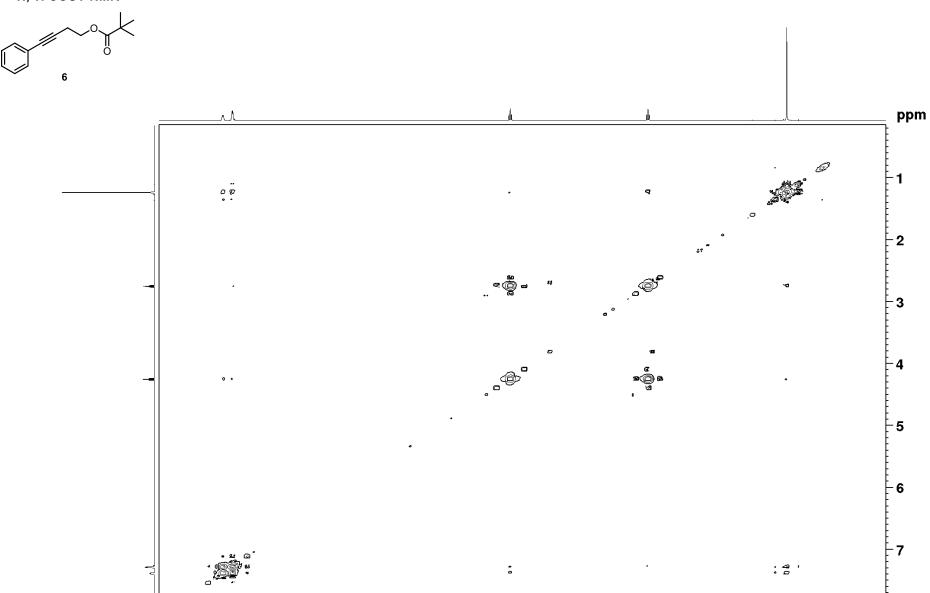
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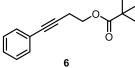
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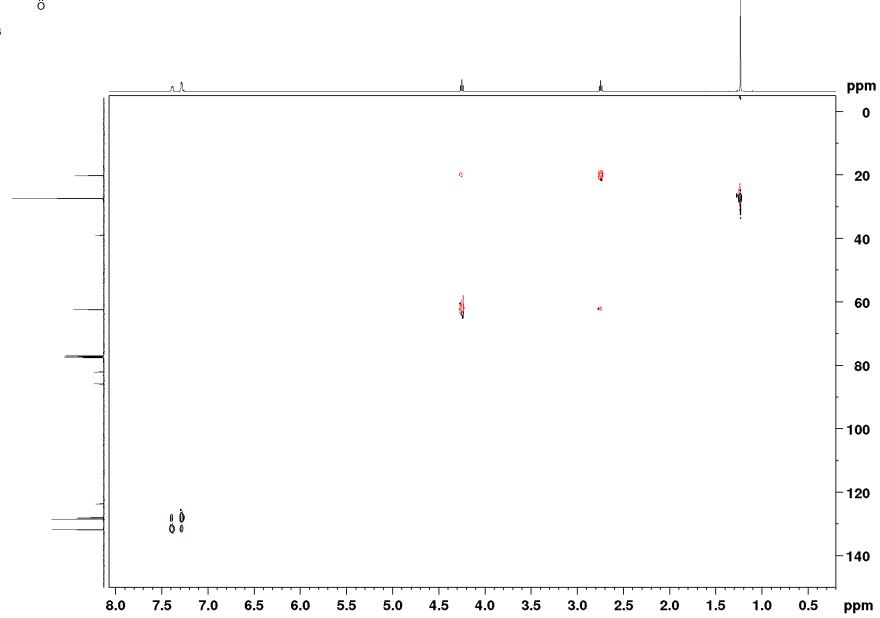
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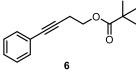
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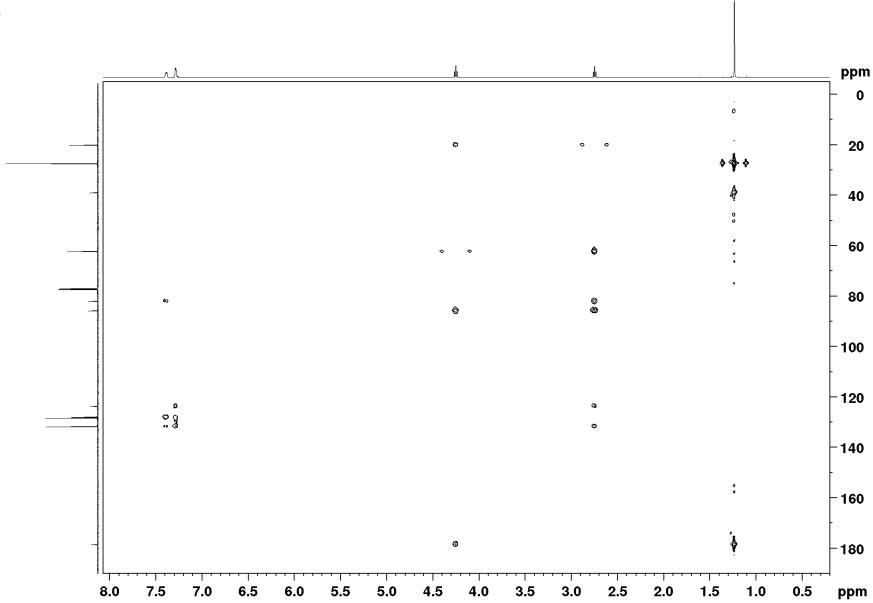


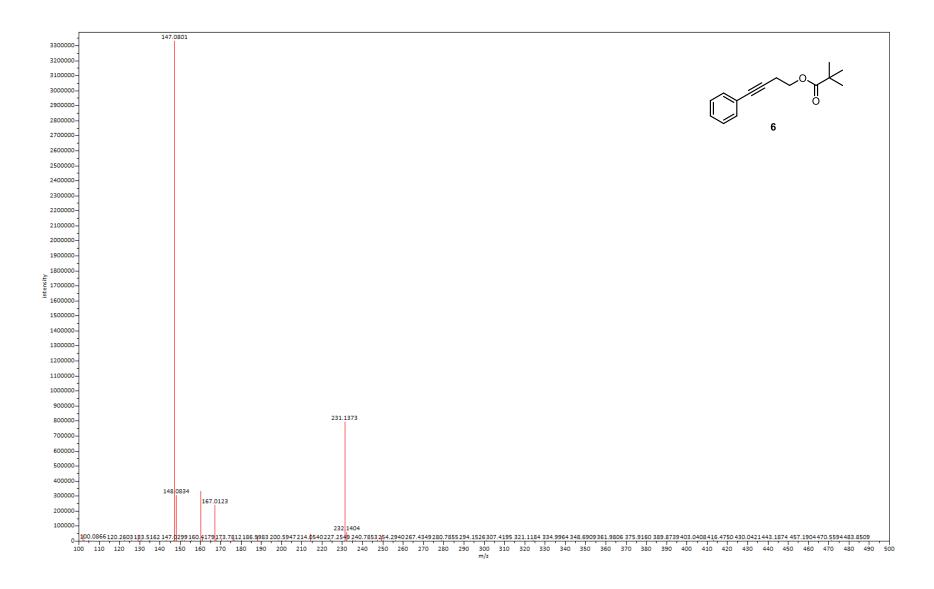


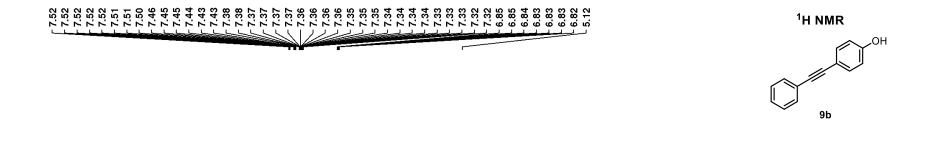


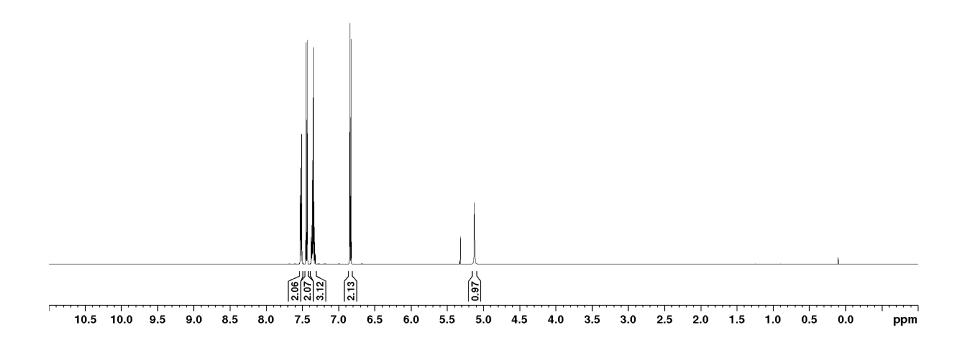


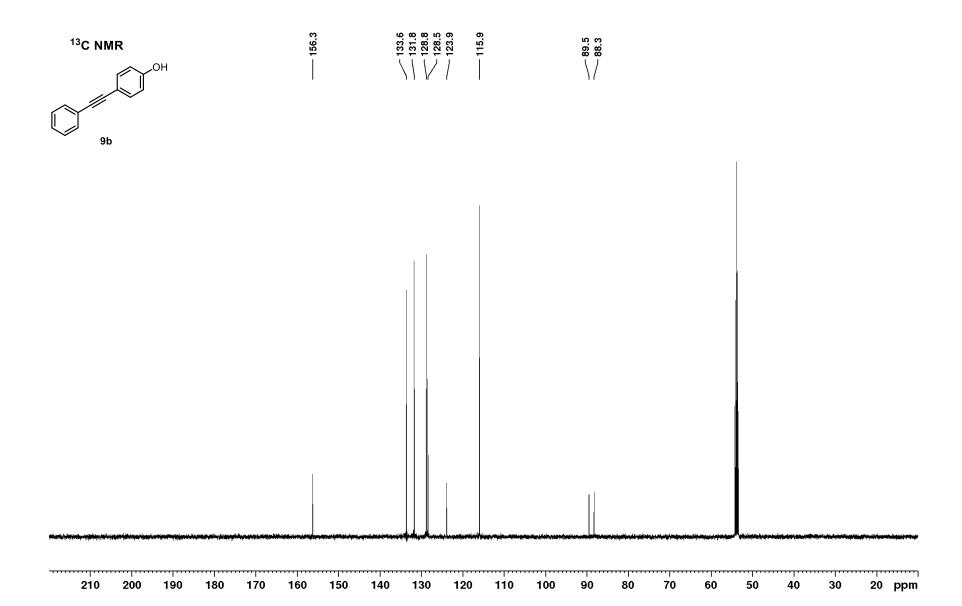


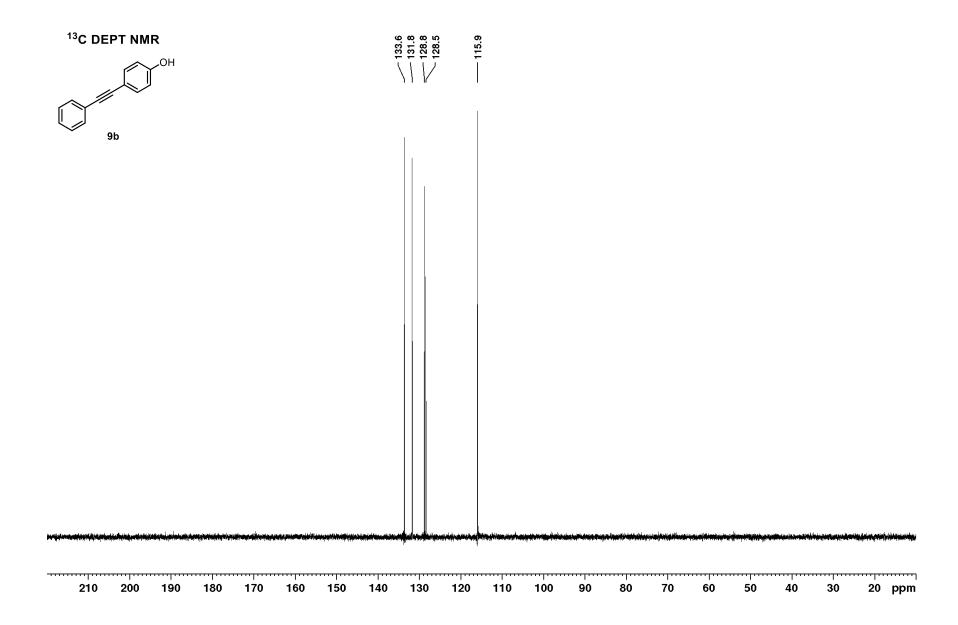


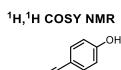


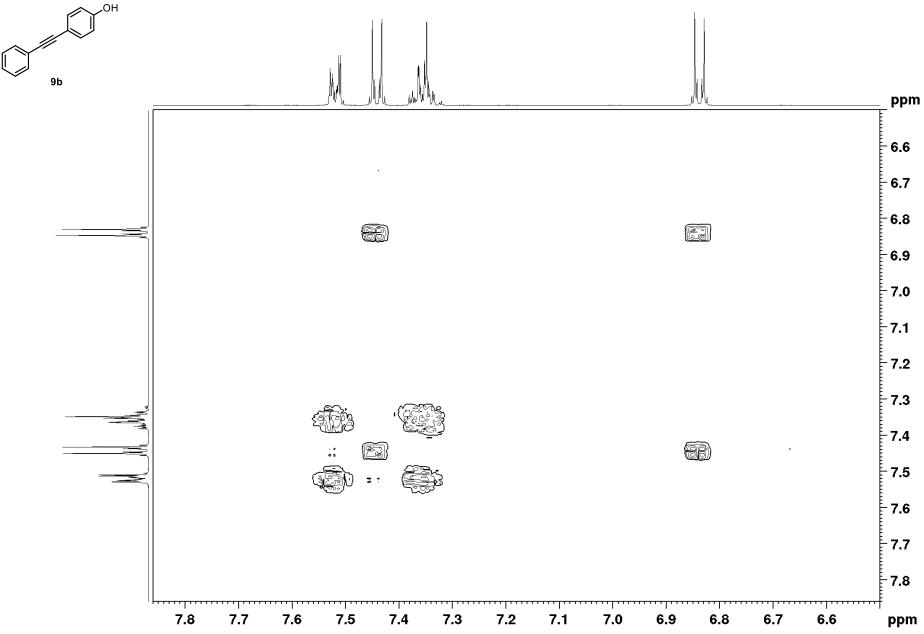




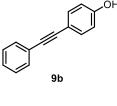


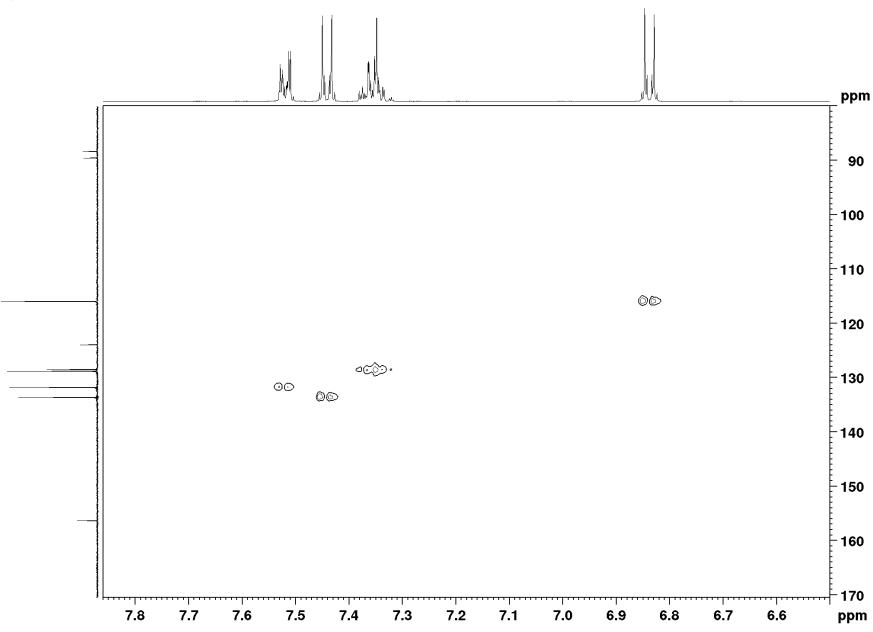


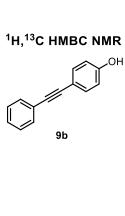


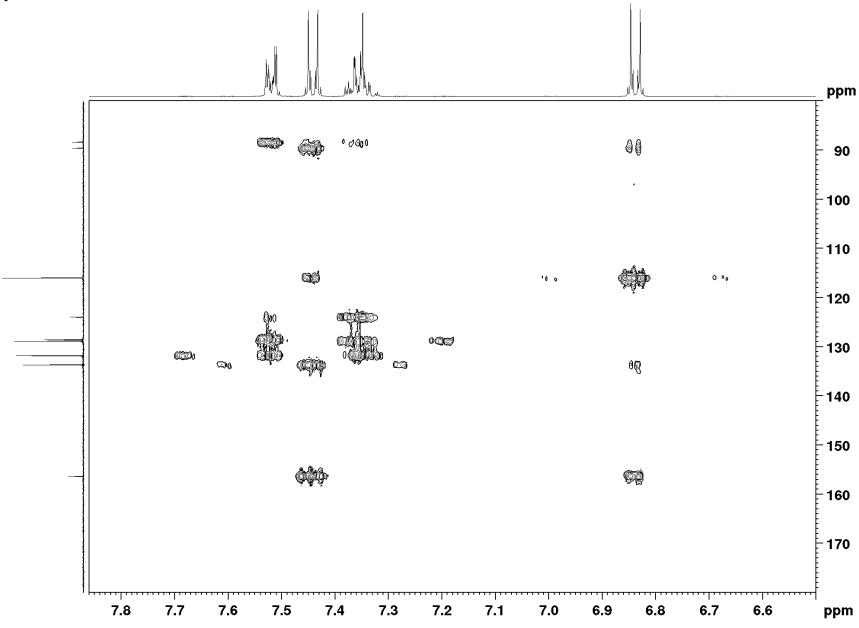


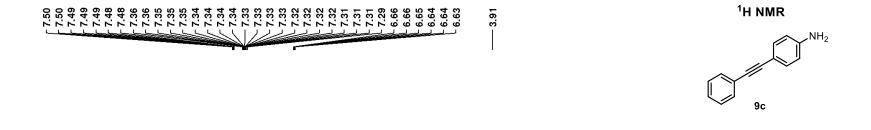


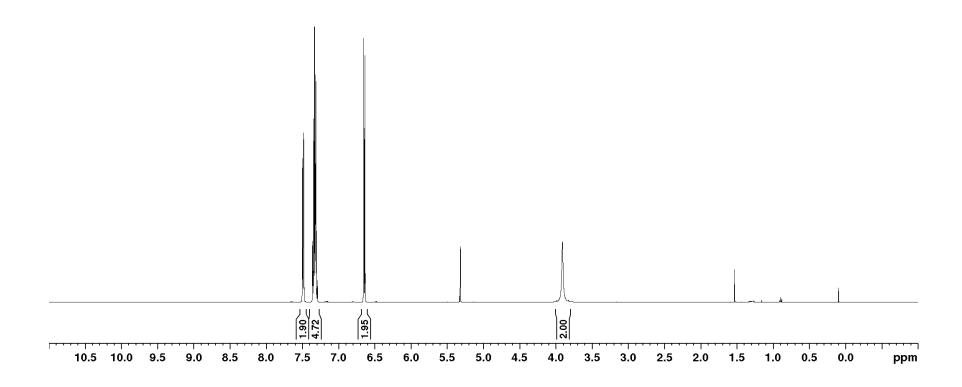


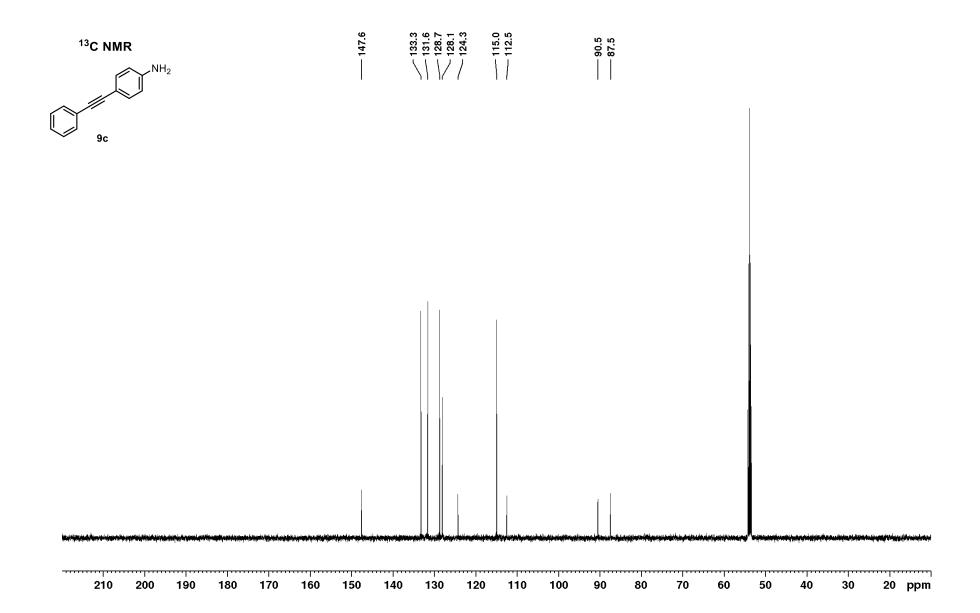


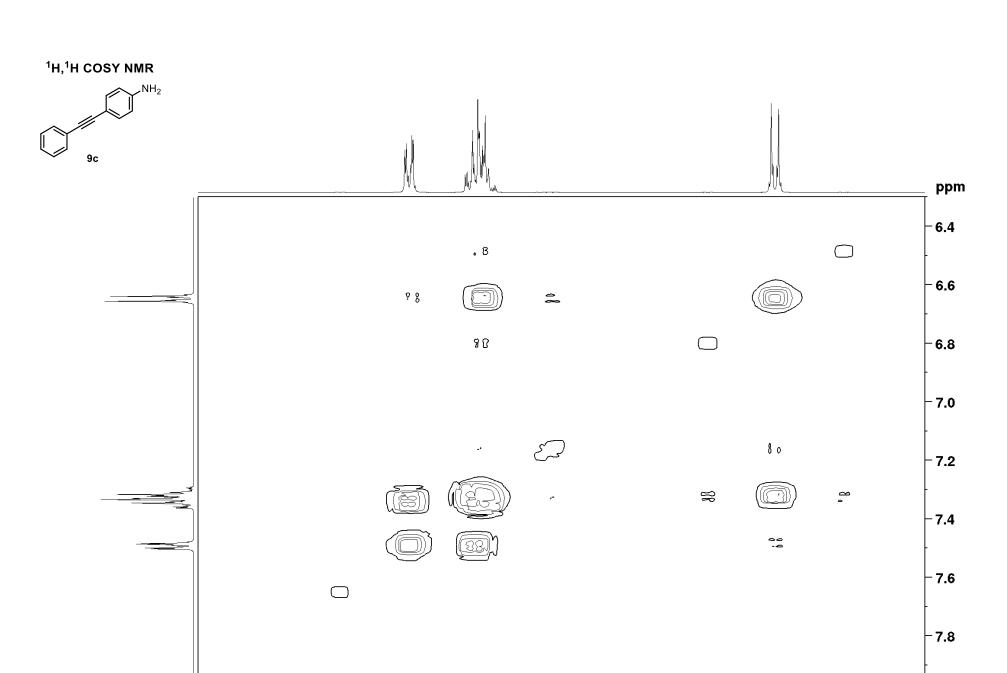












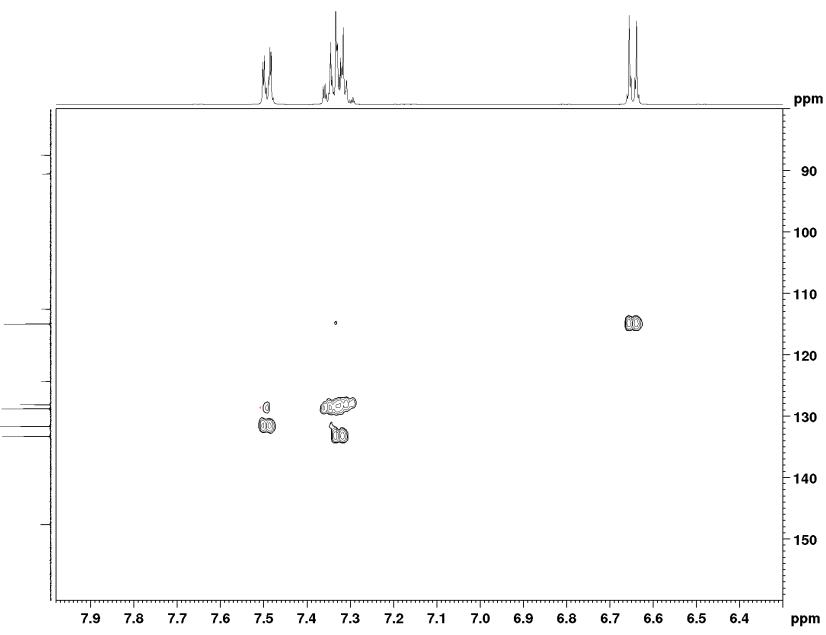
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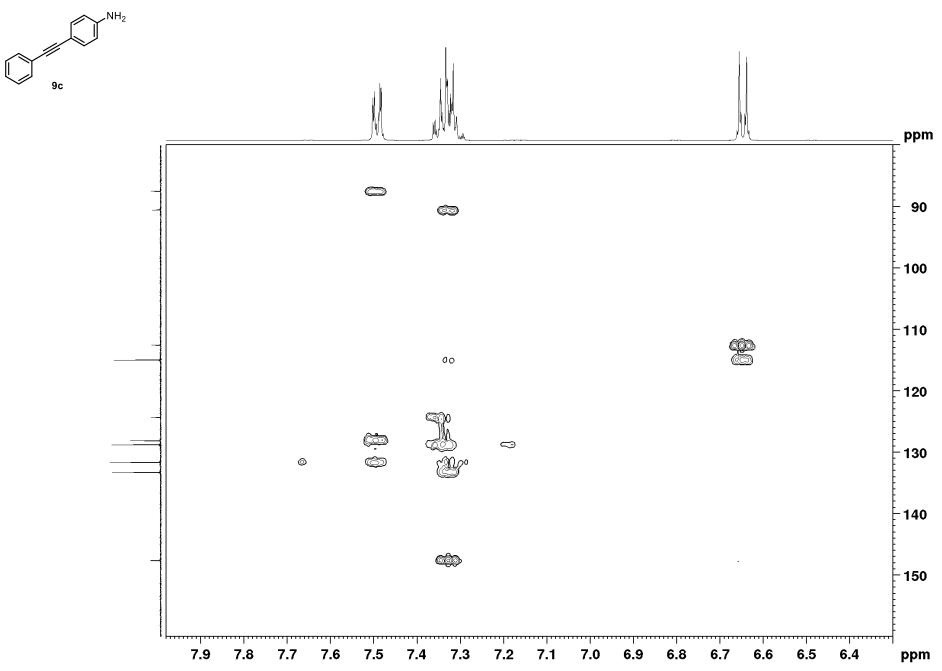
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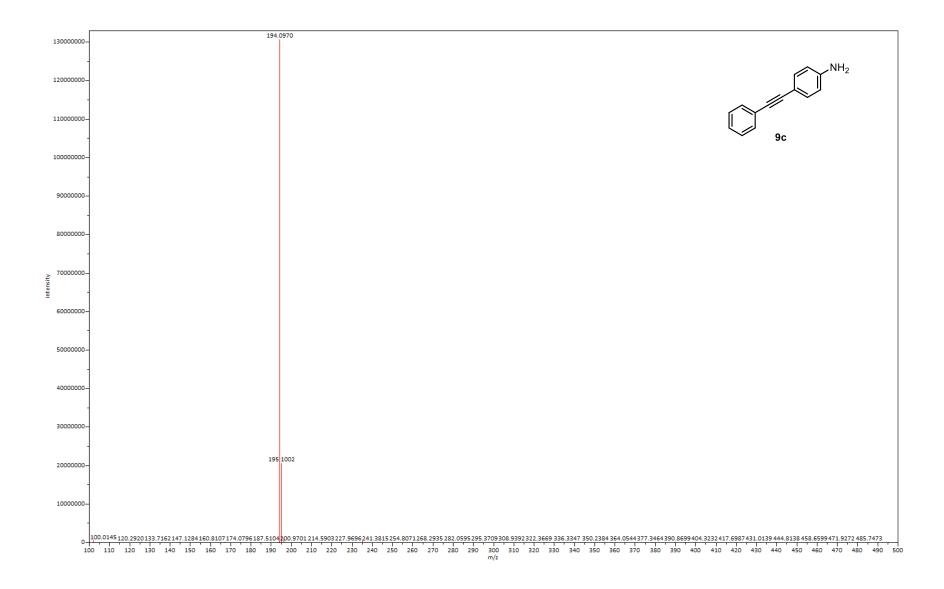
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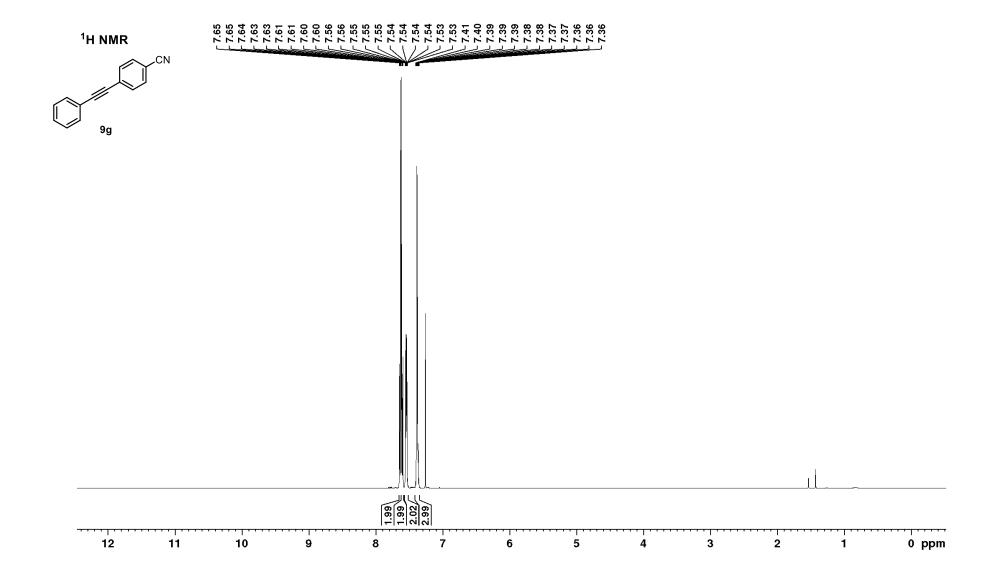


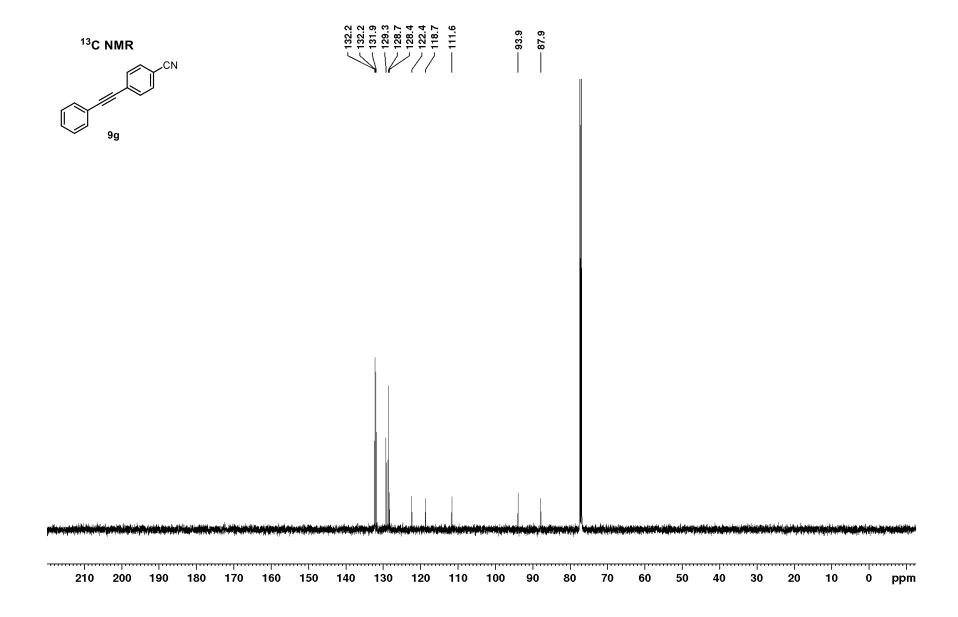


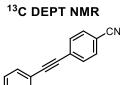




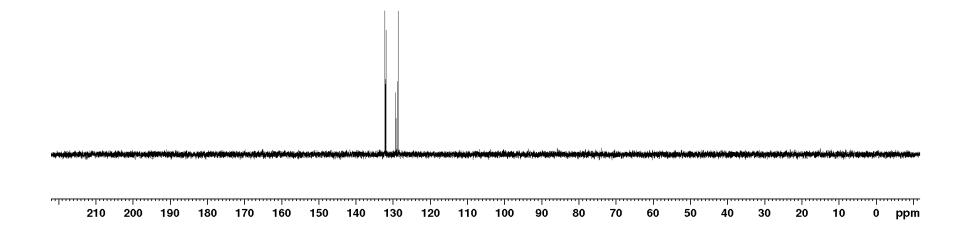




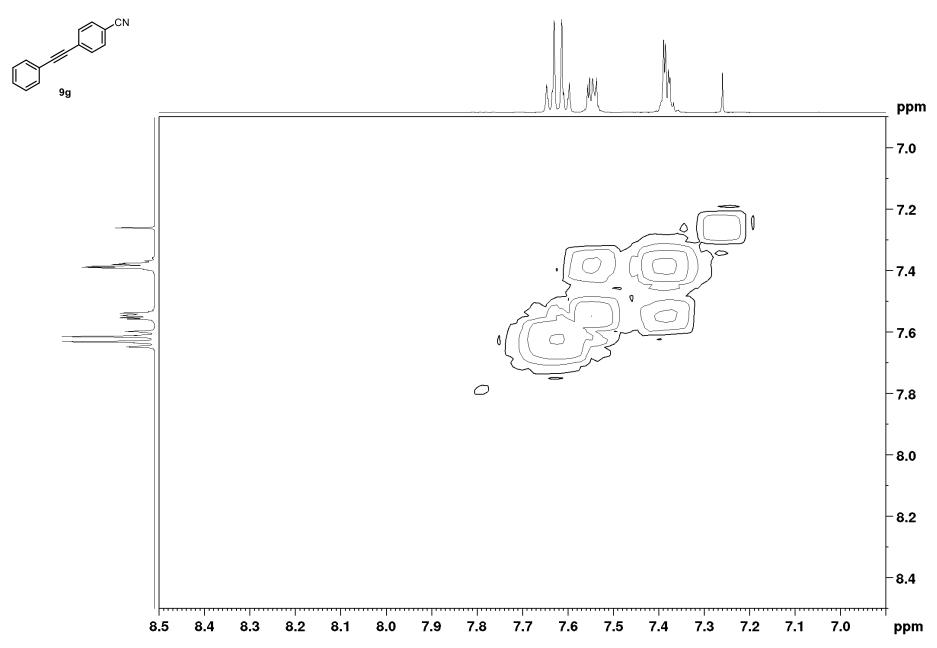




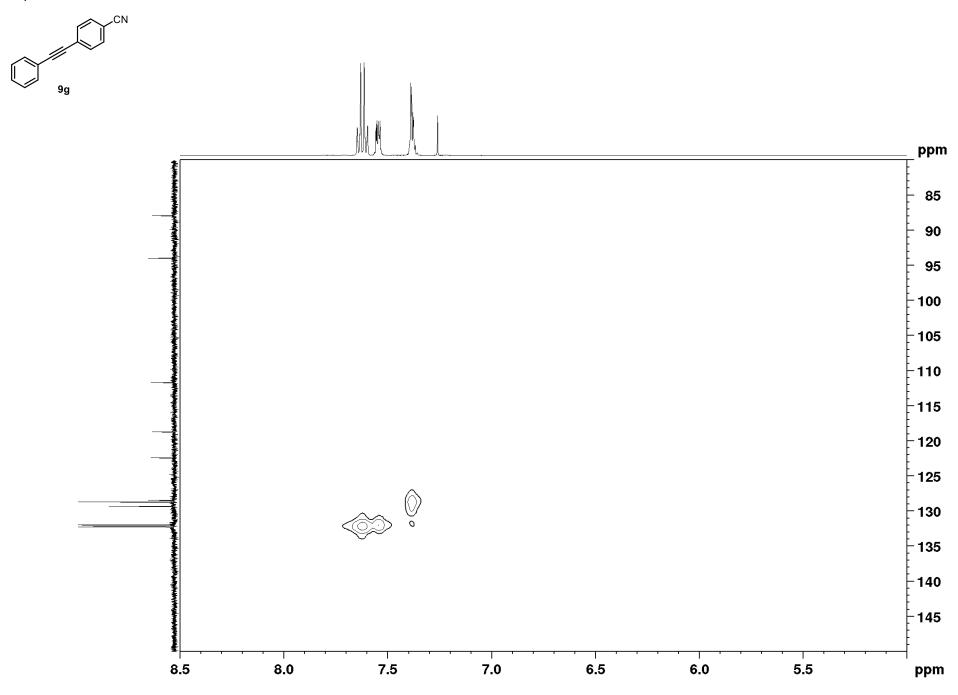




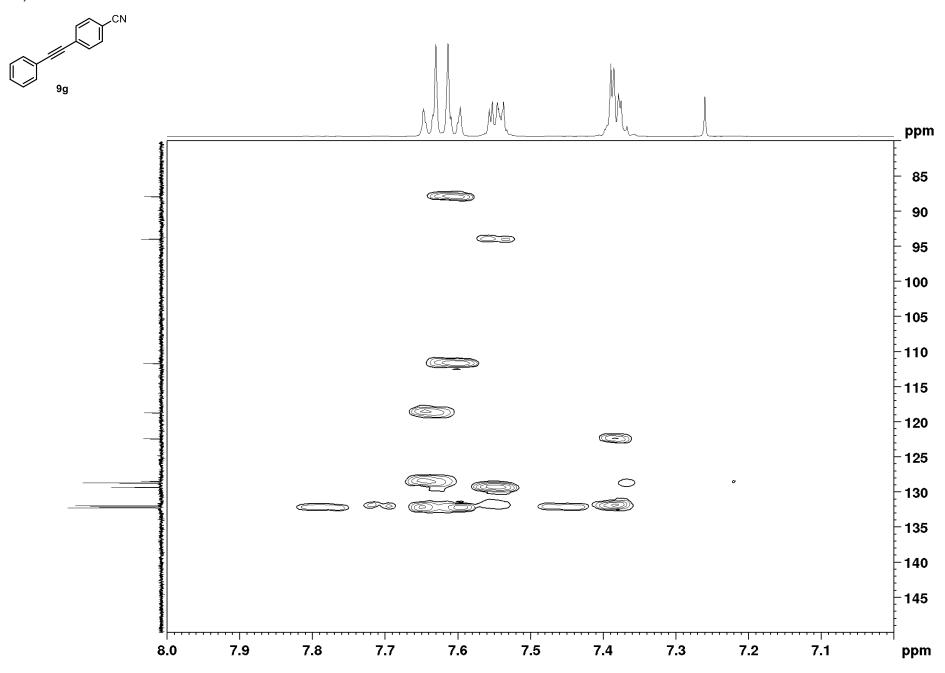


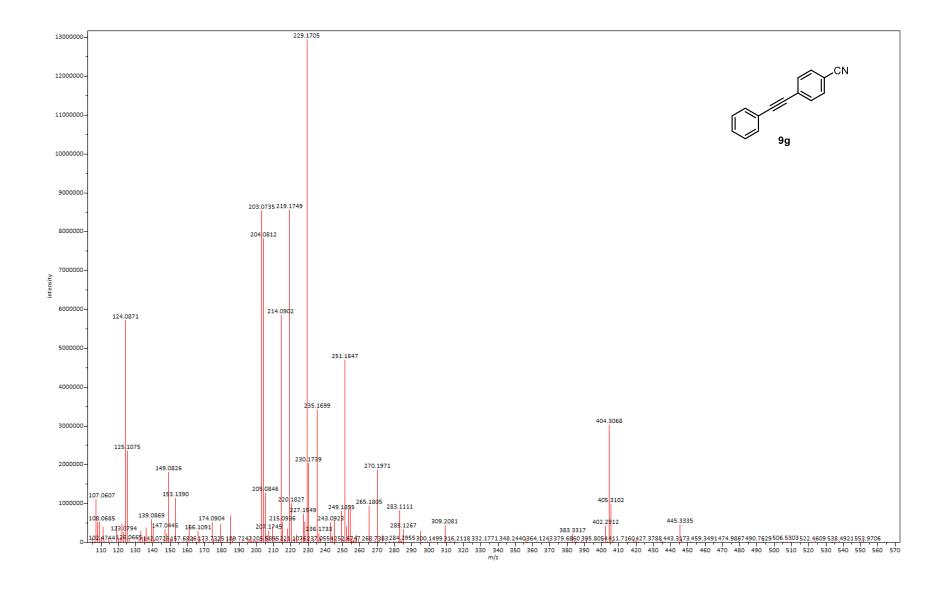




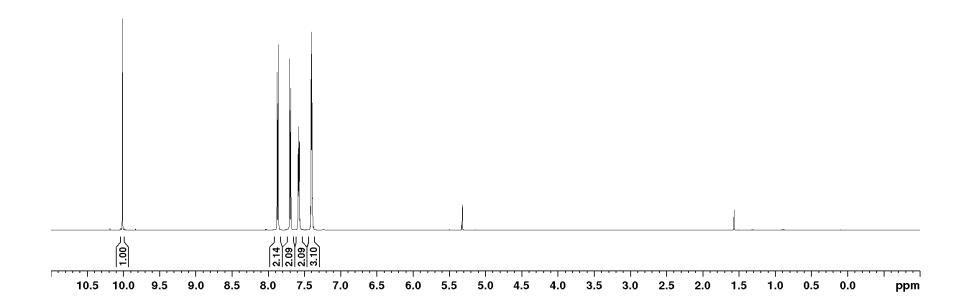


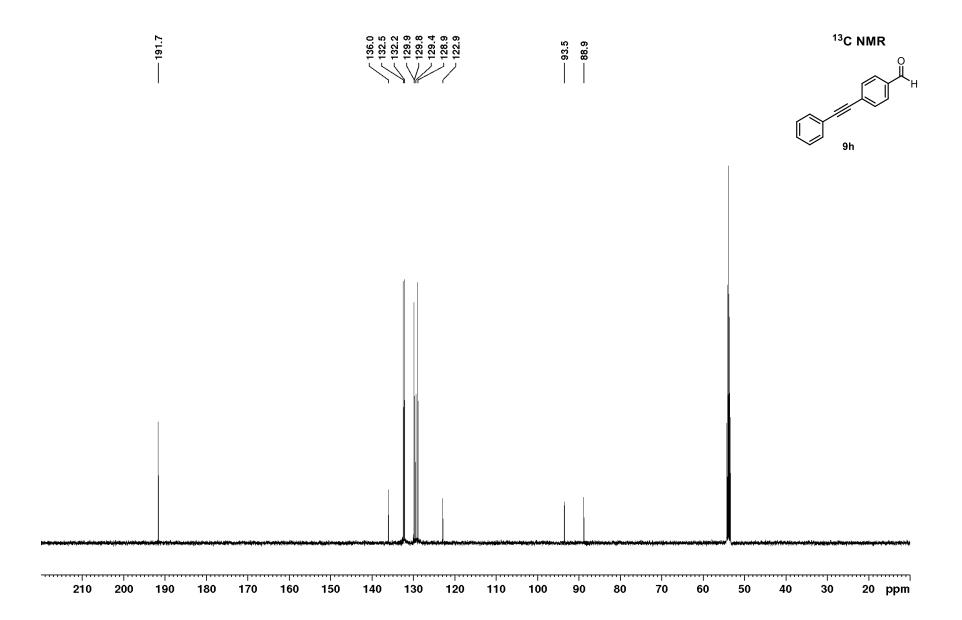


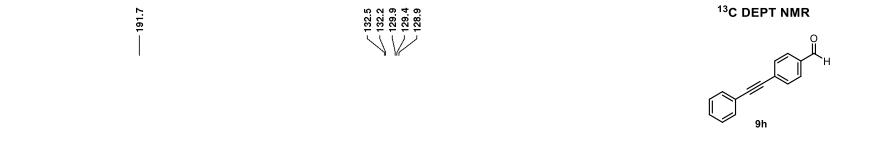


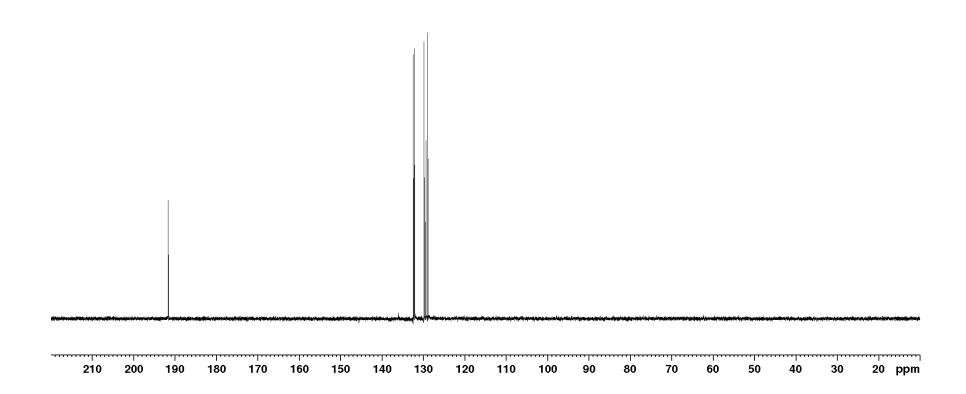




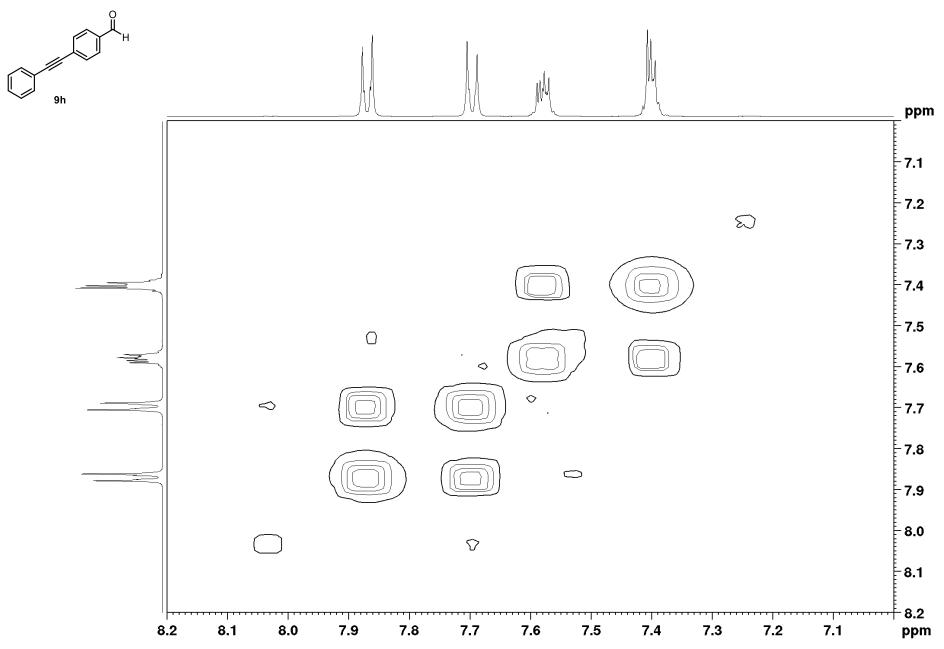




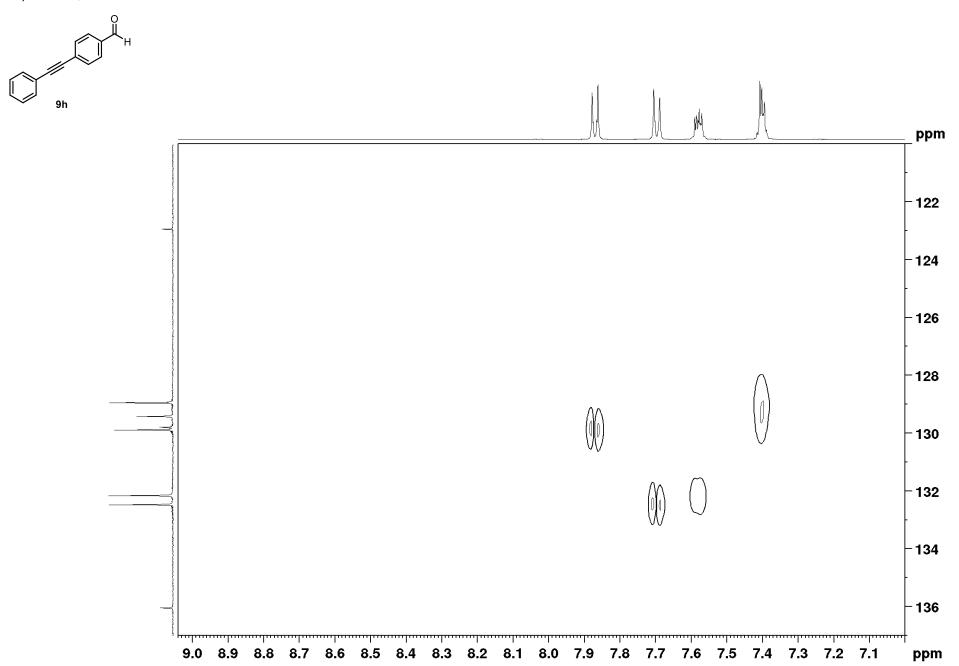




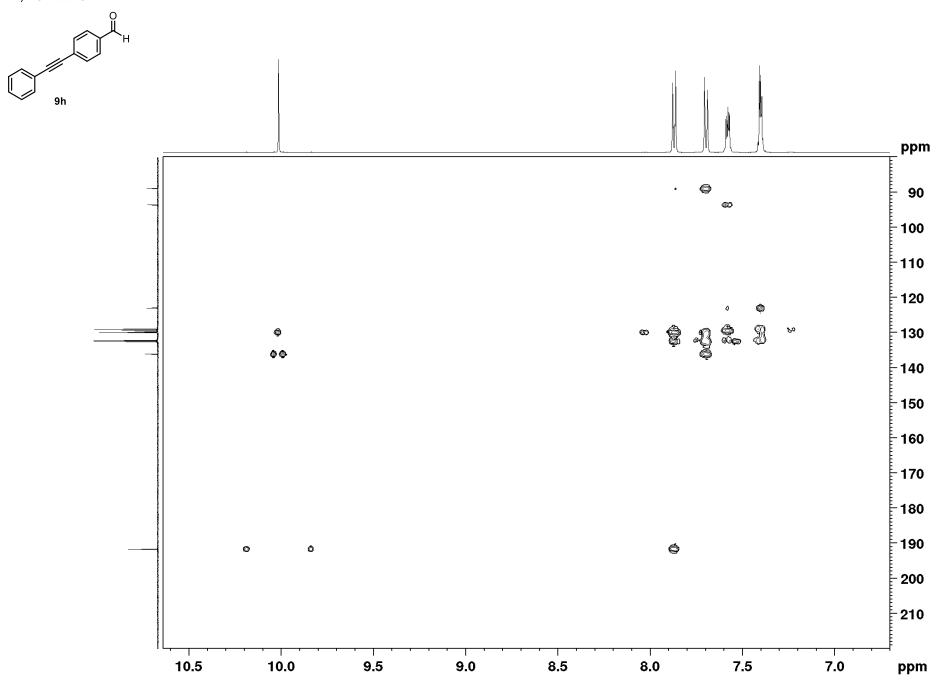


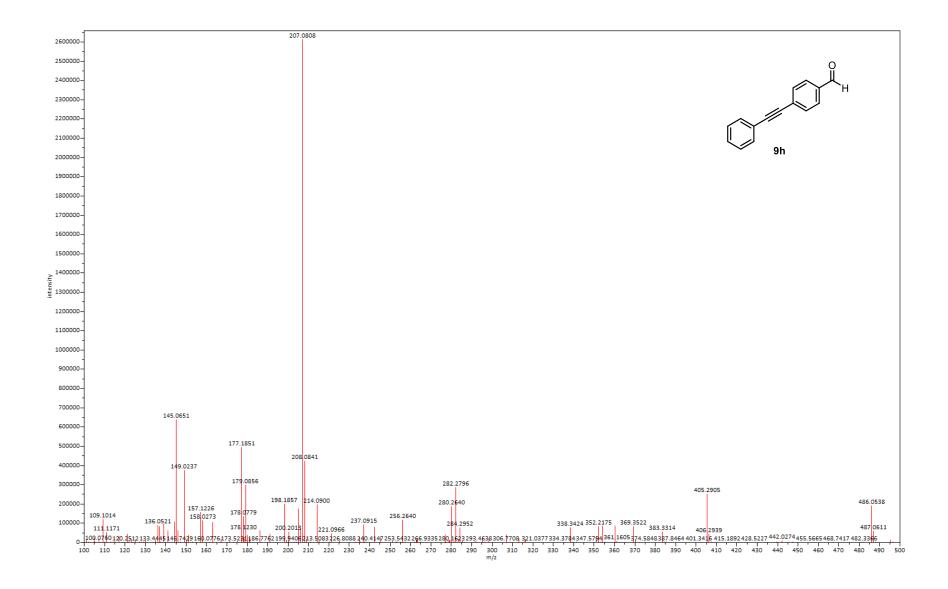


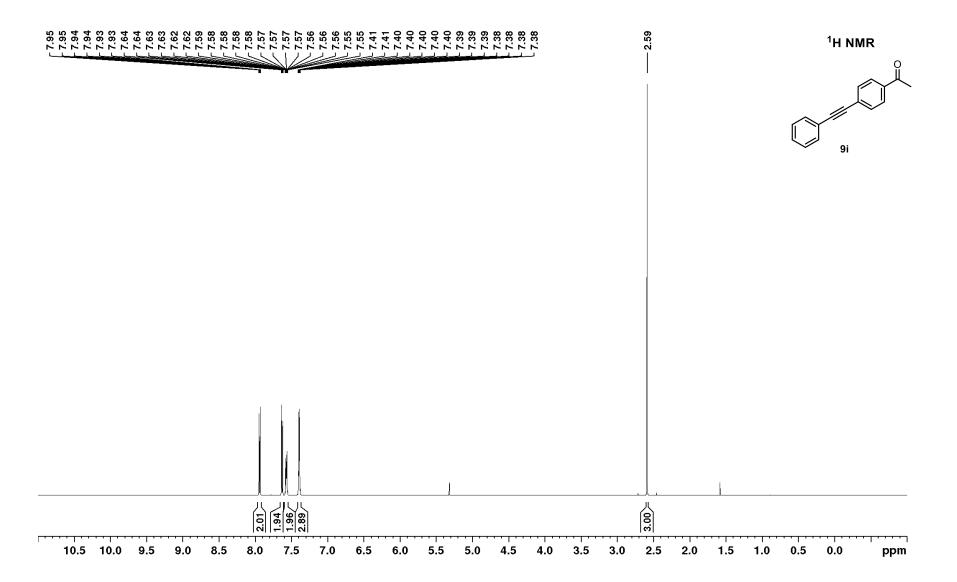


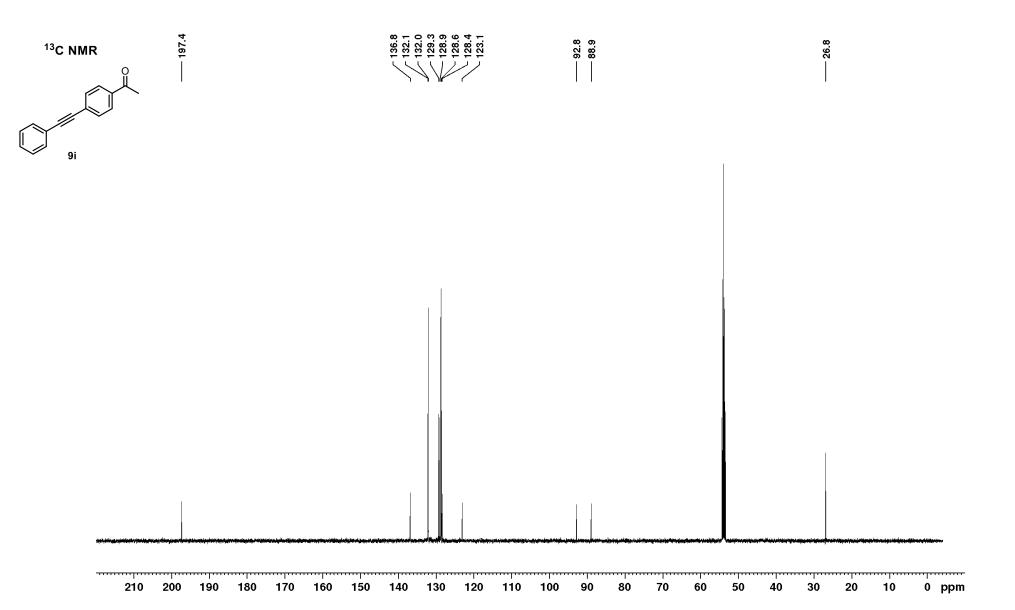




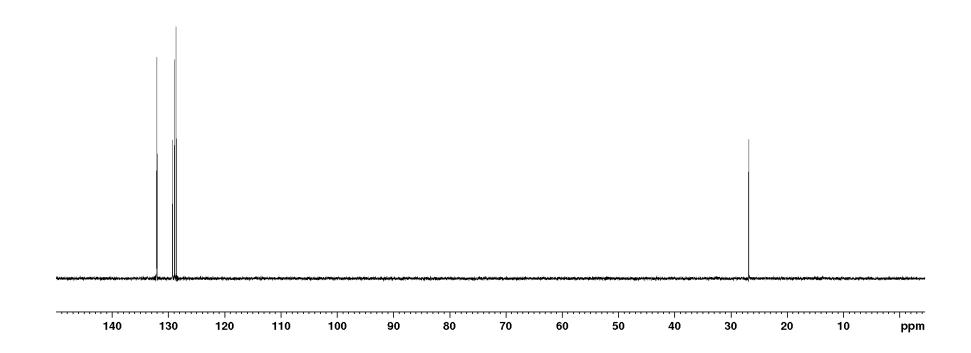




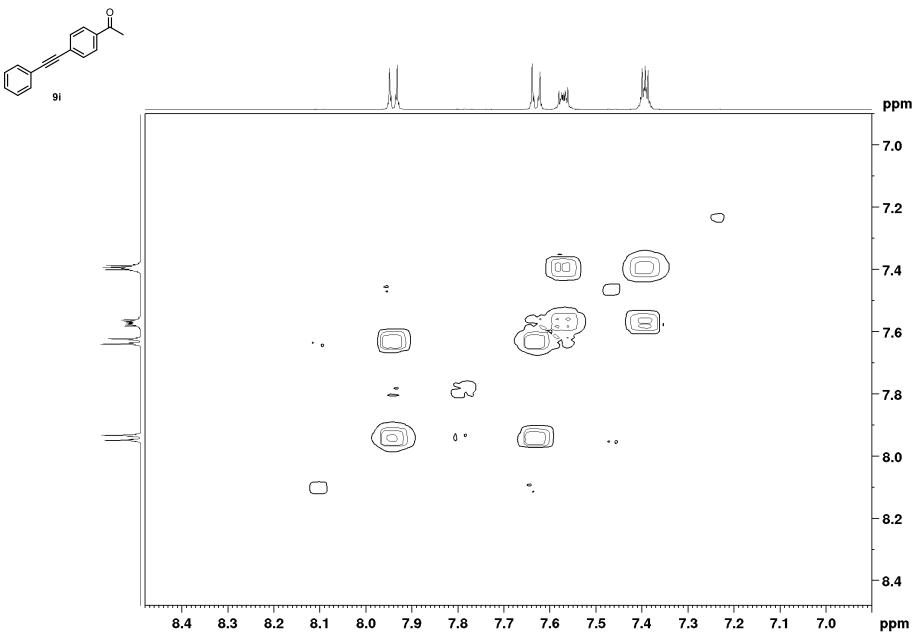










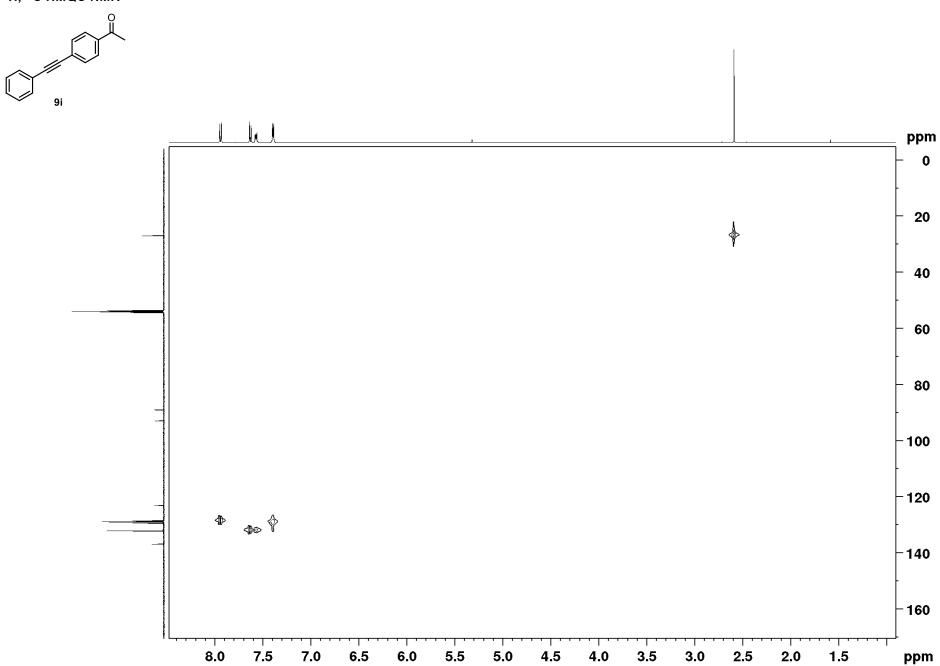




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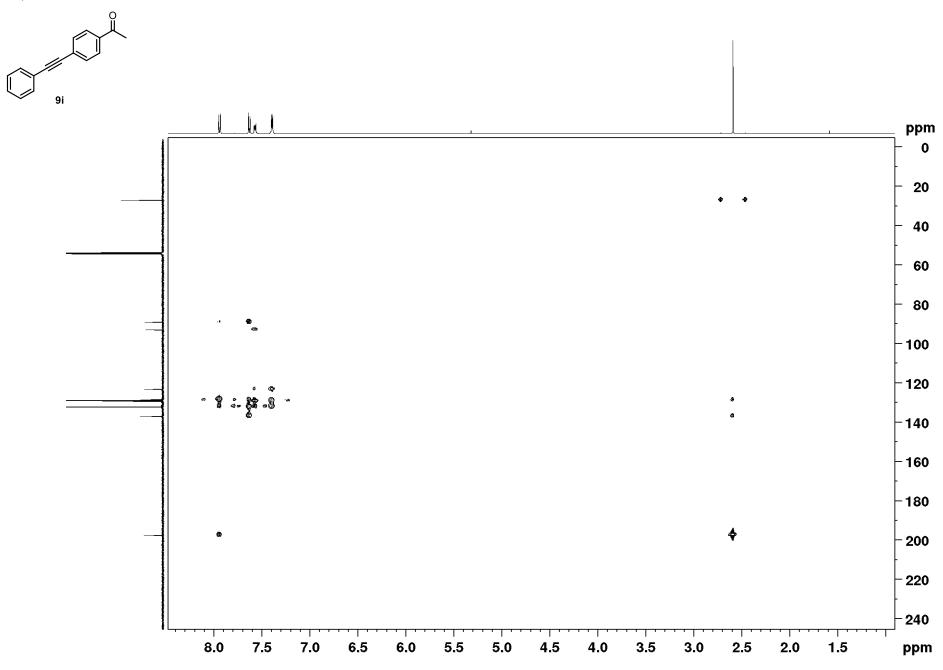
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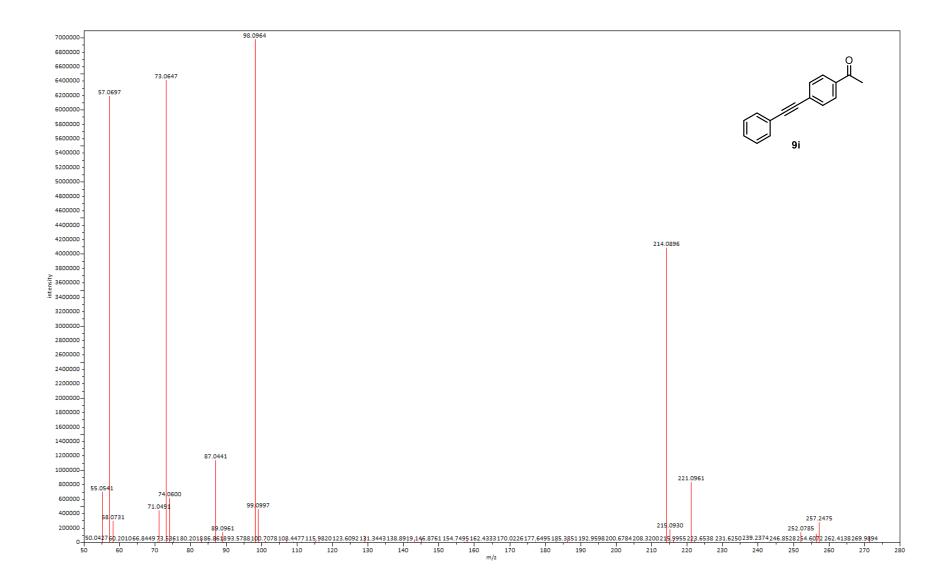
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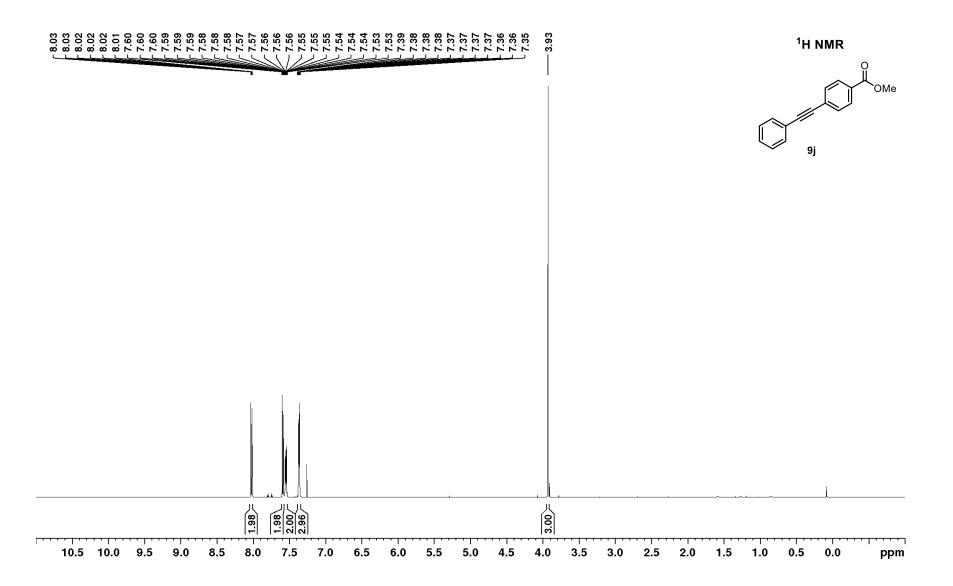


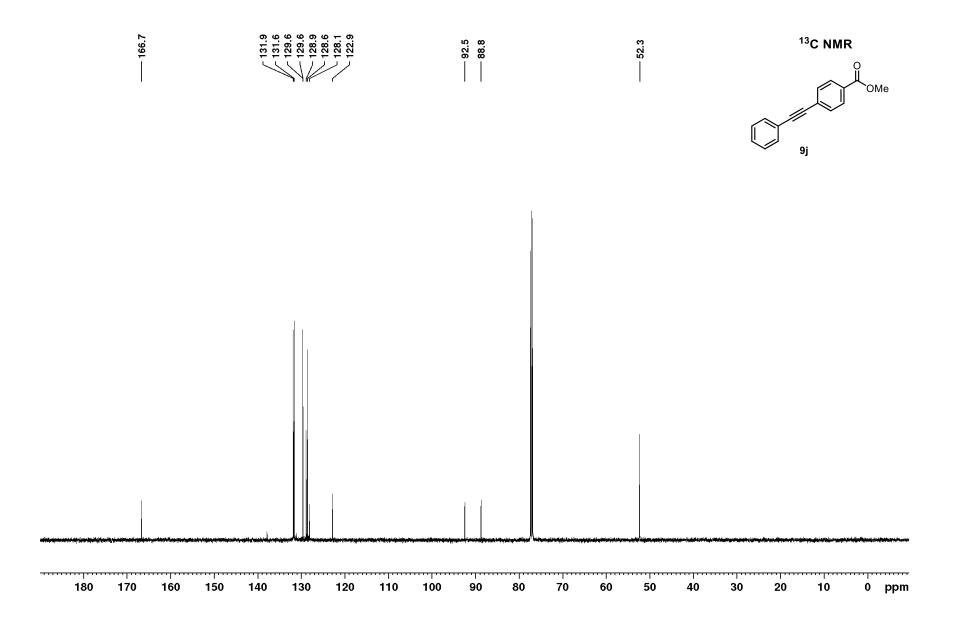
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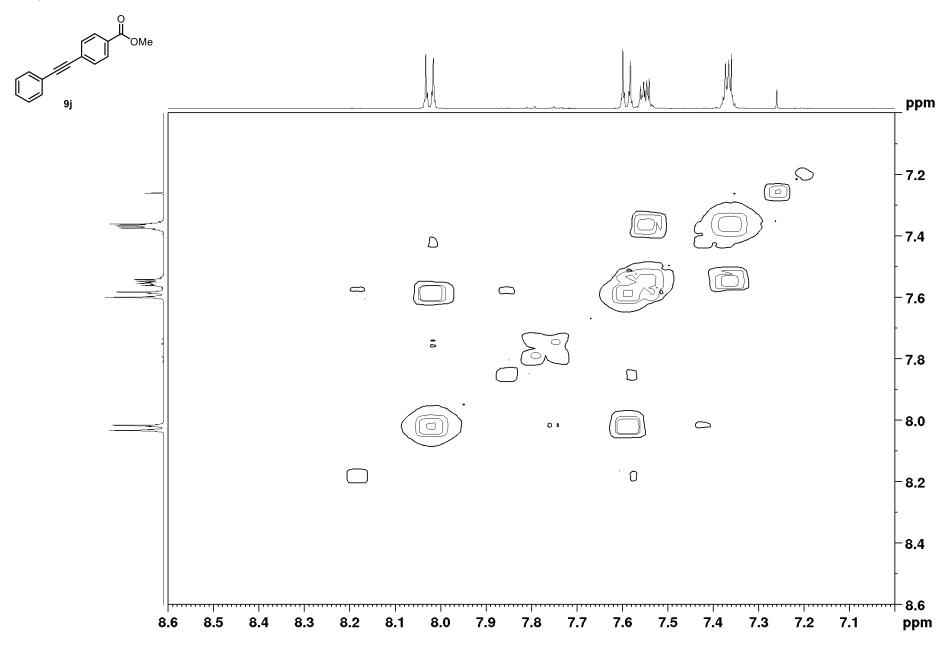




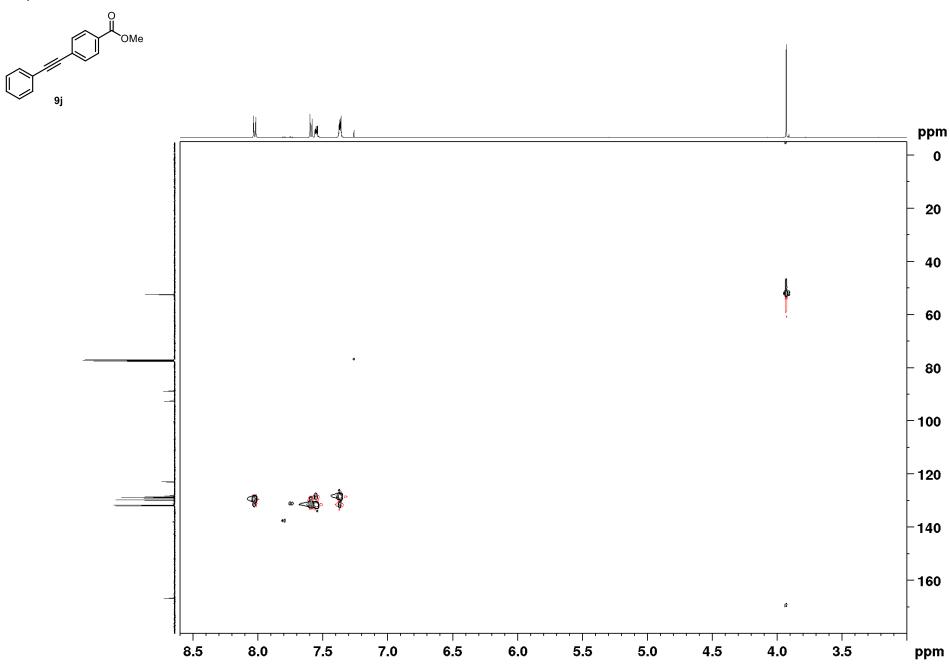




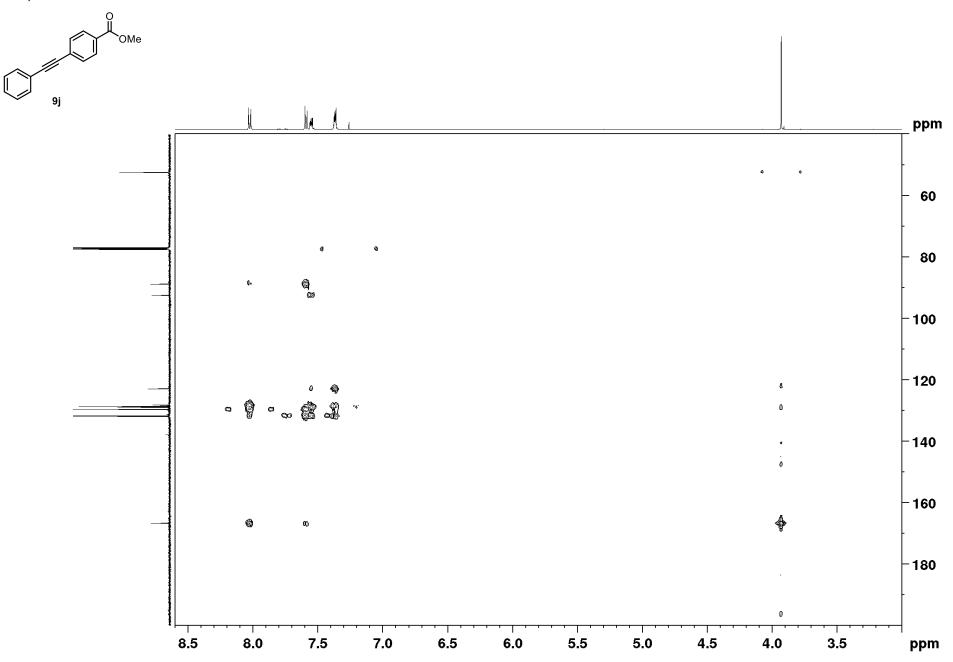


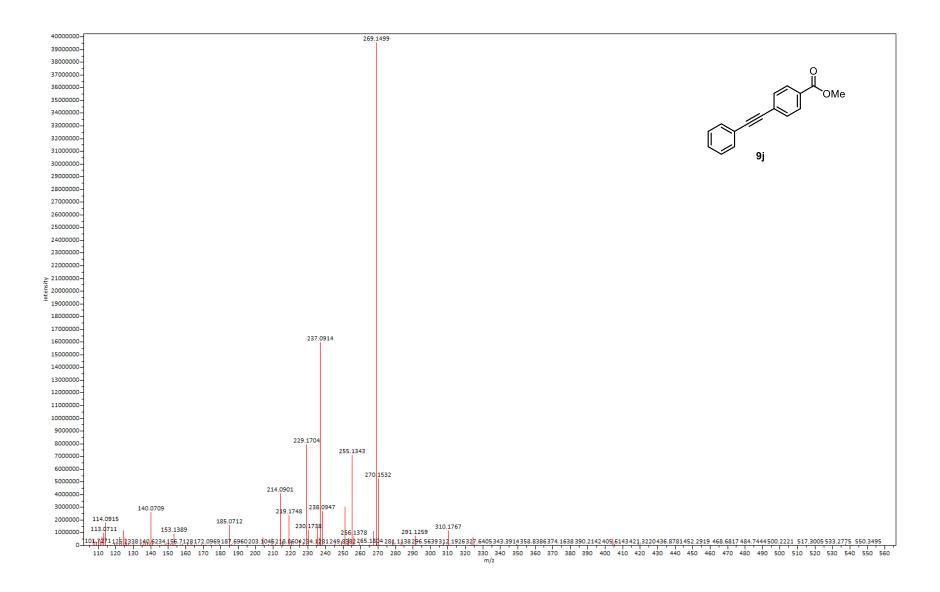


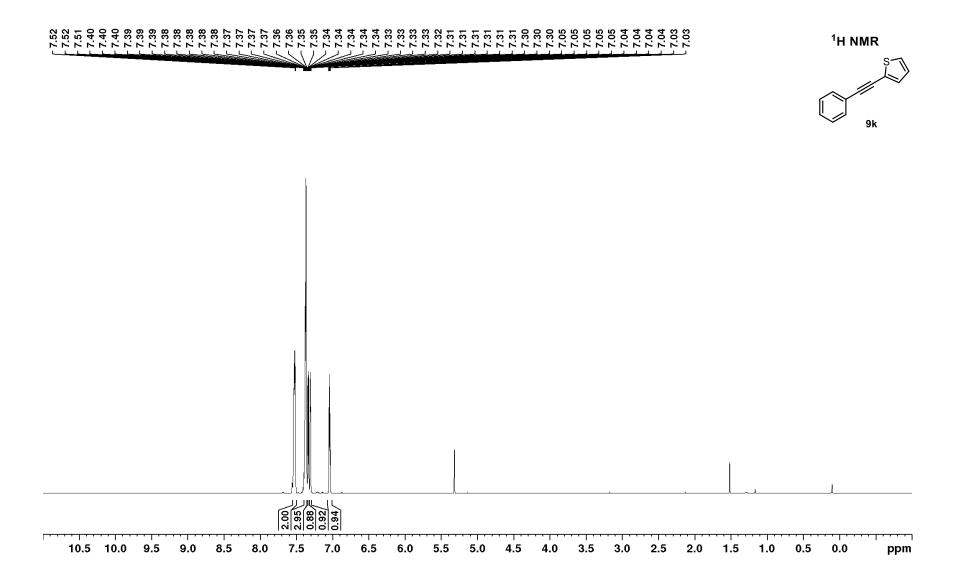


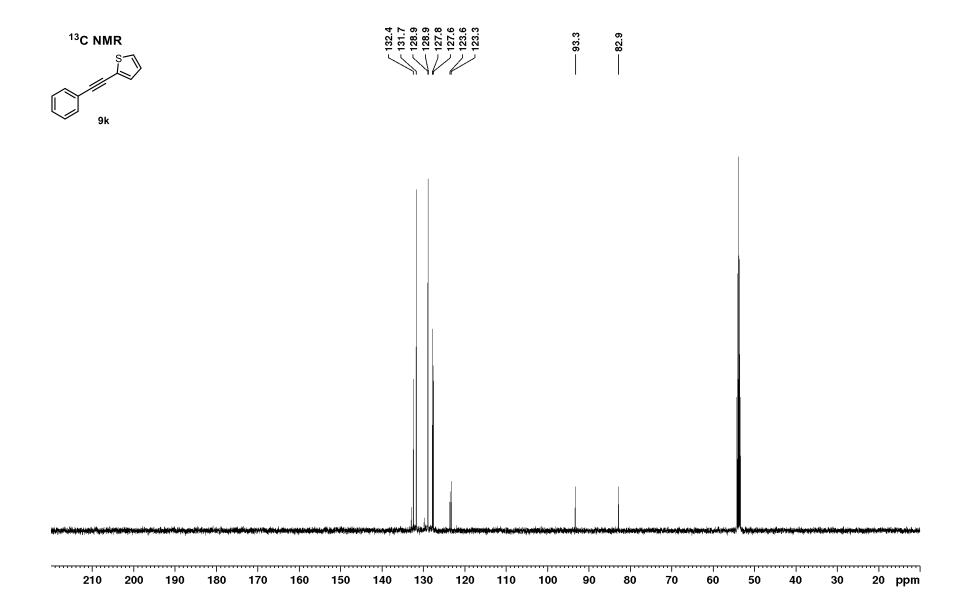


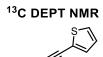




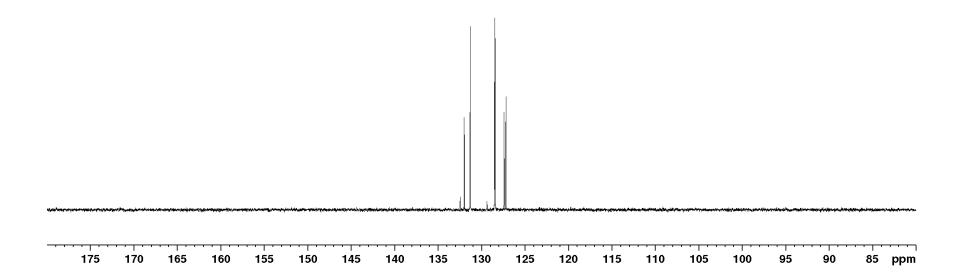




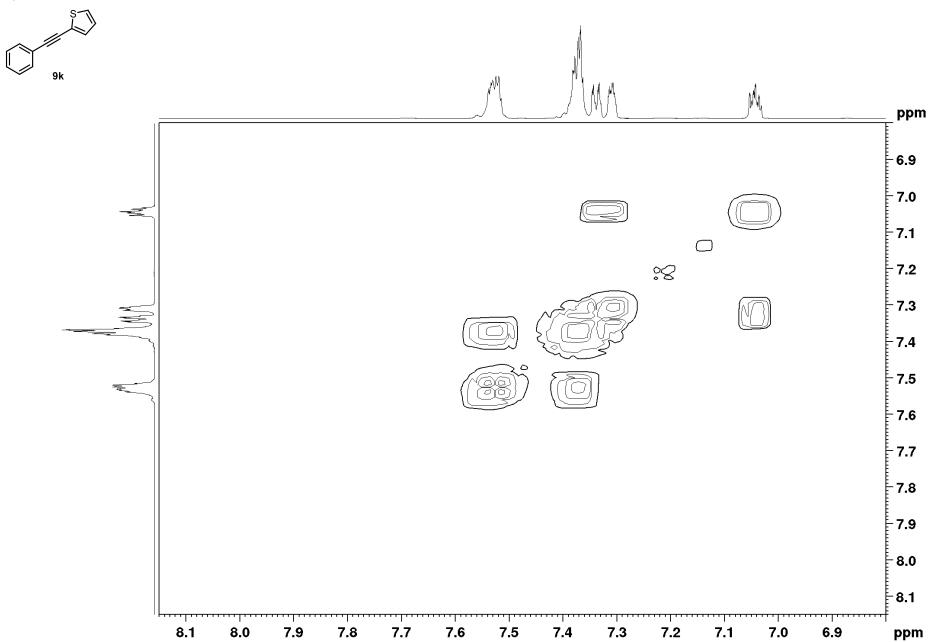




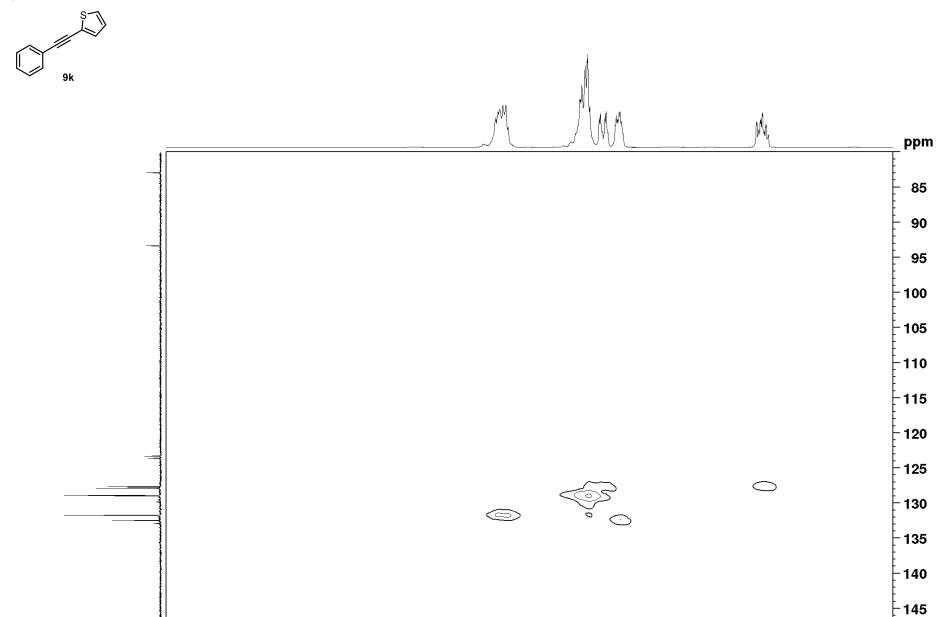












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7.4

7.6

7.3

7.2

7.1

7.0

6.9

ppm

7.9

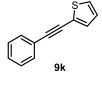
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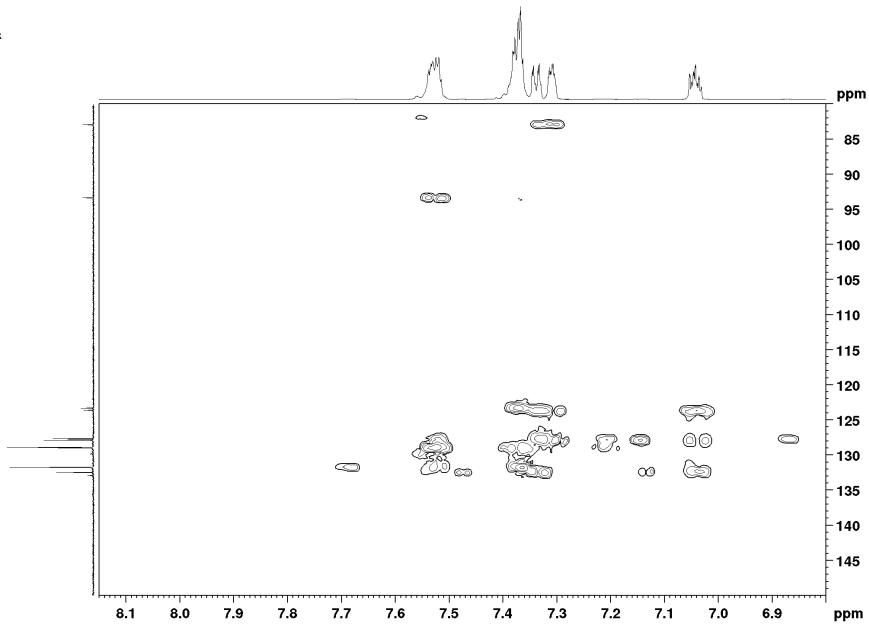
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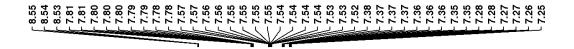
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7.7

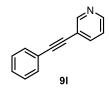


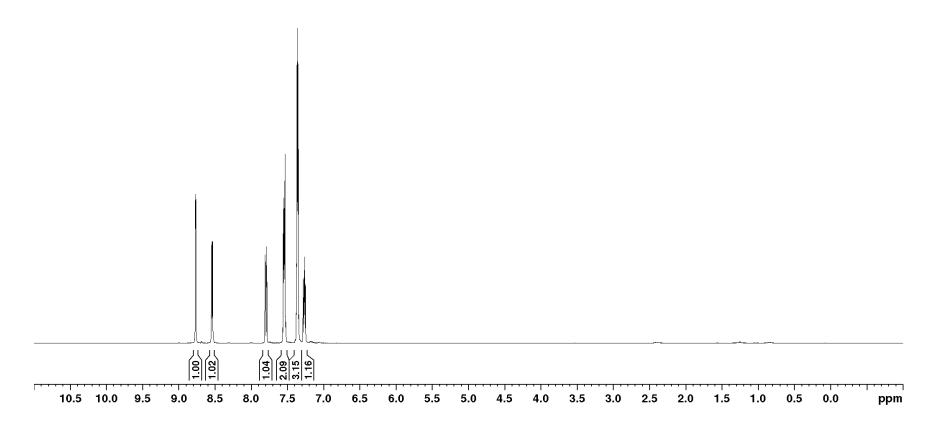


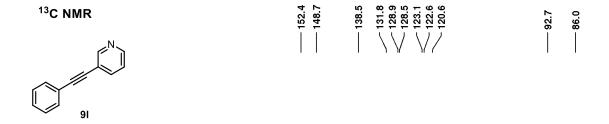


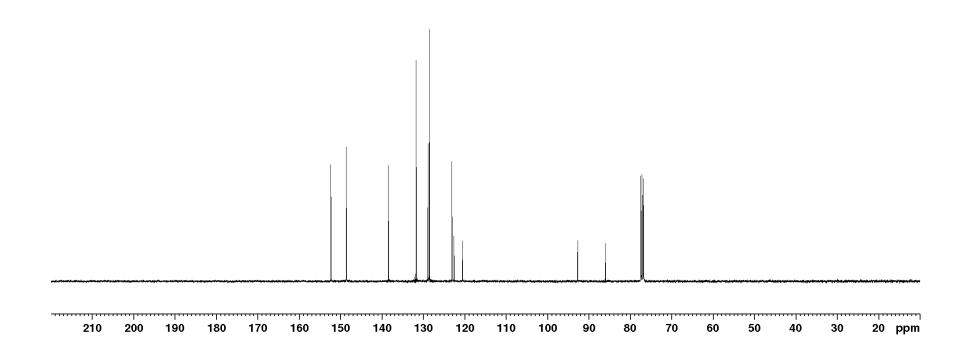


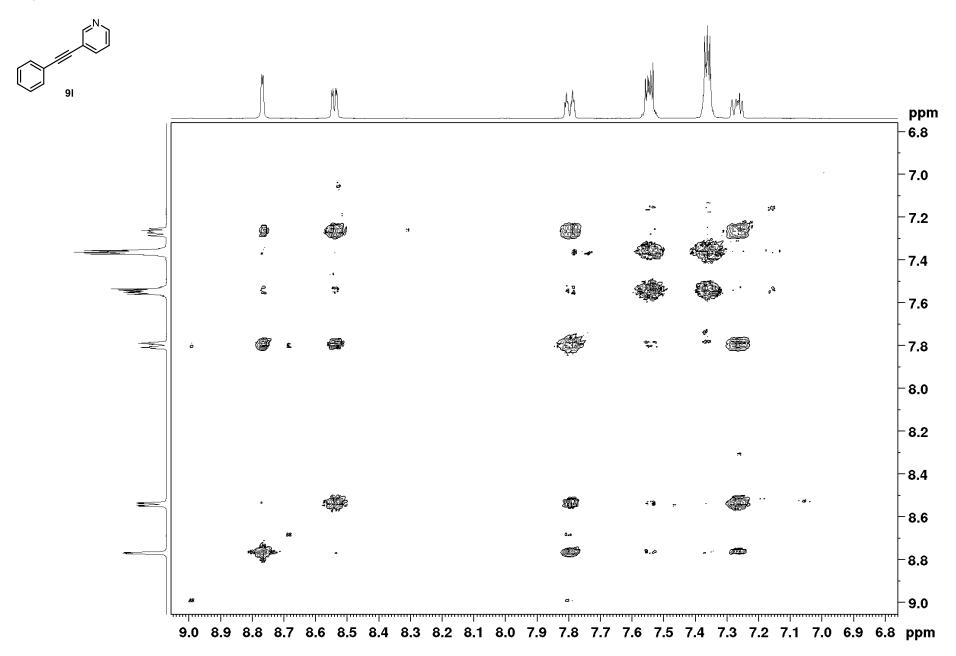
## <sup>1</sup>H NMR



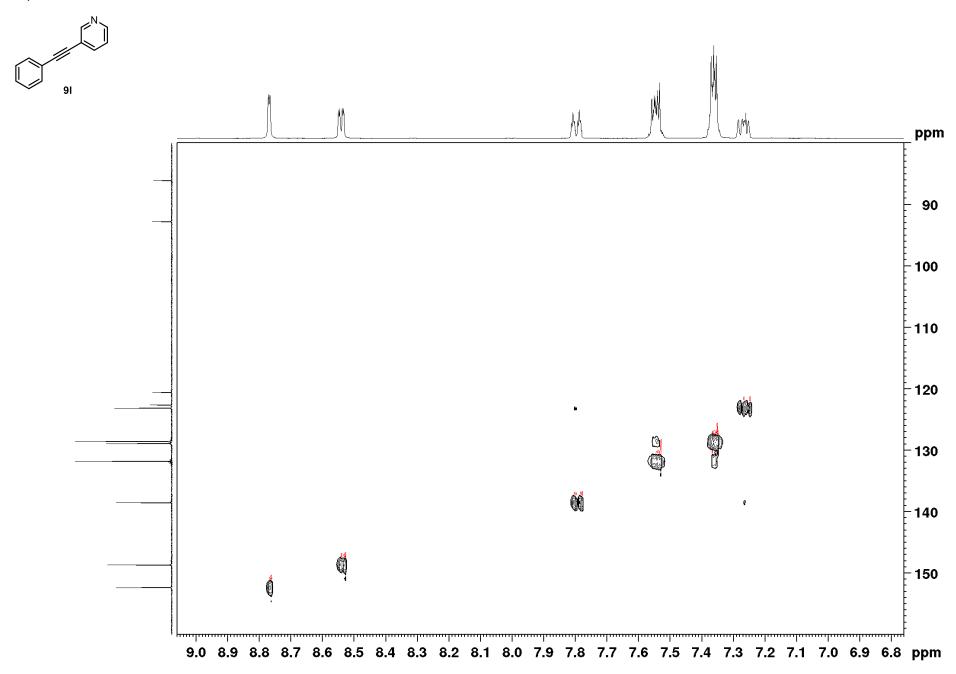




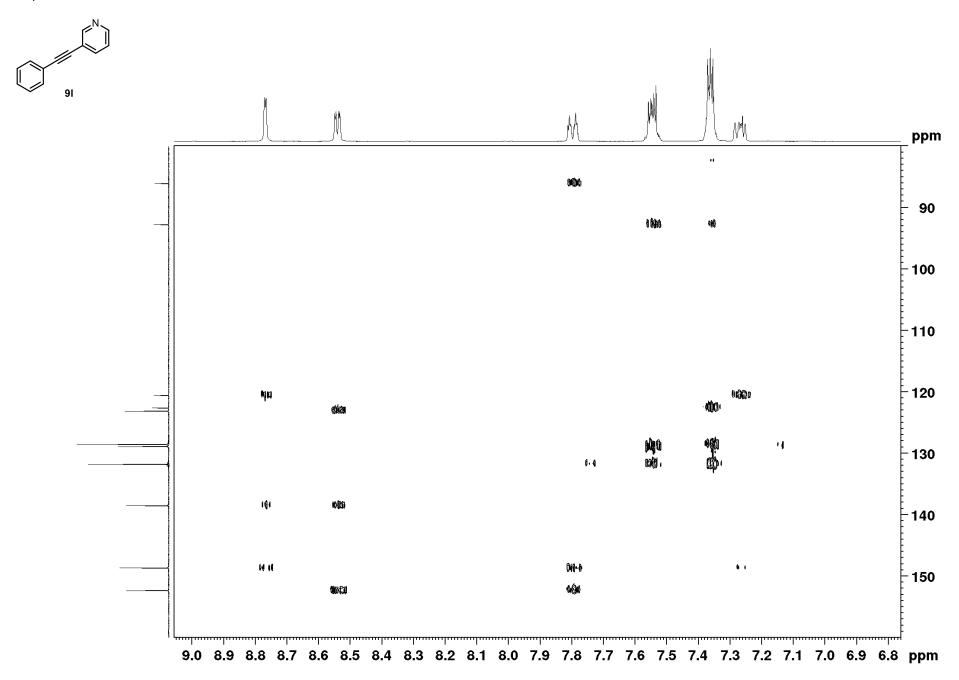


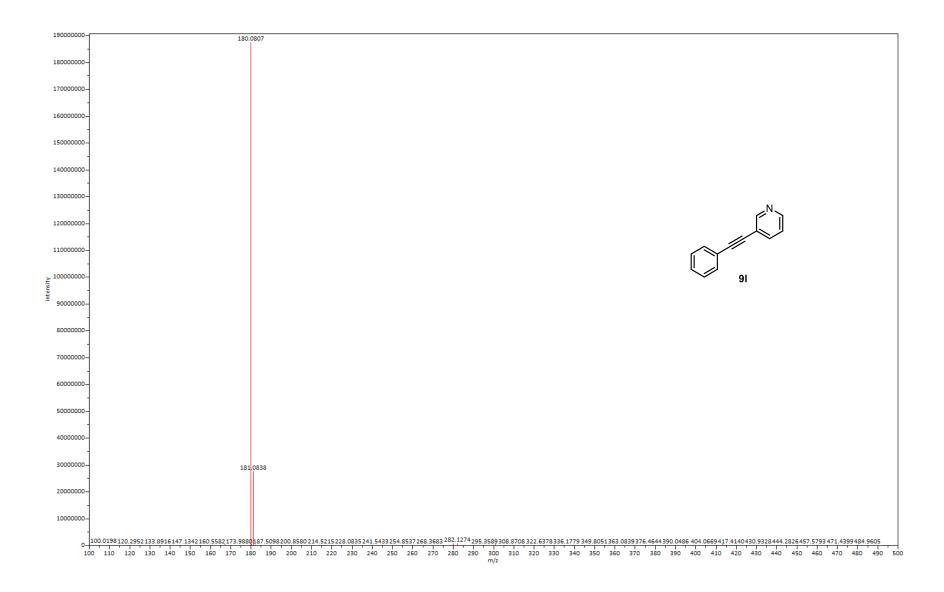


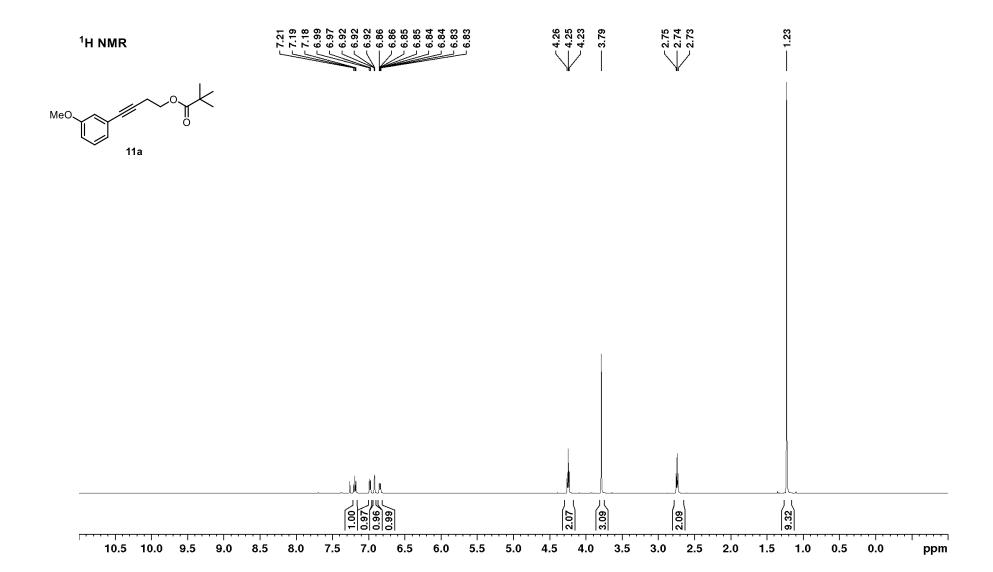


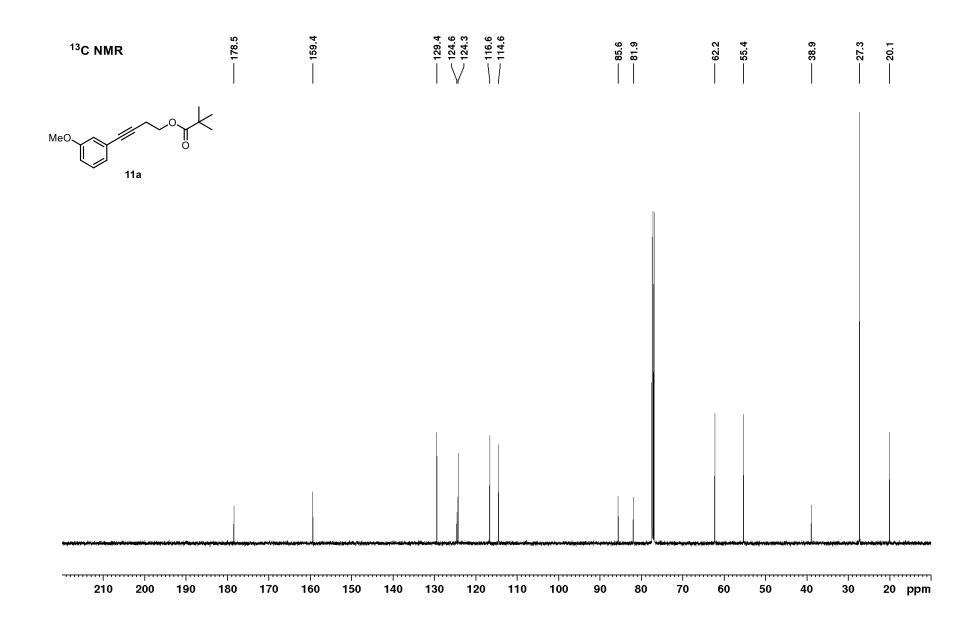


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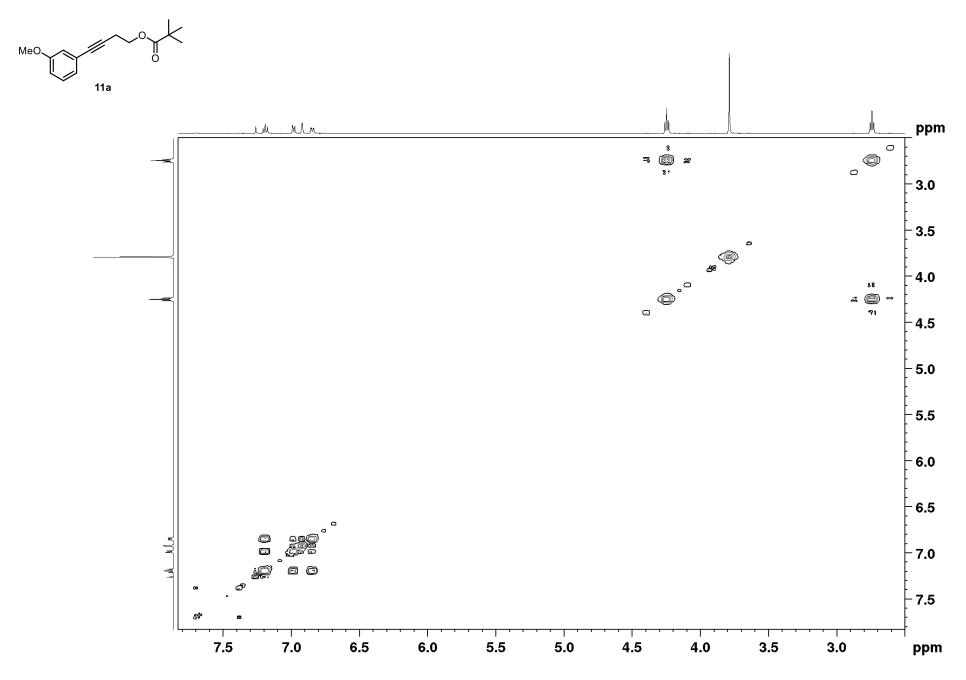


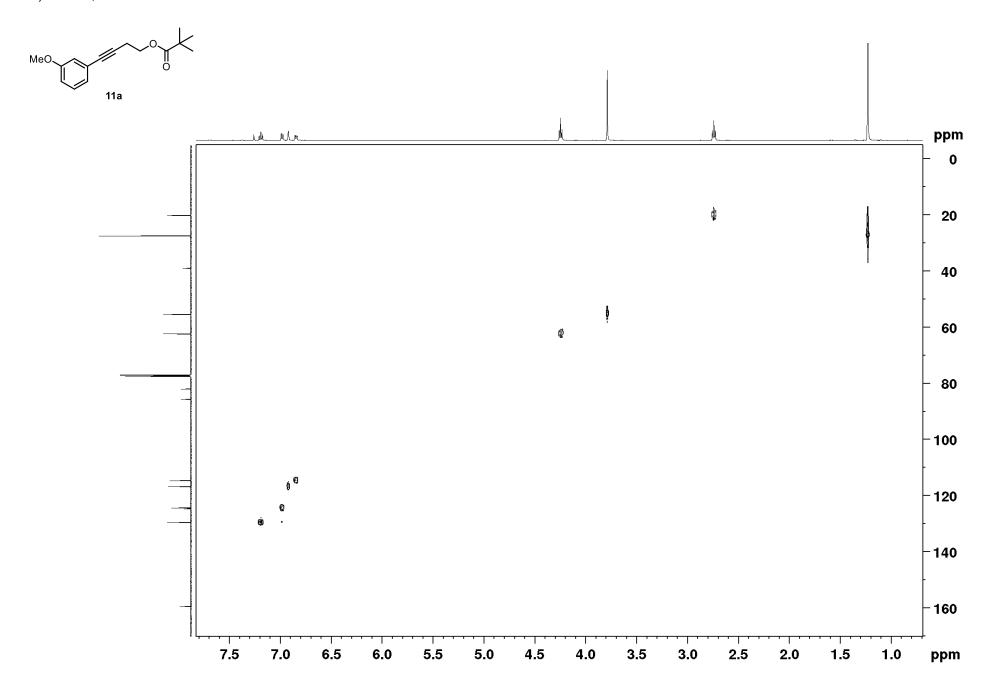




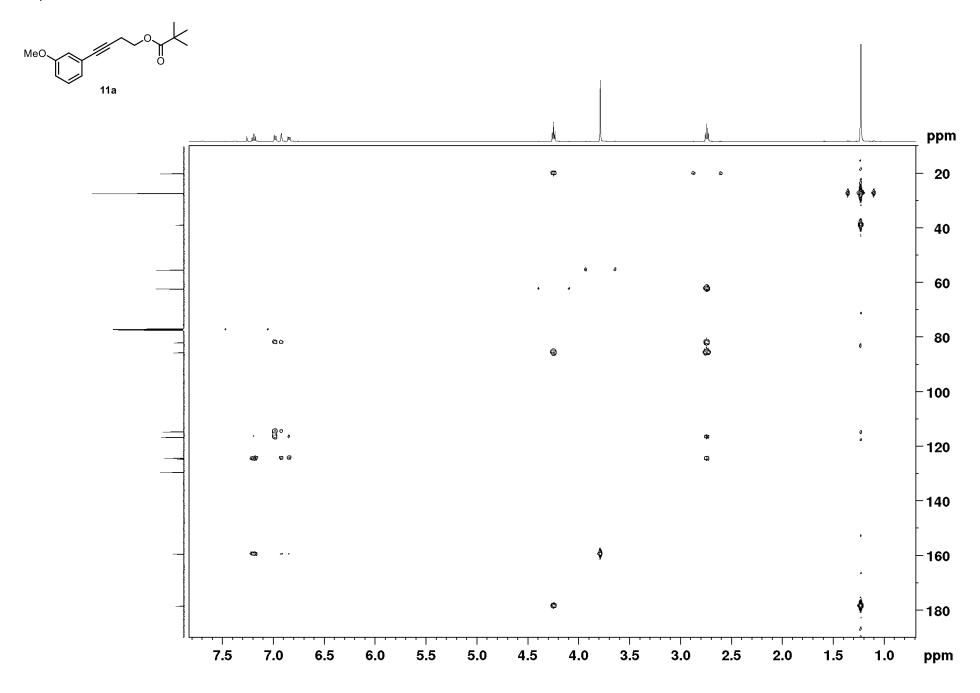


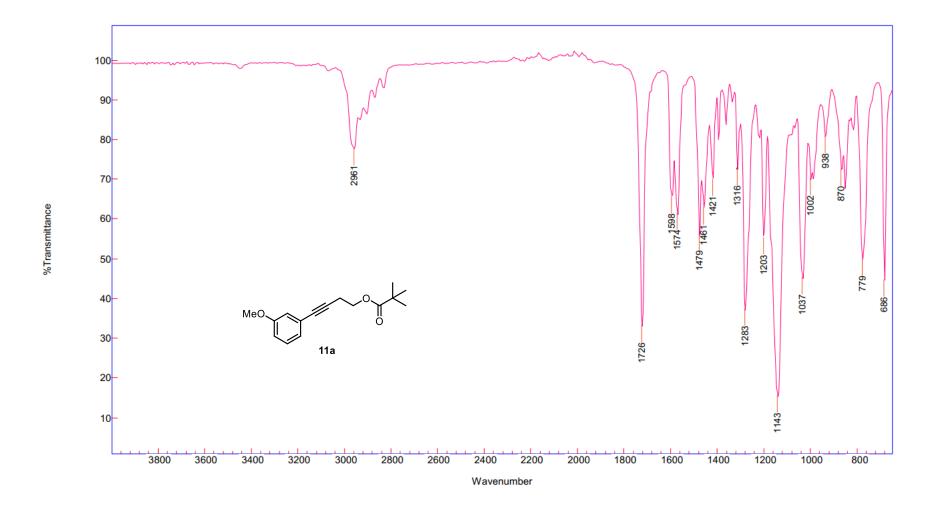


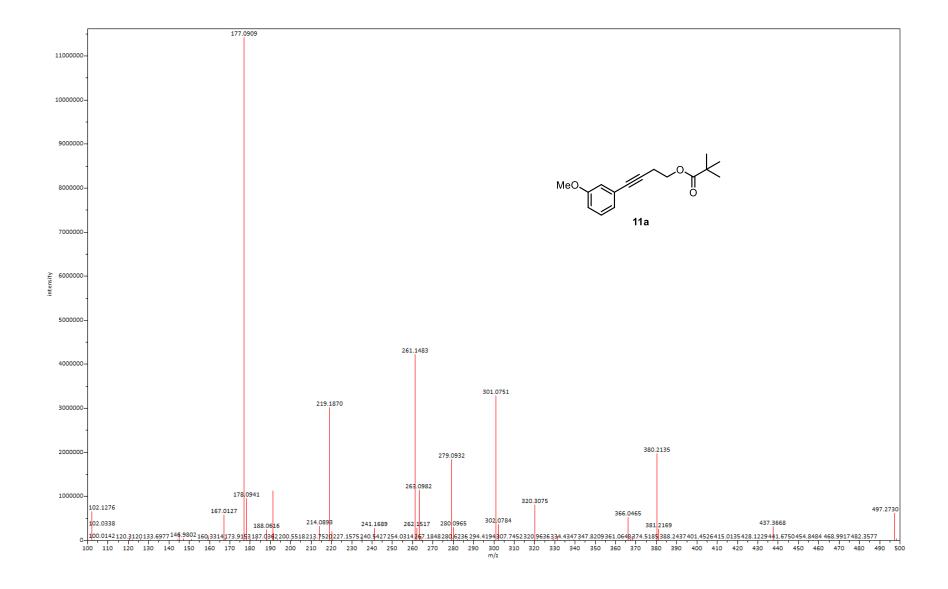


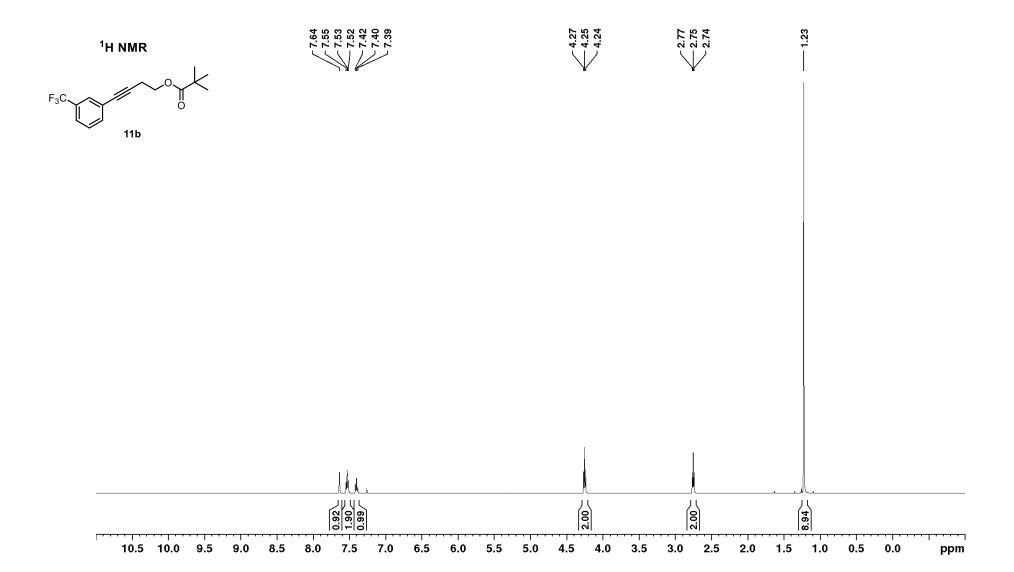


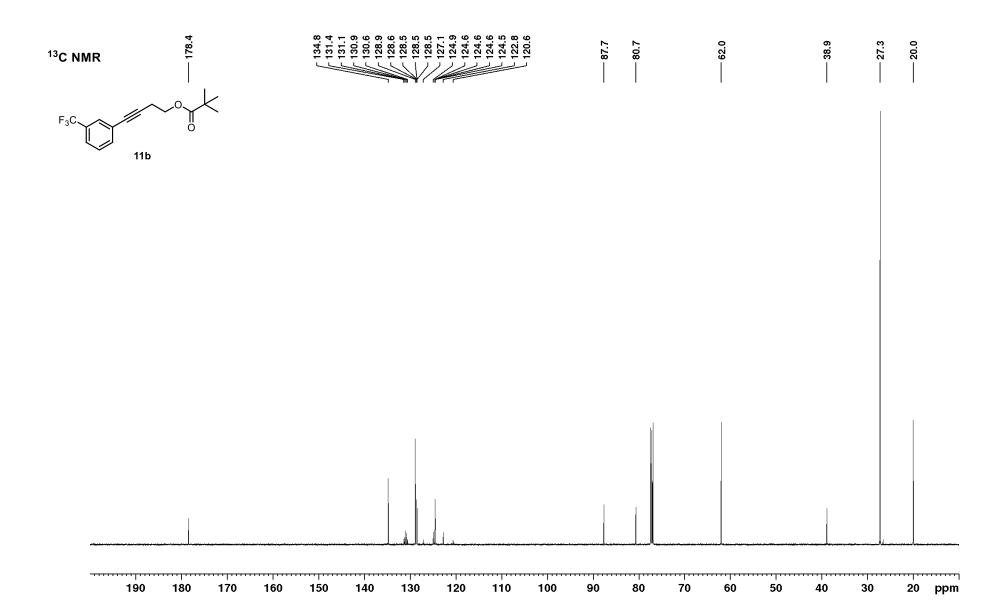
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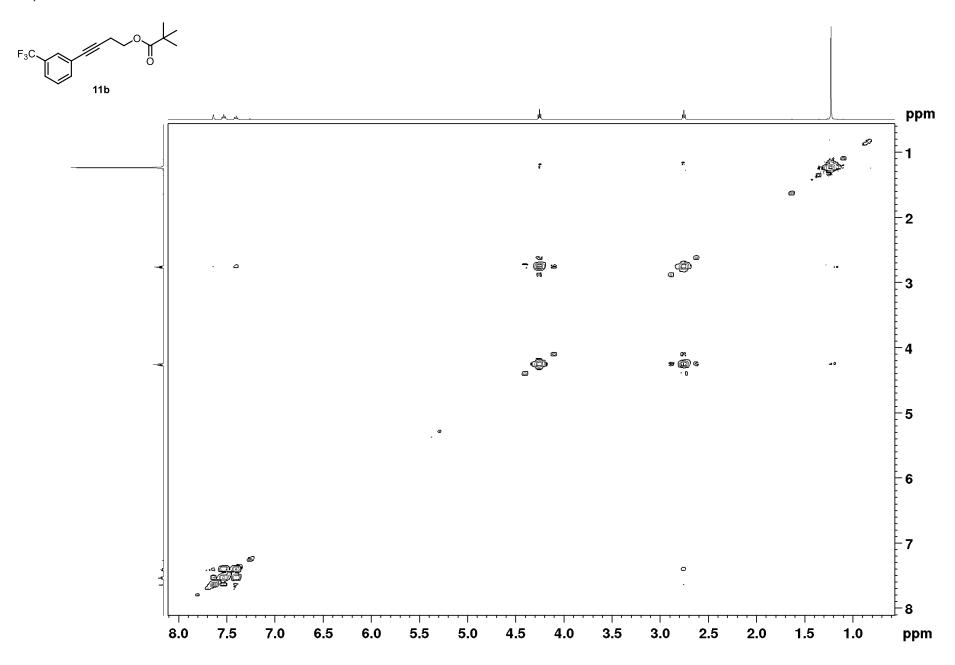


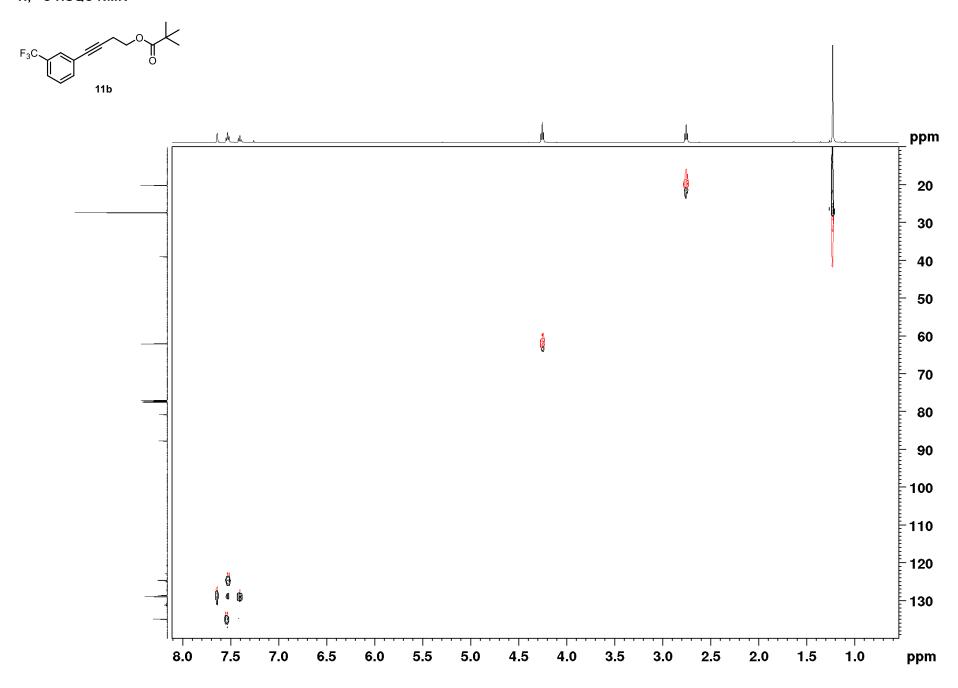




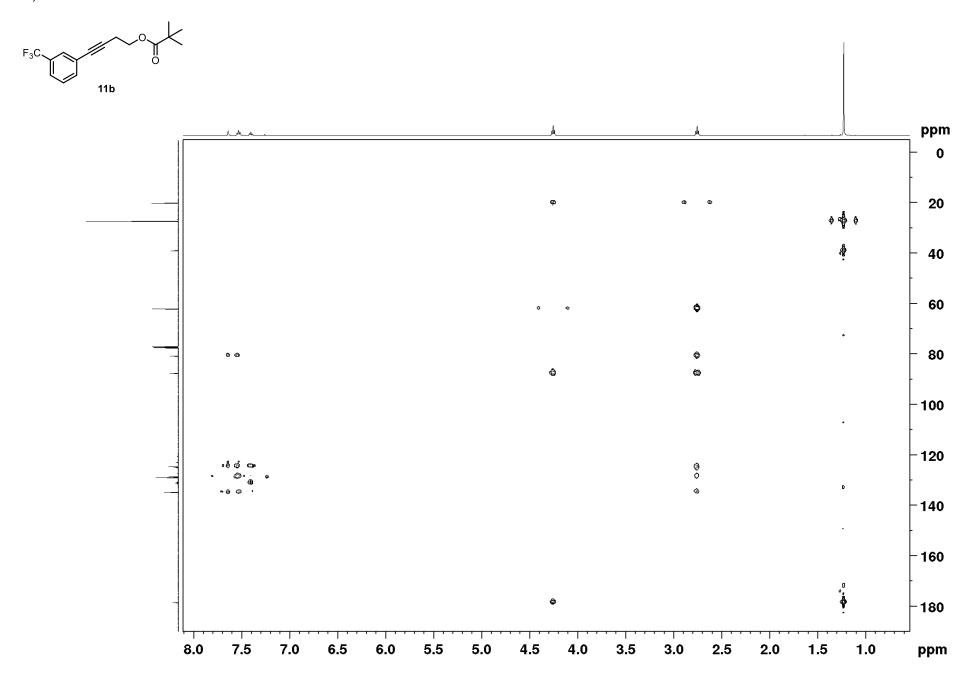


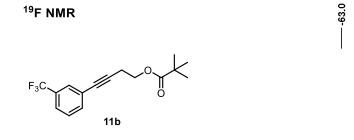
## <sup>1</sup>H, <sup>1</sup>H COSY NMR

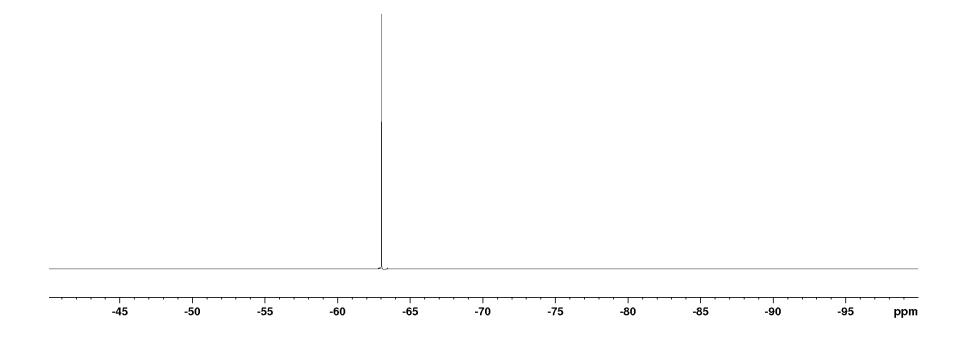


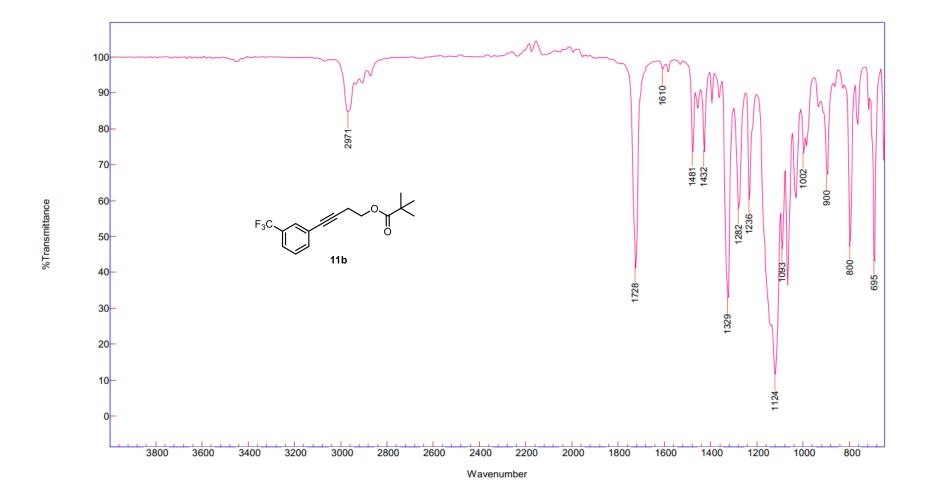


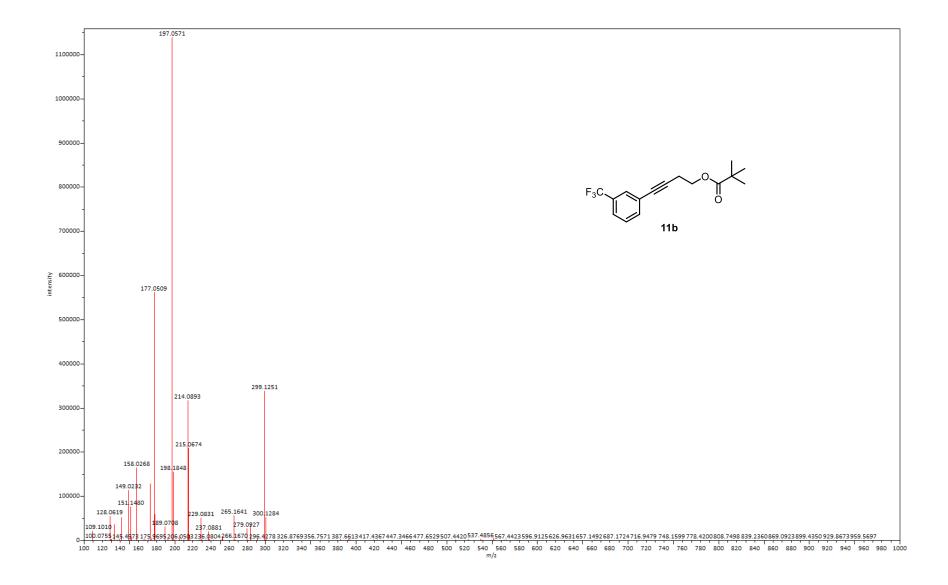


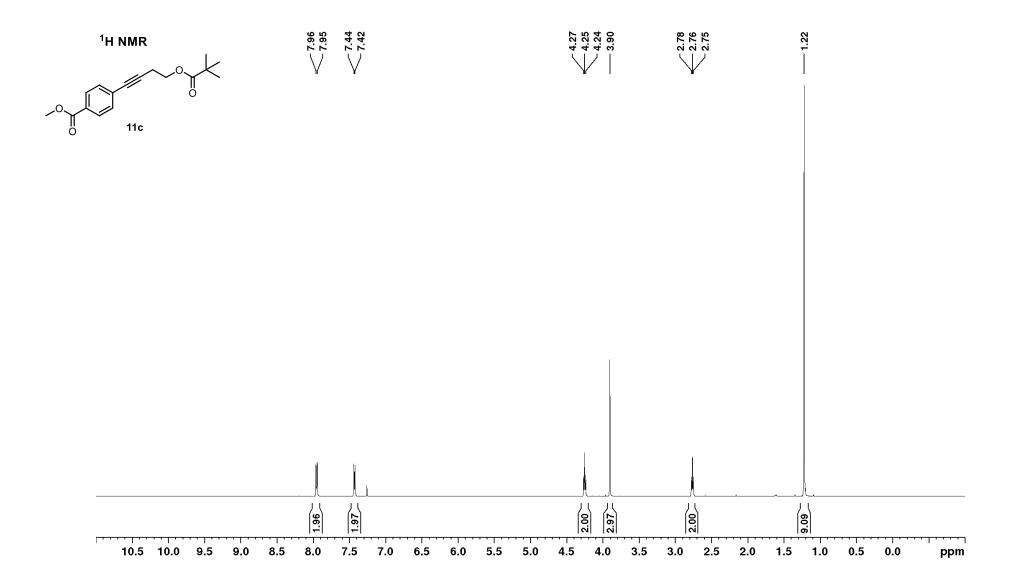


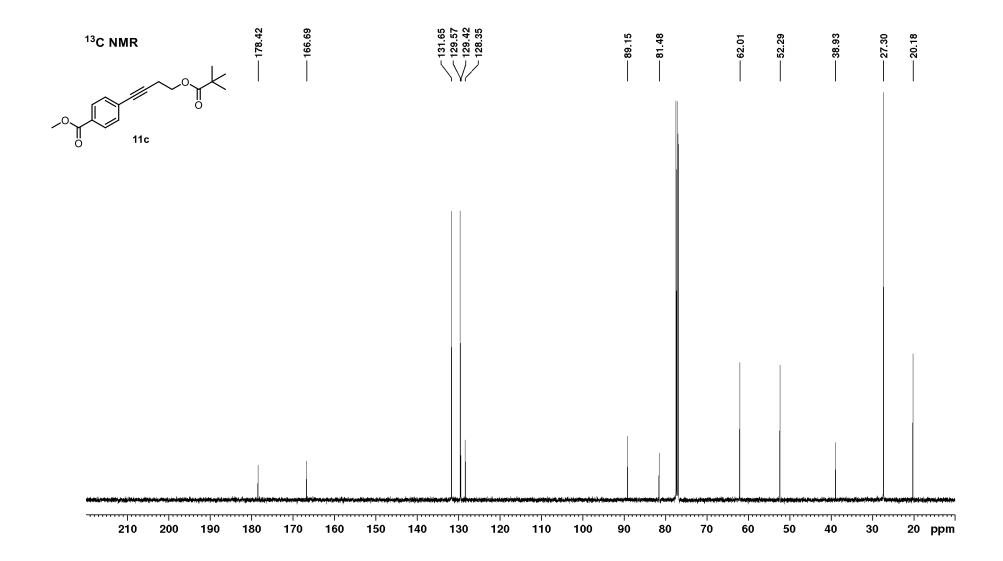


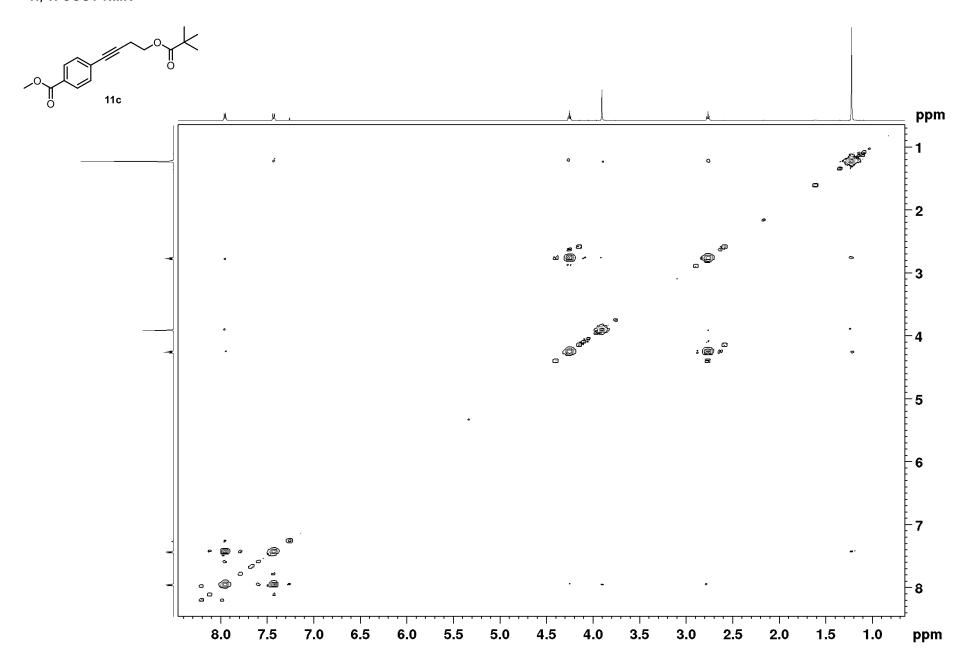


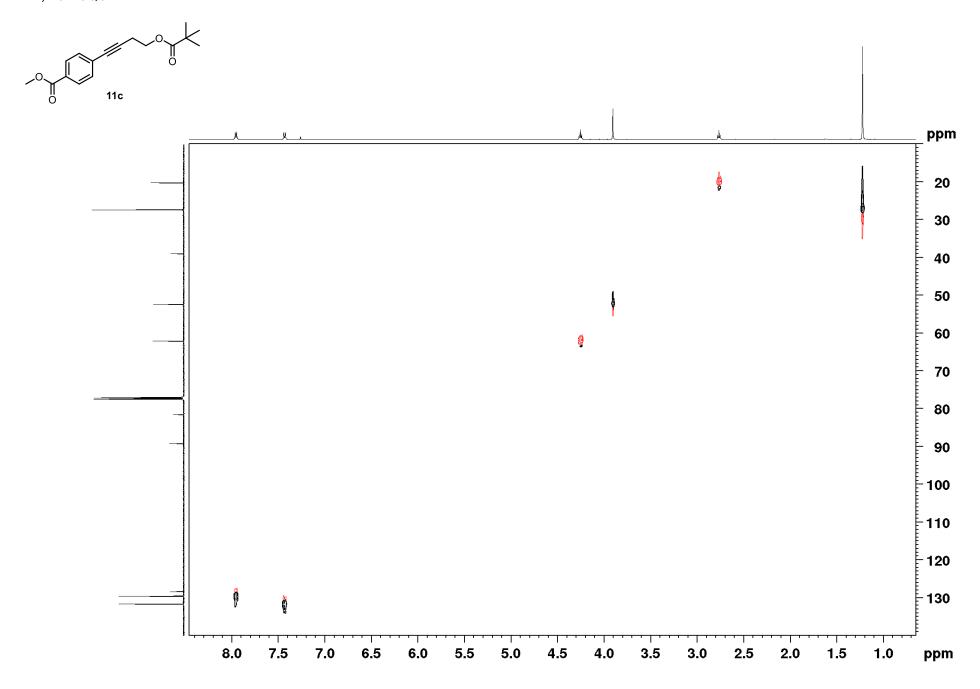




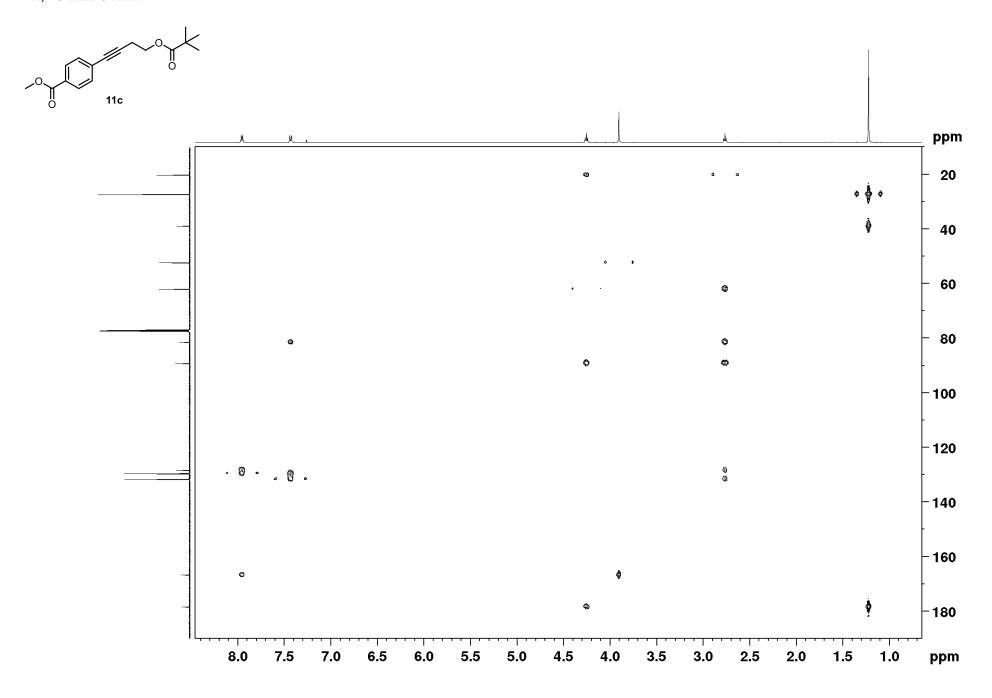


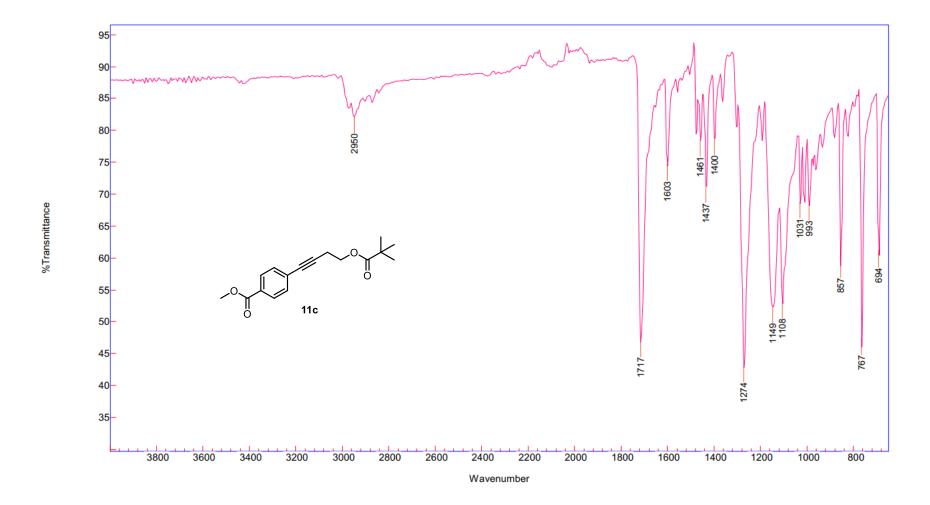


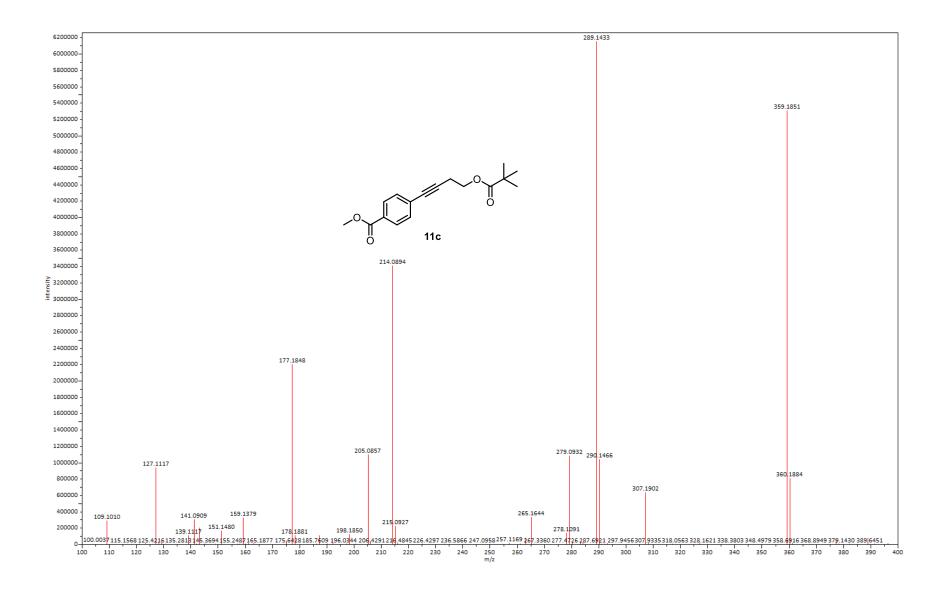


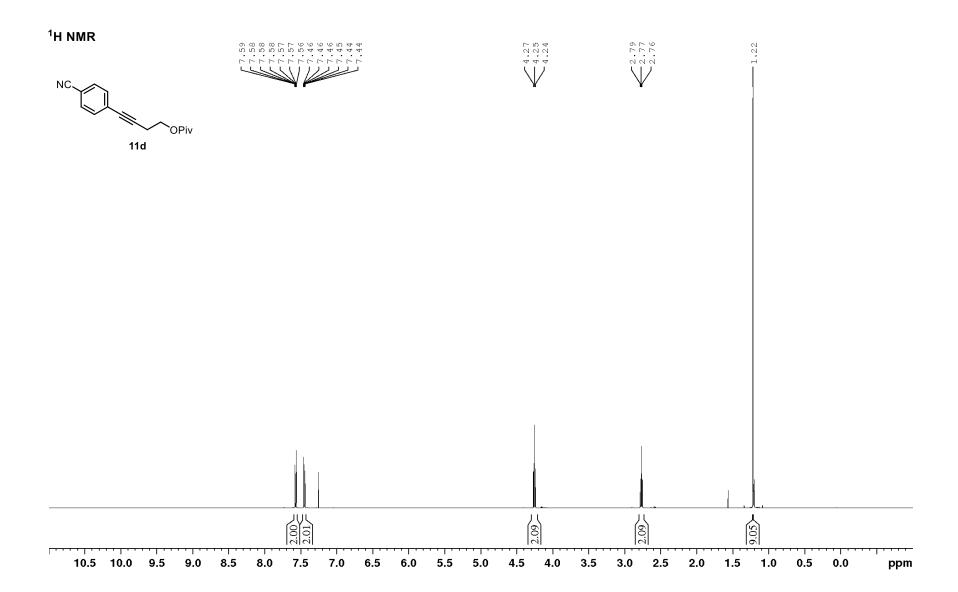


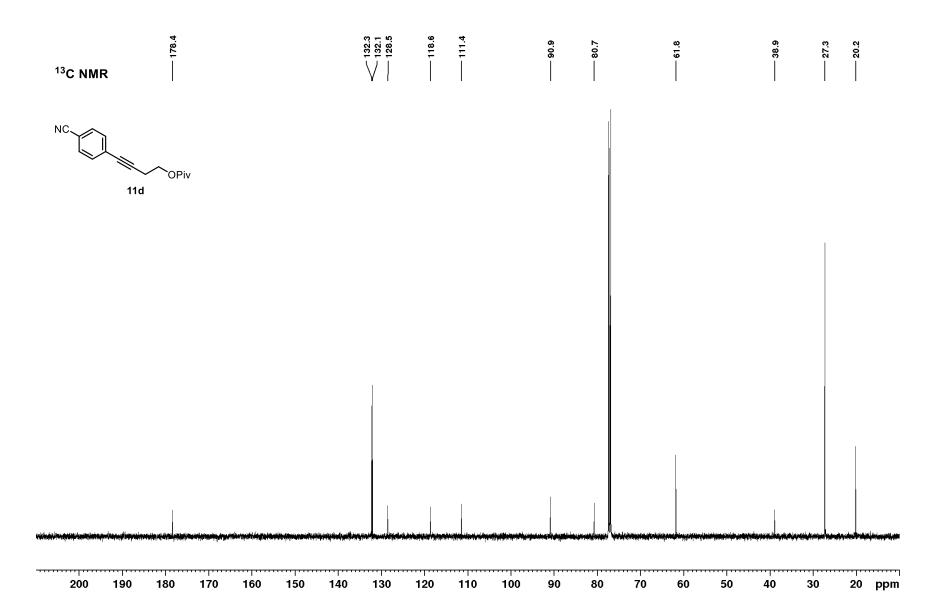
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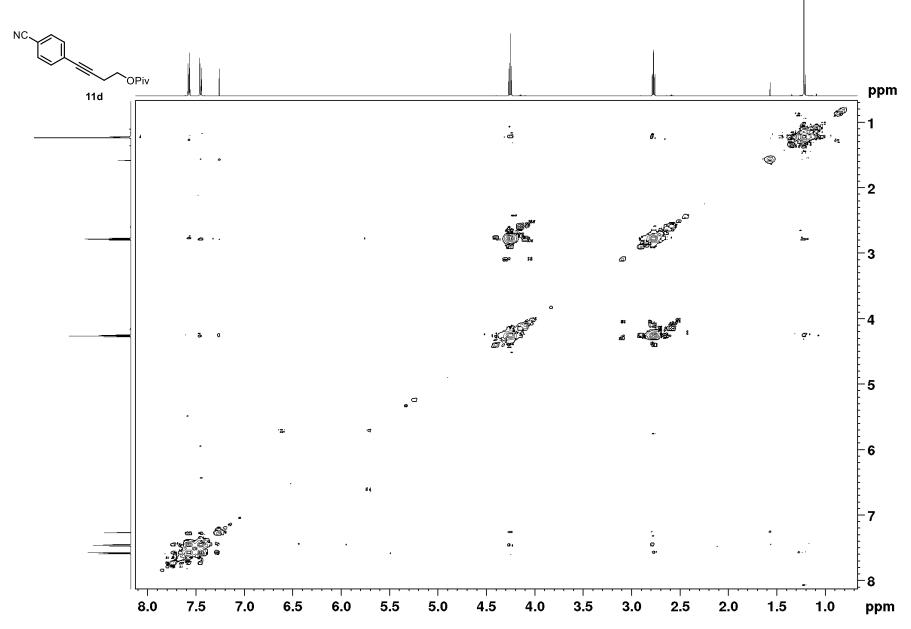




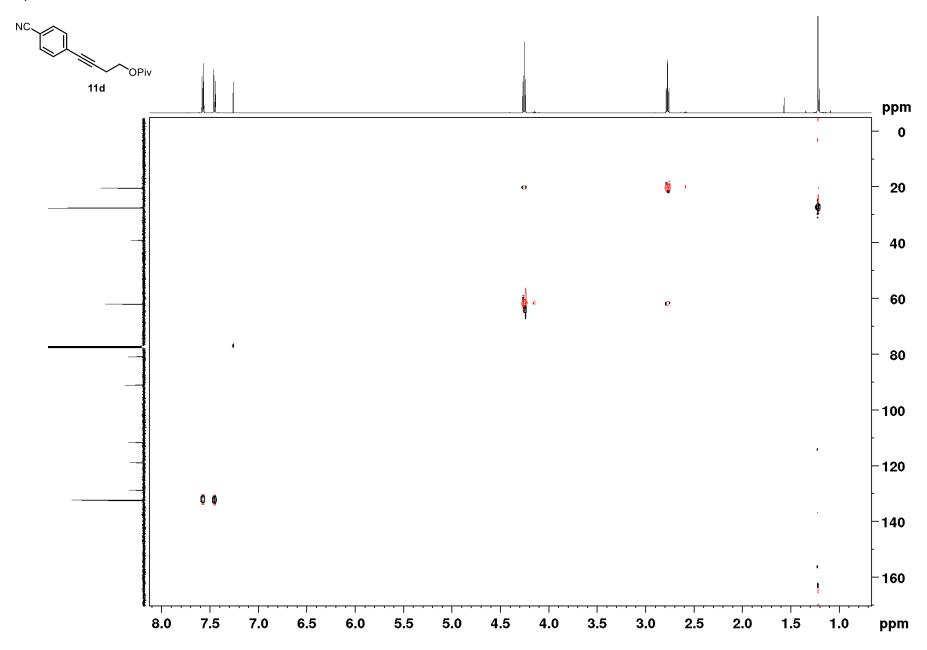




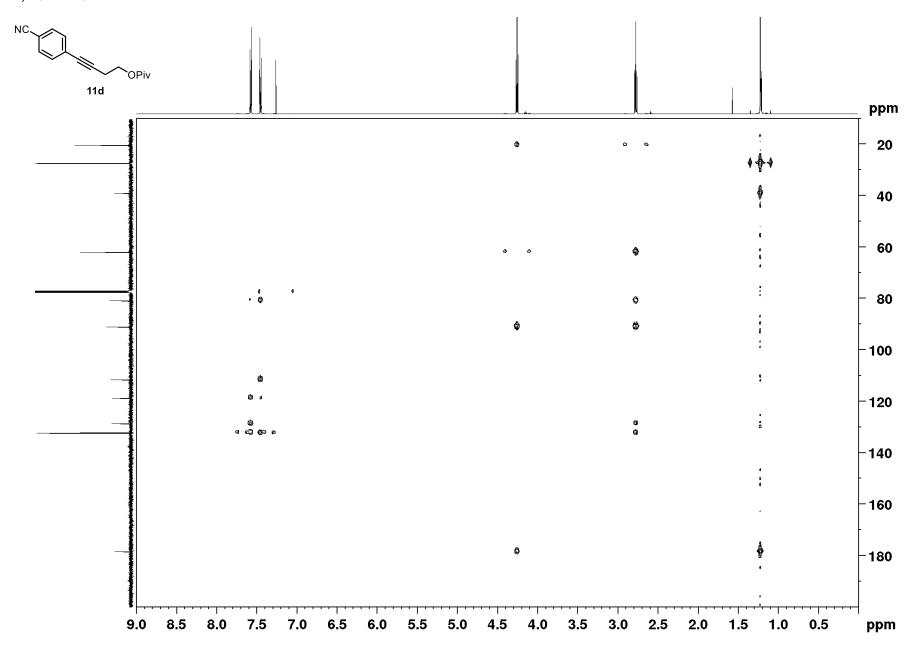




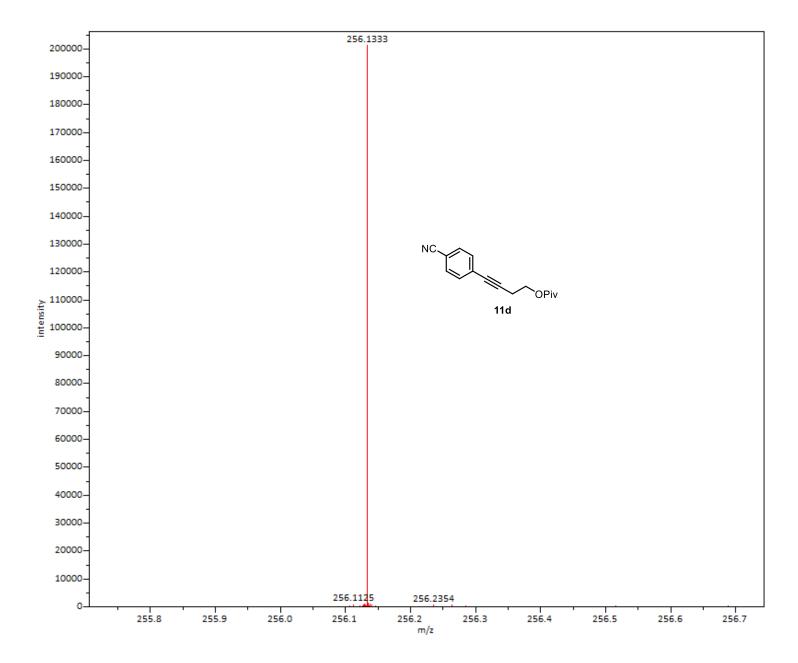
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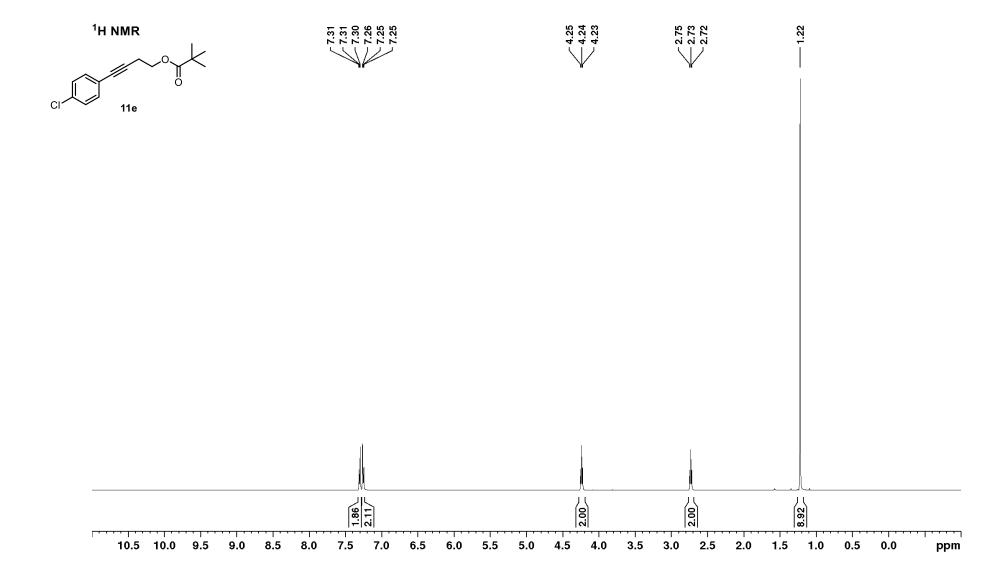


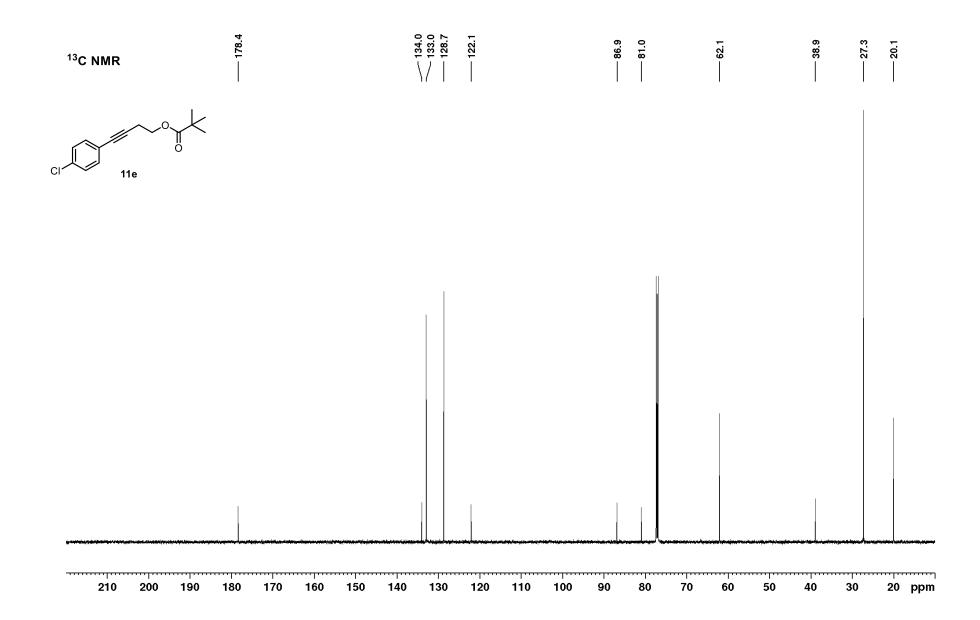
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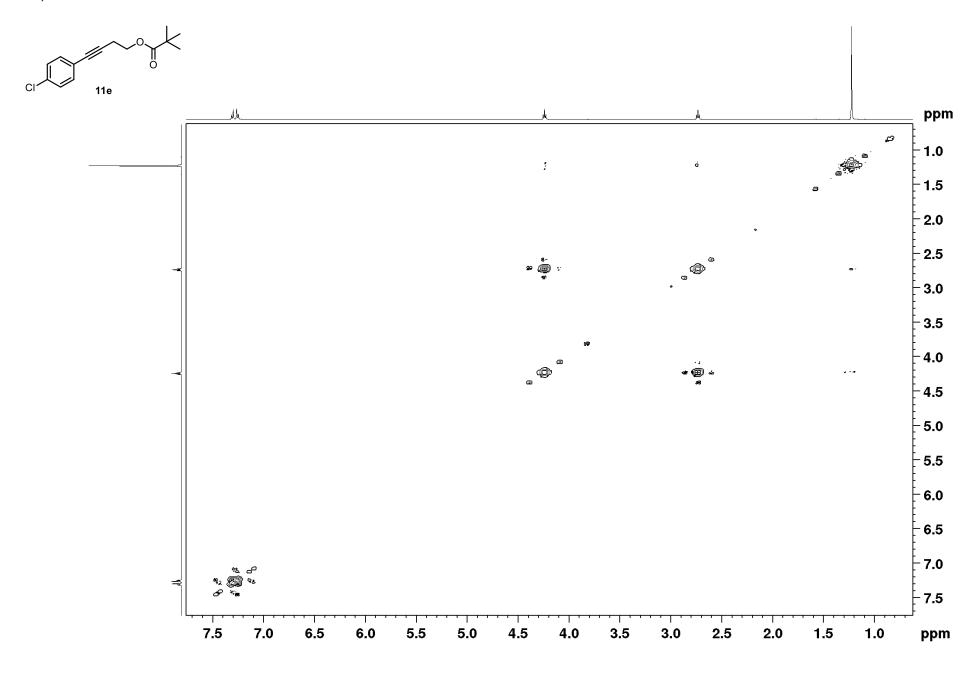


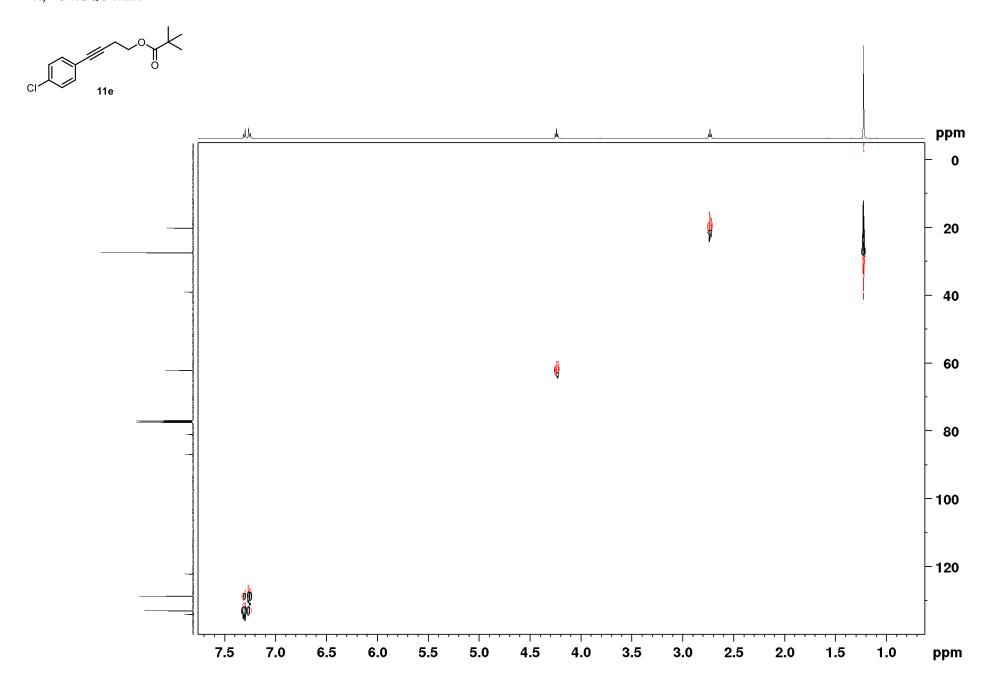




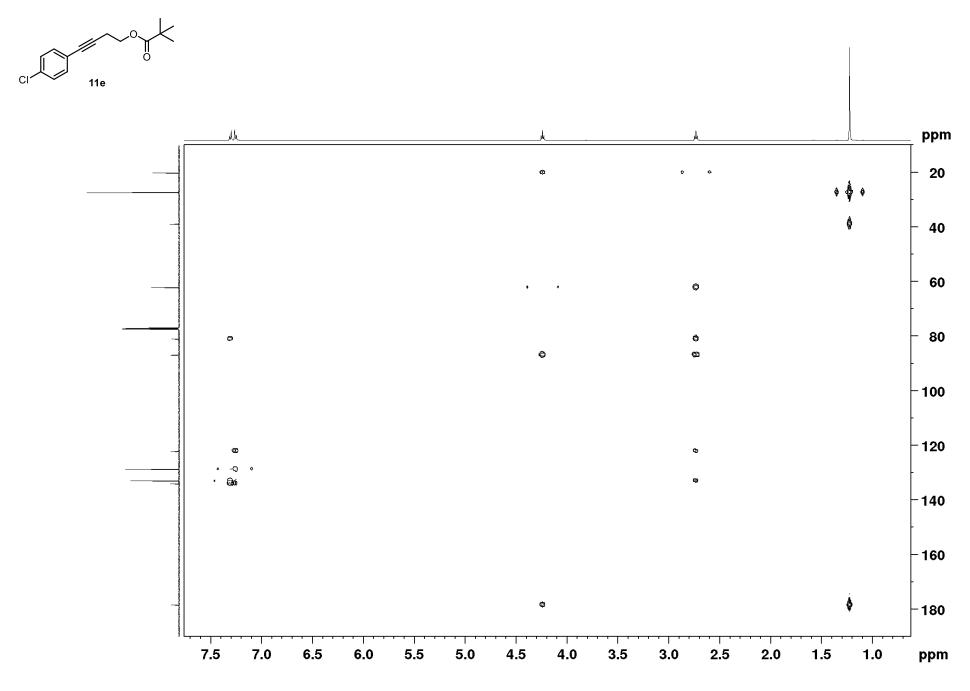


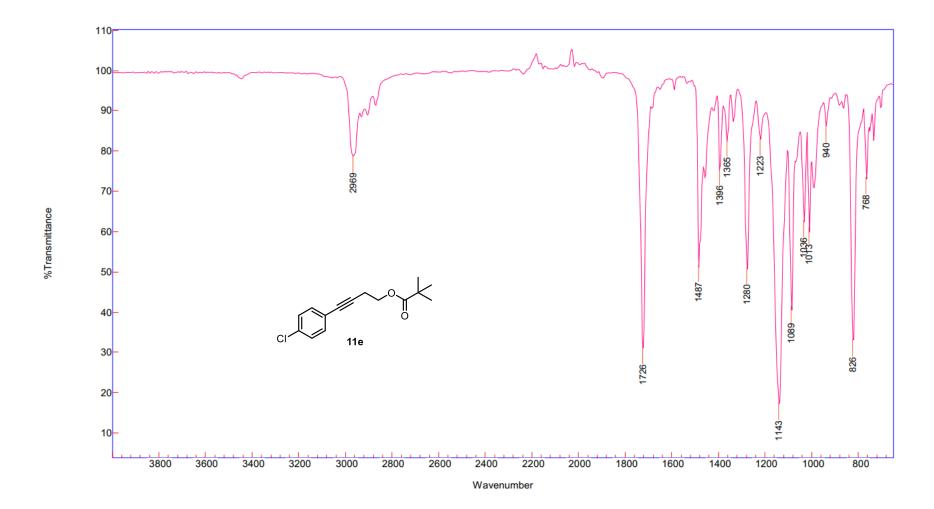
## <sup>1</sup>H, <sup>1</sup>H COSY NMR

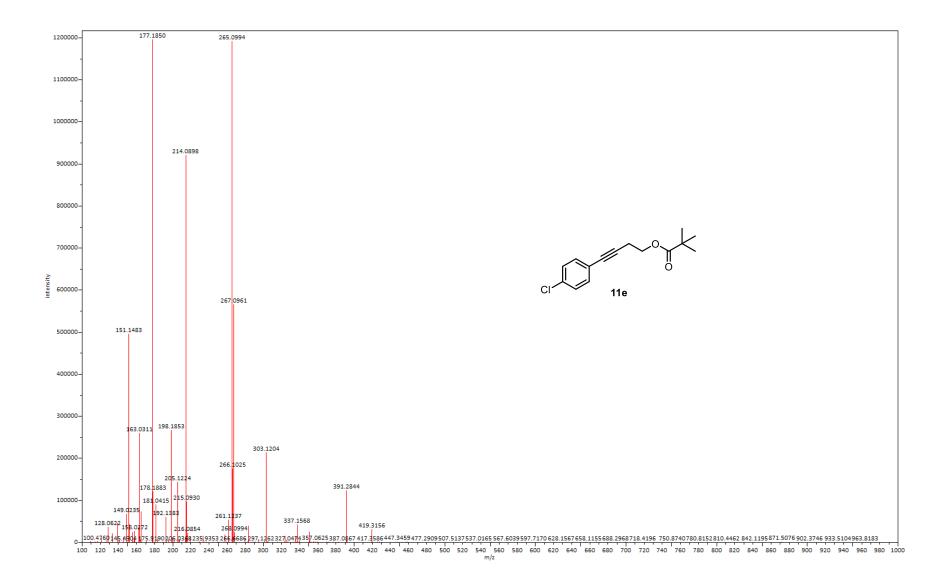




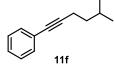




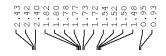


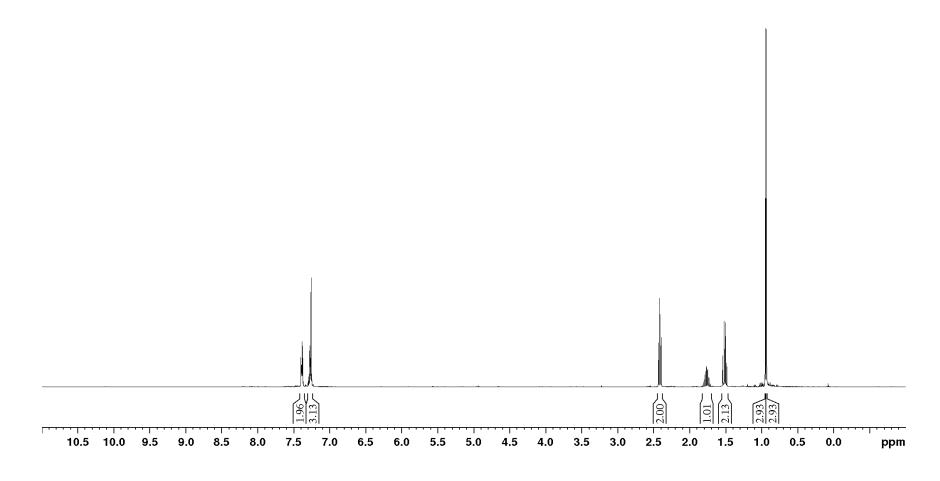




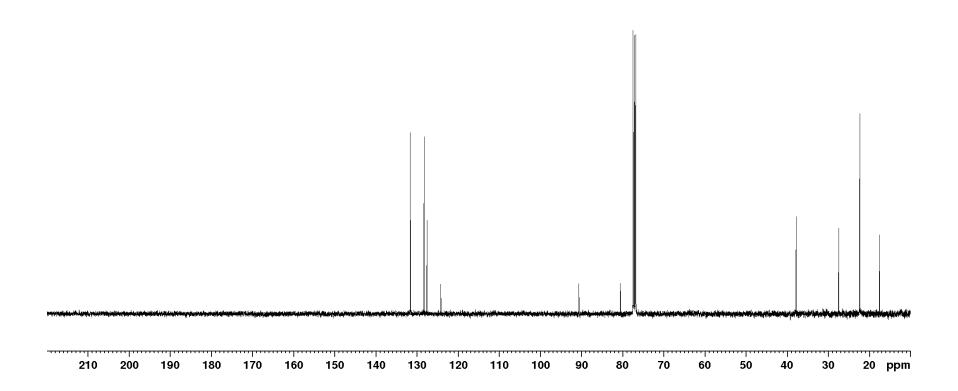


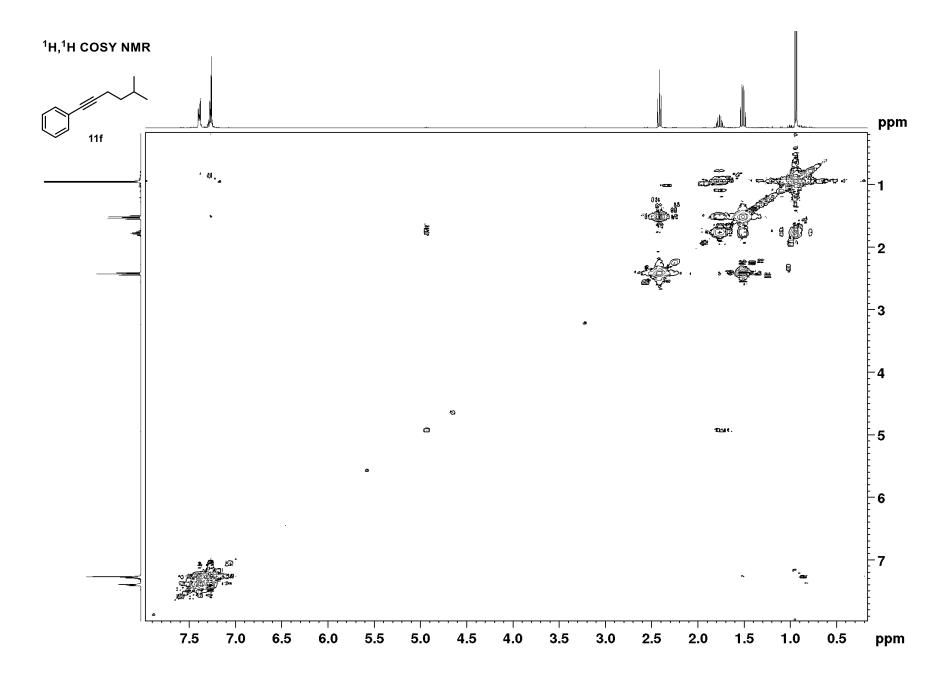




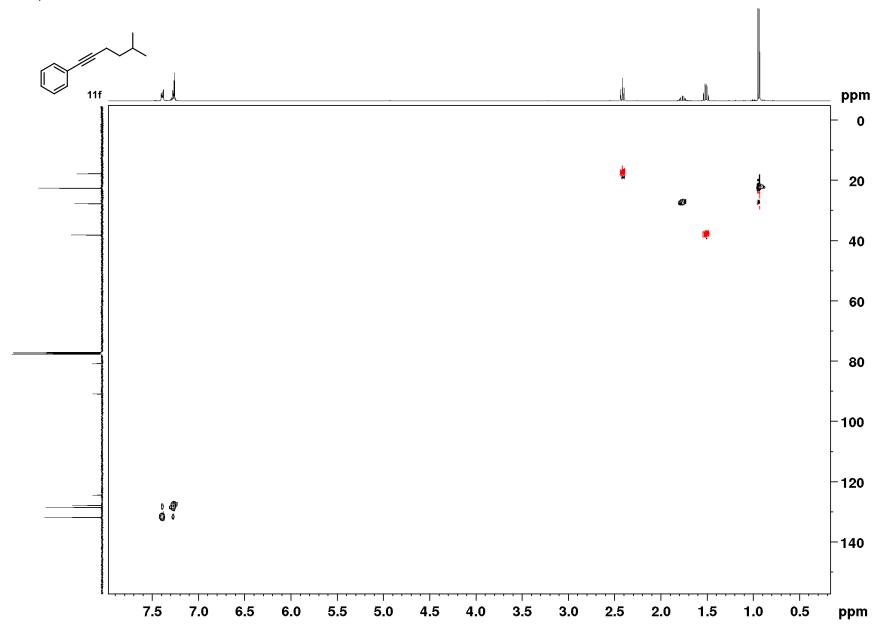


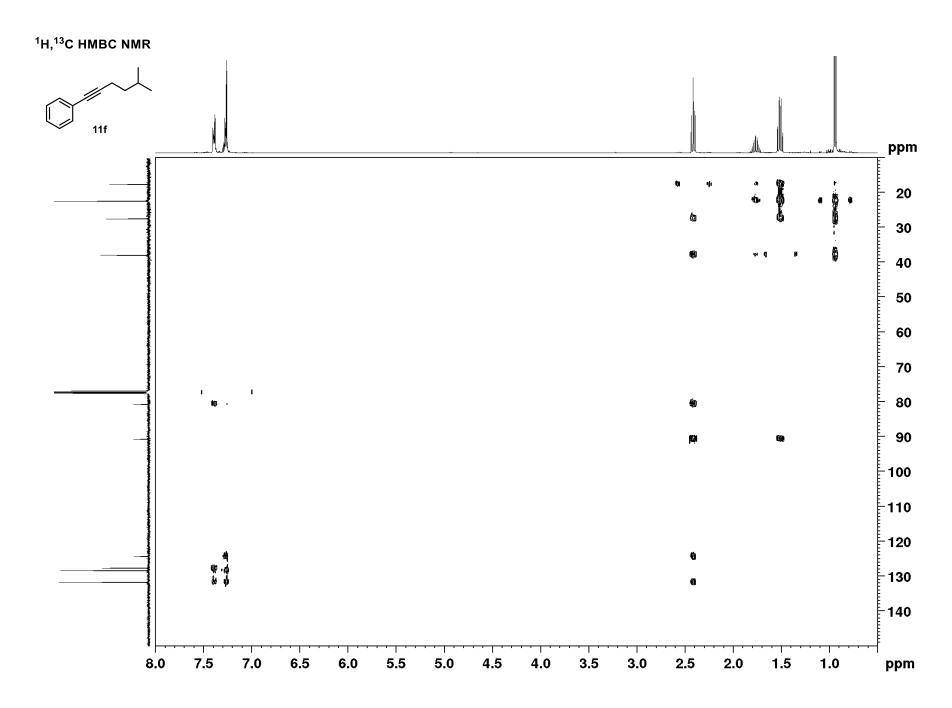


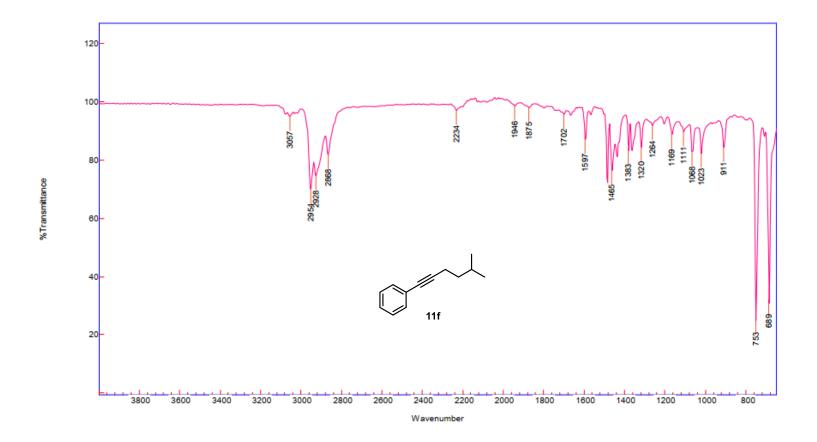


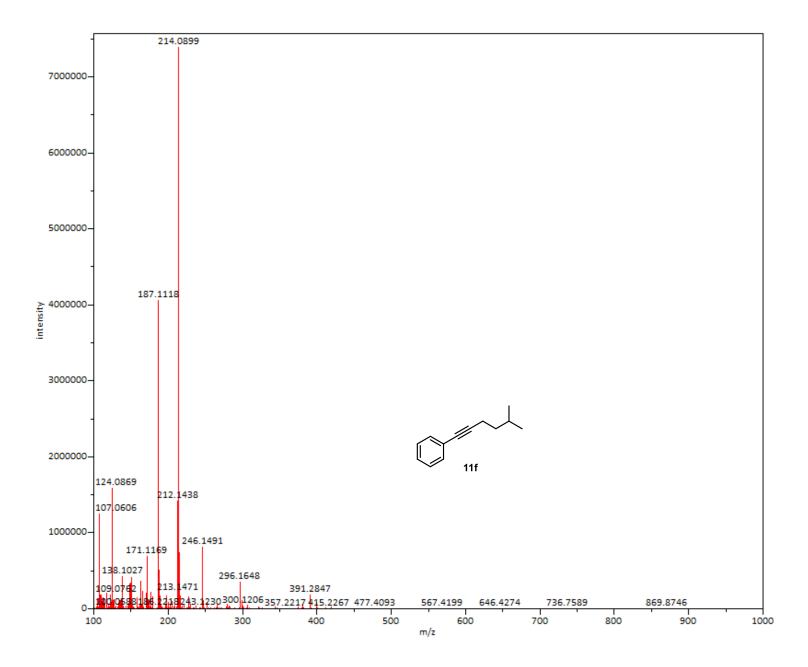


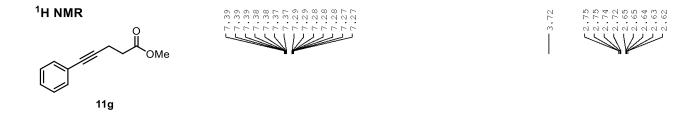


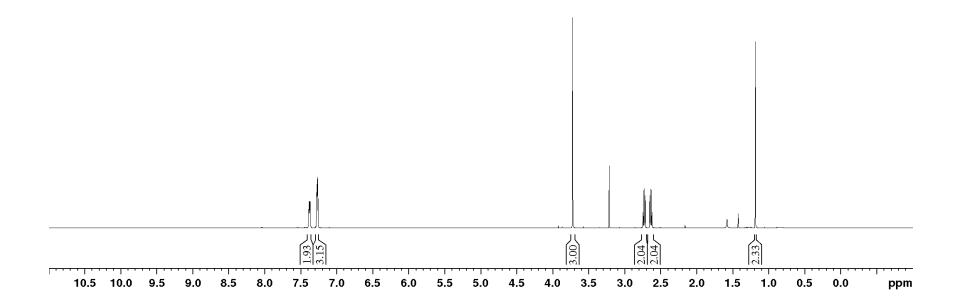


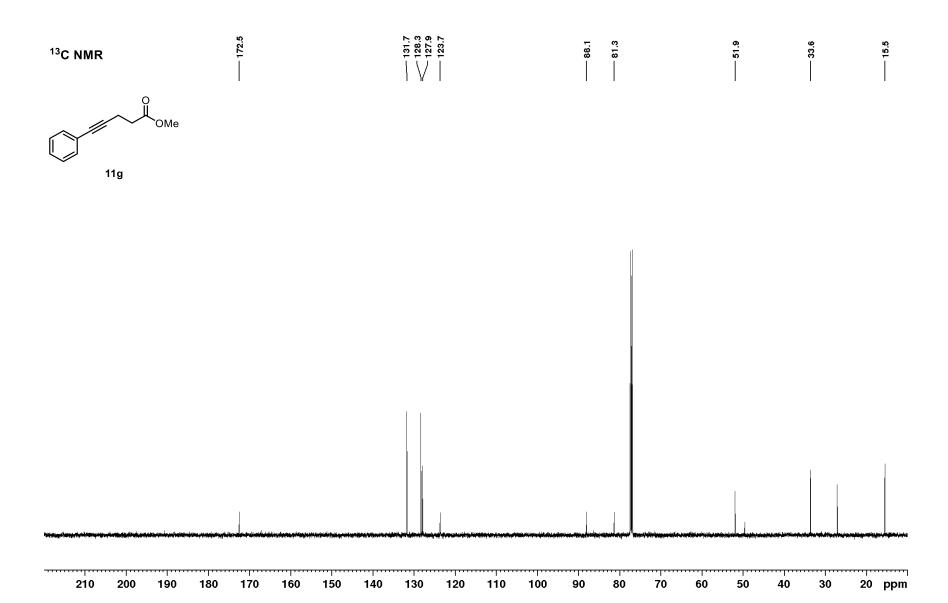


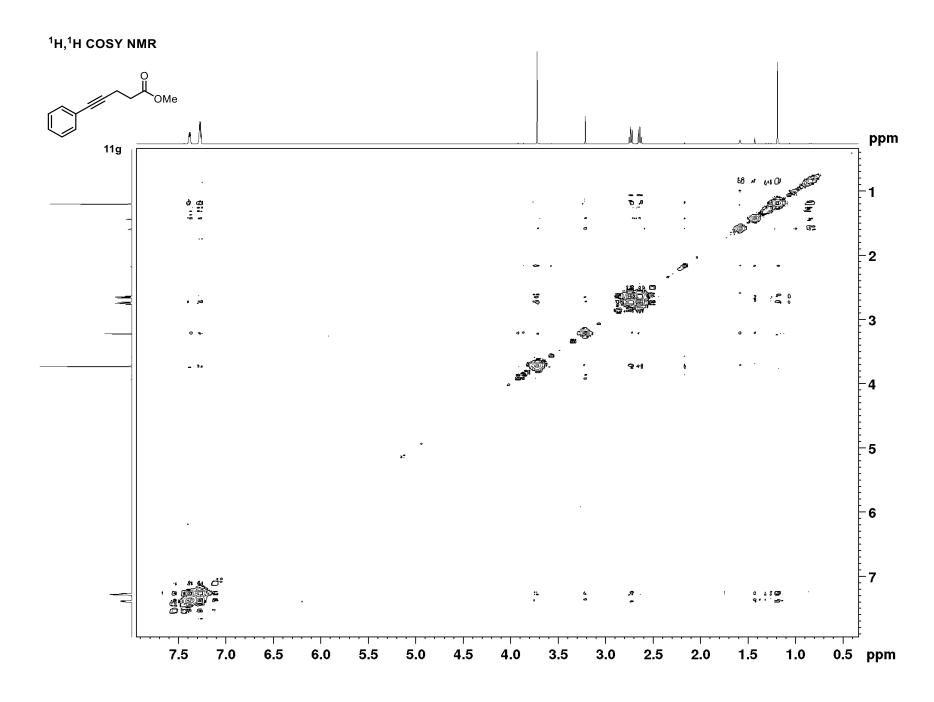


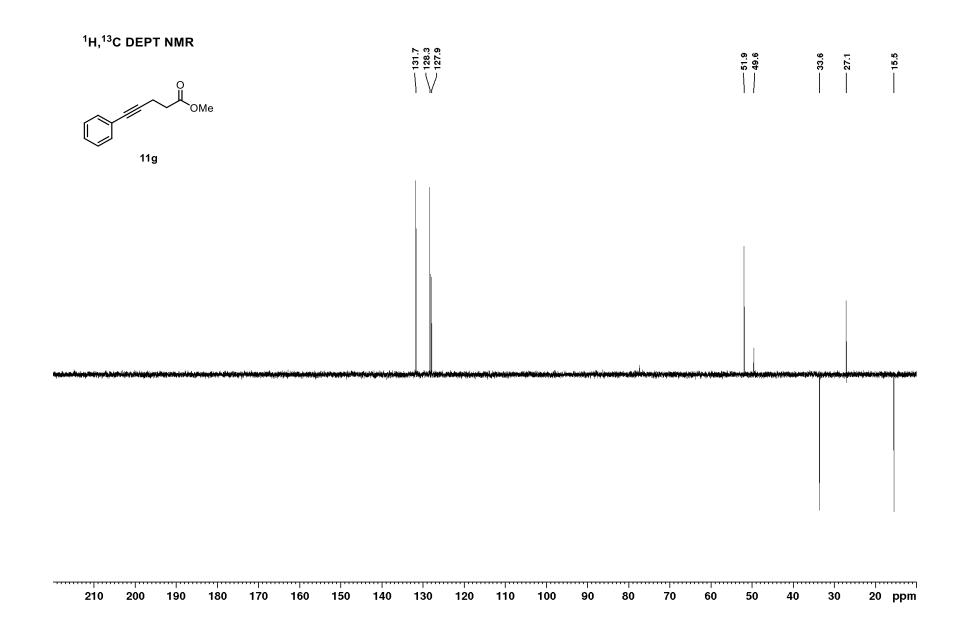




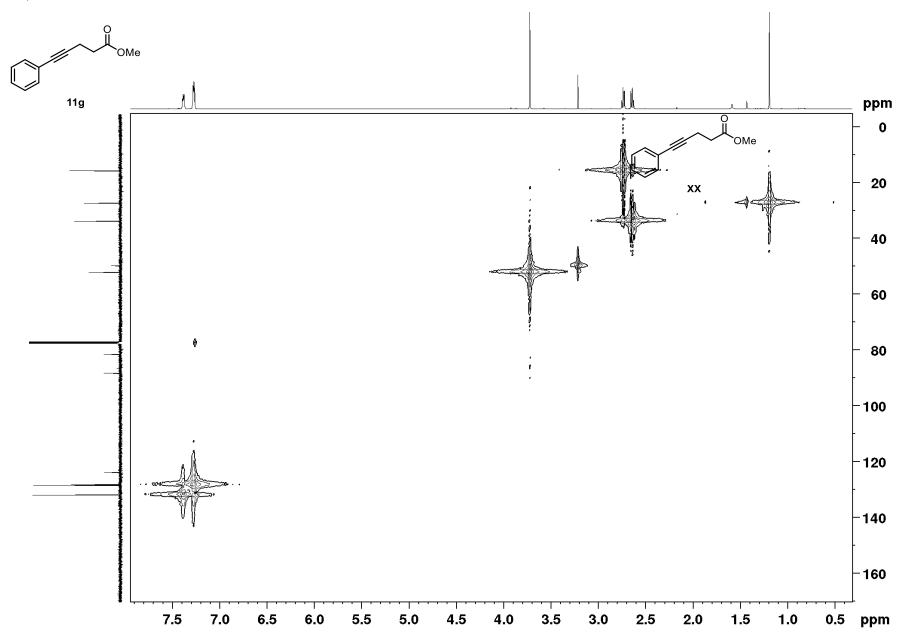




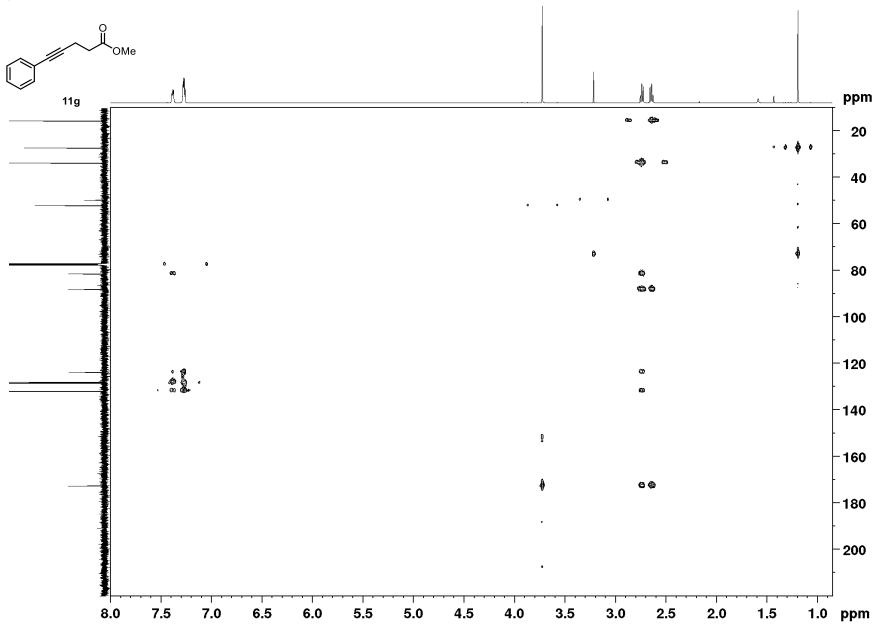


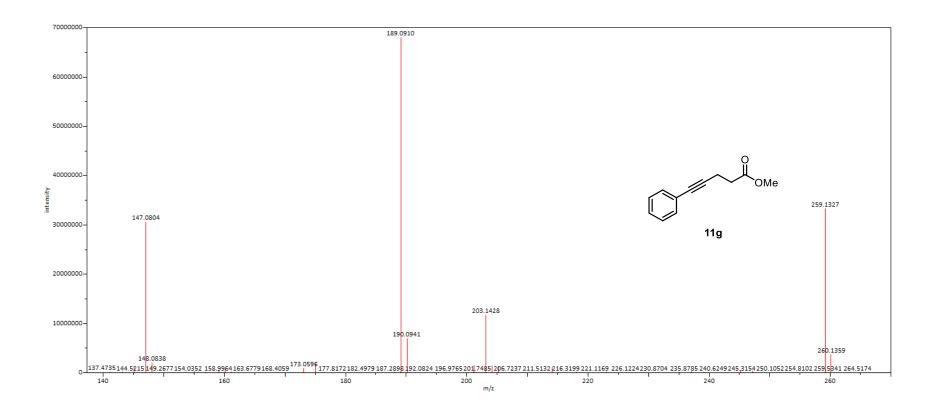


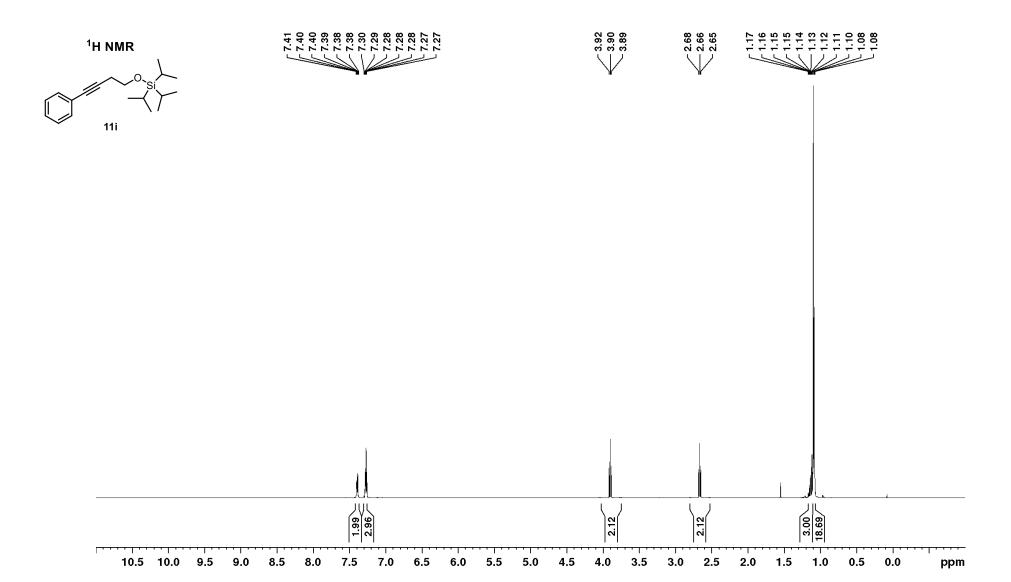




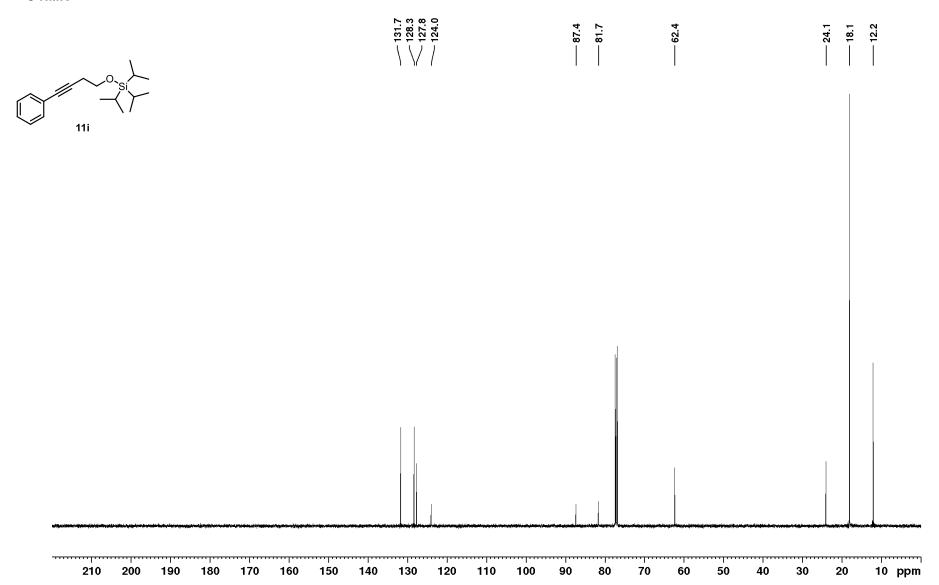


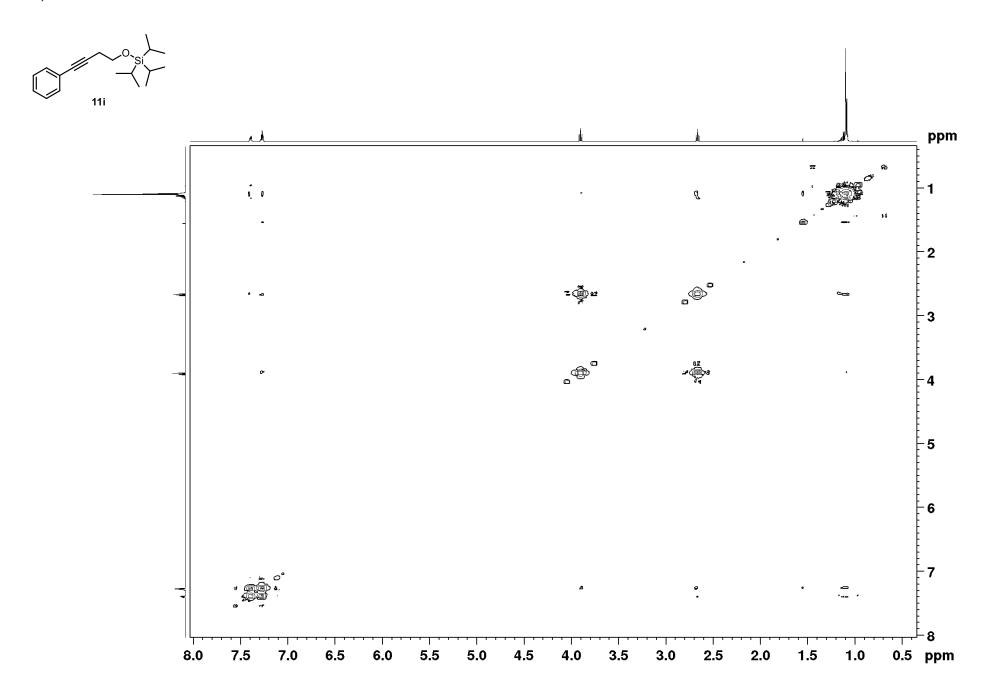




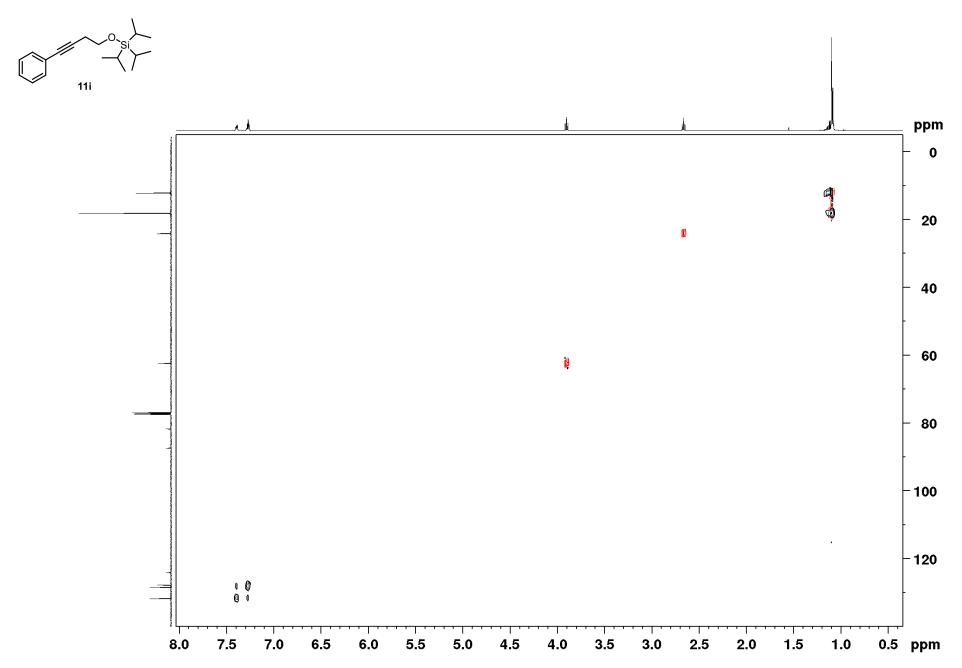




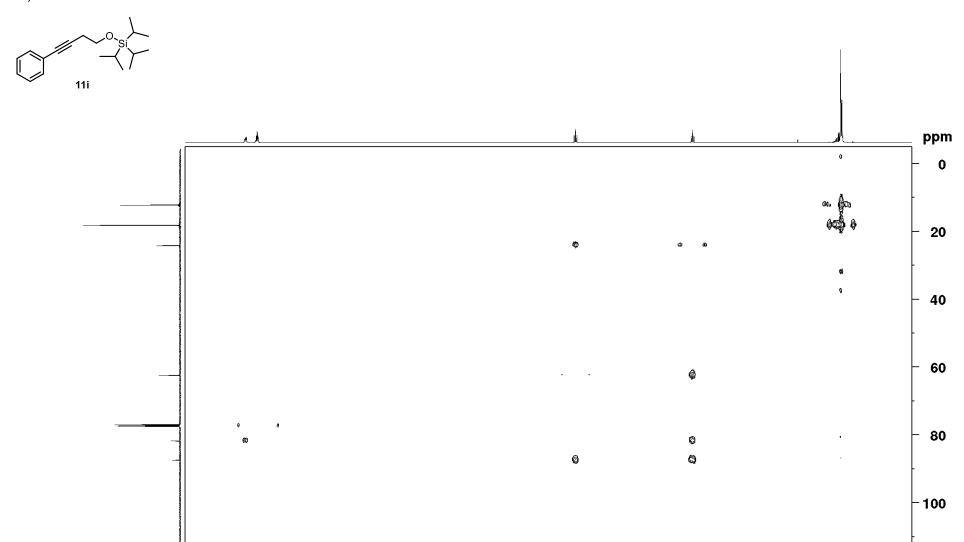












4.5

5.0

7.5

8.0

7.0

6.5

6.0

5.5

3.5

3.0

4.0

2.5

2.0

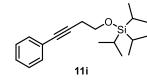
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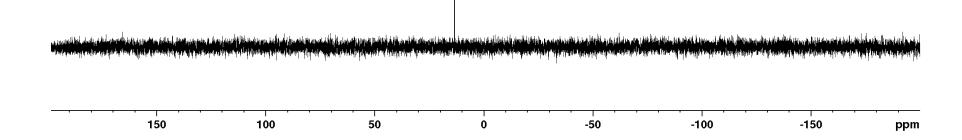
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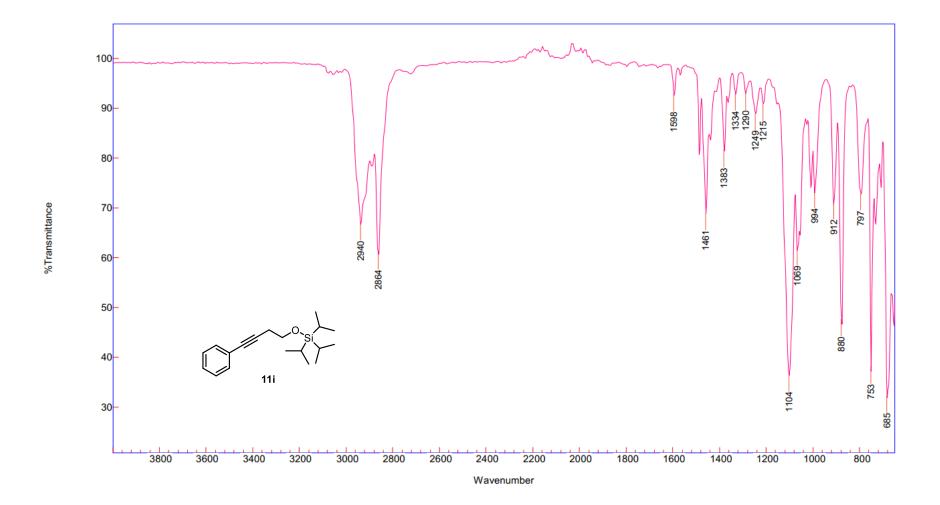
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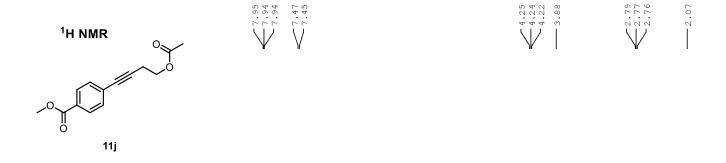
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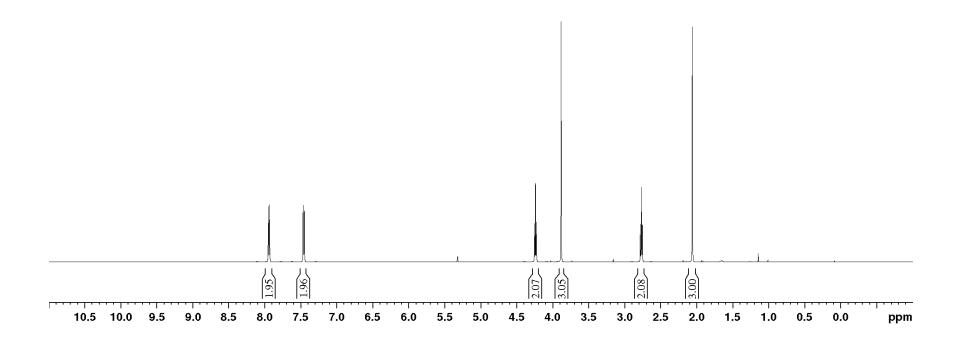


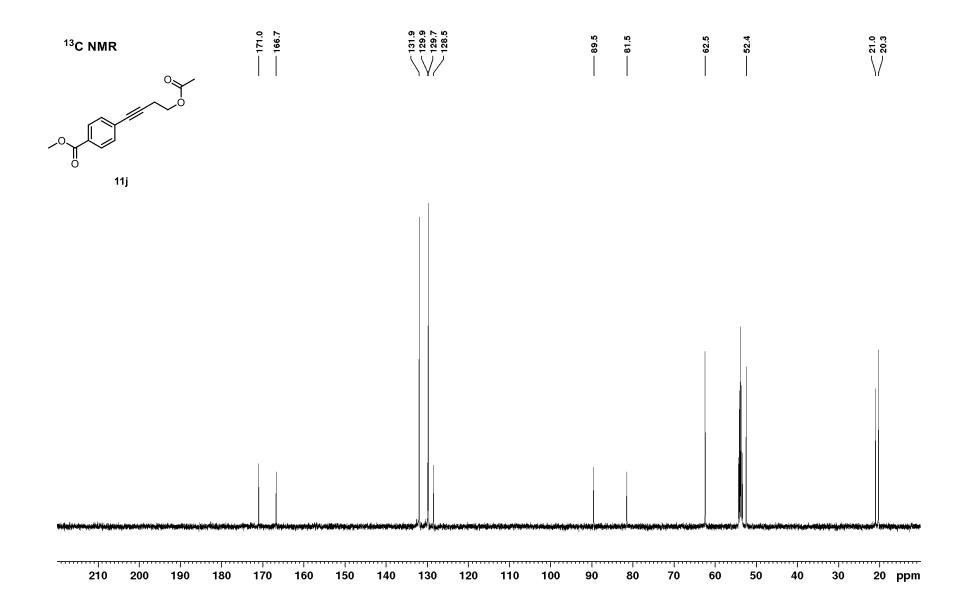




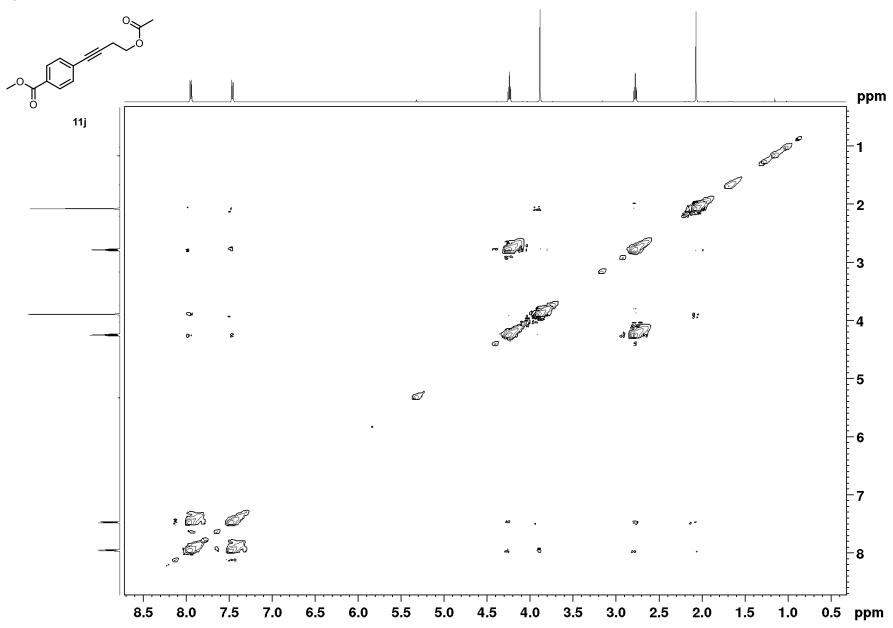


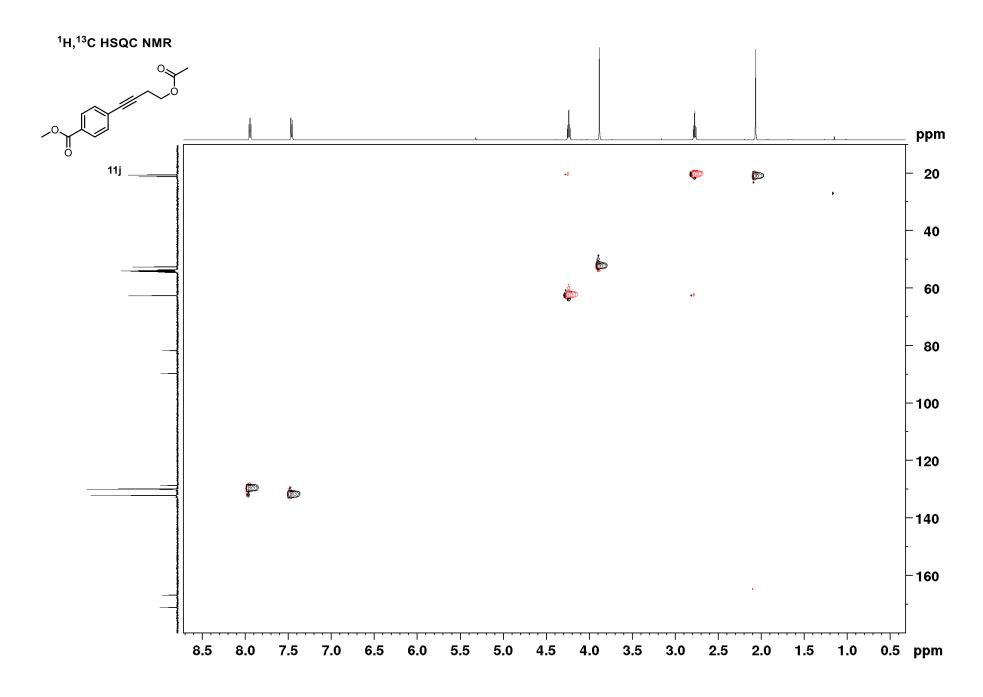




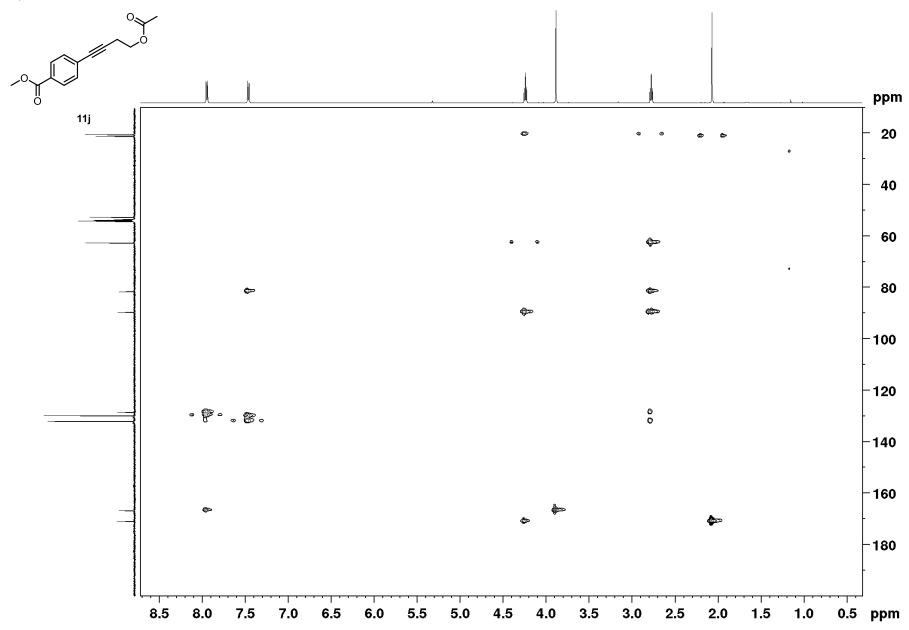


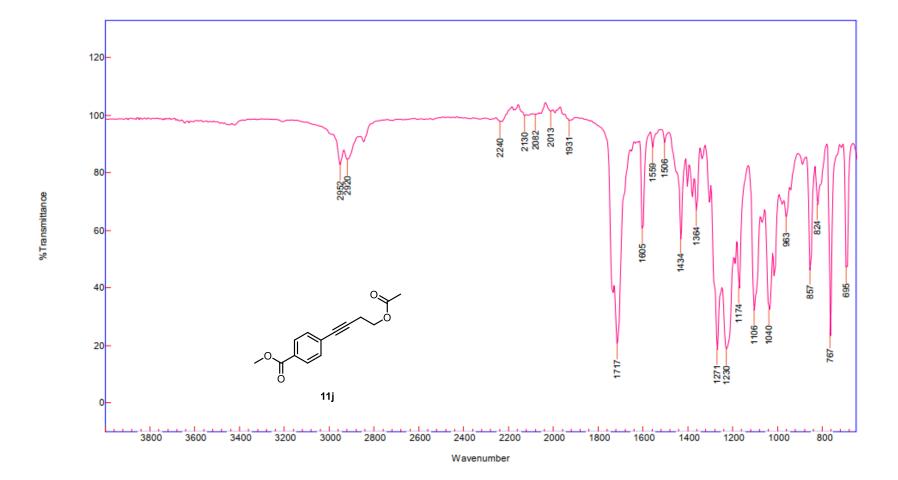


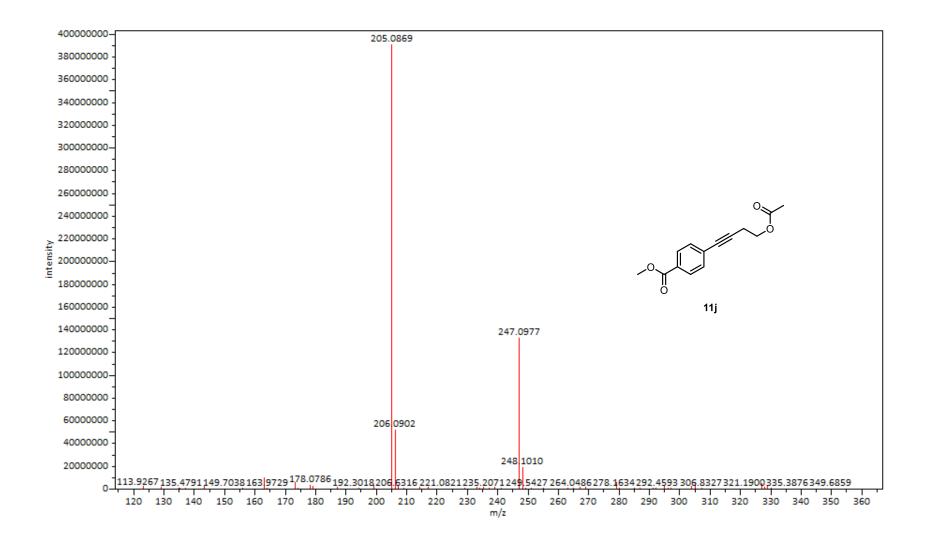


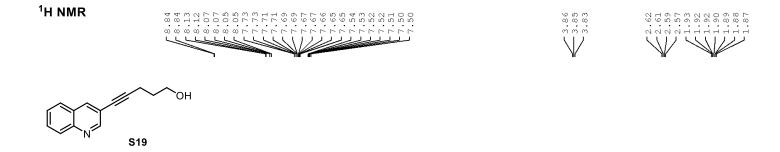


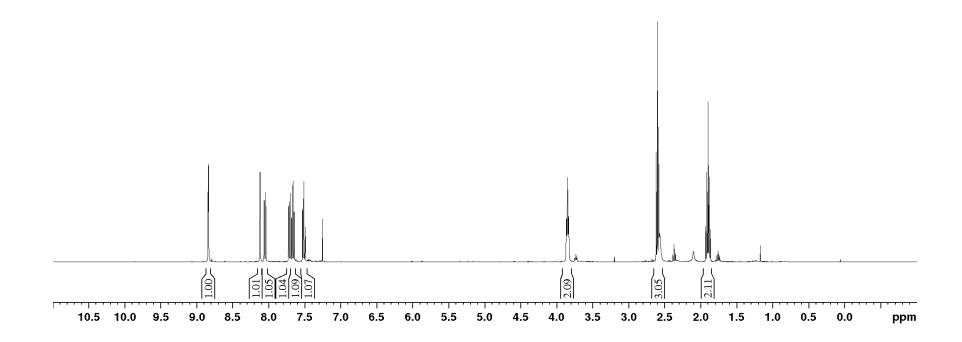




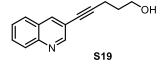


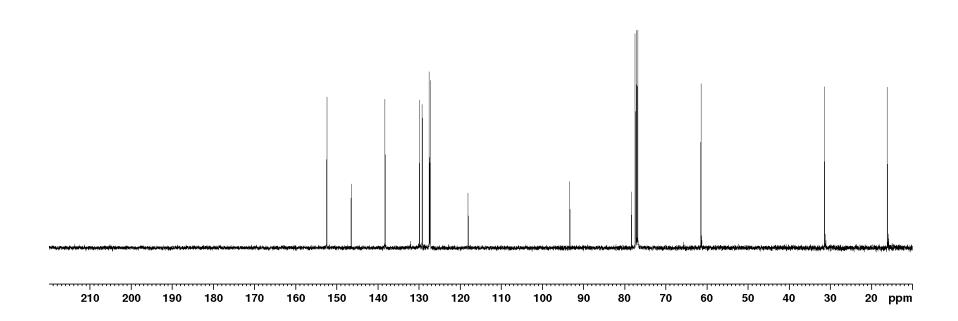


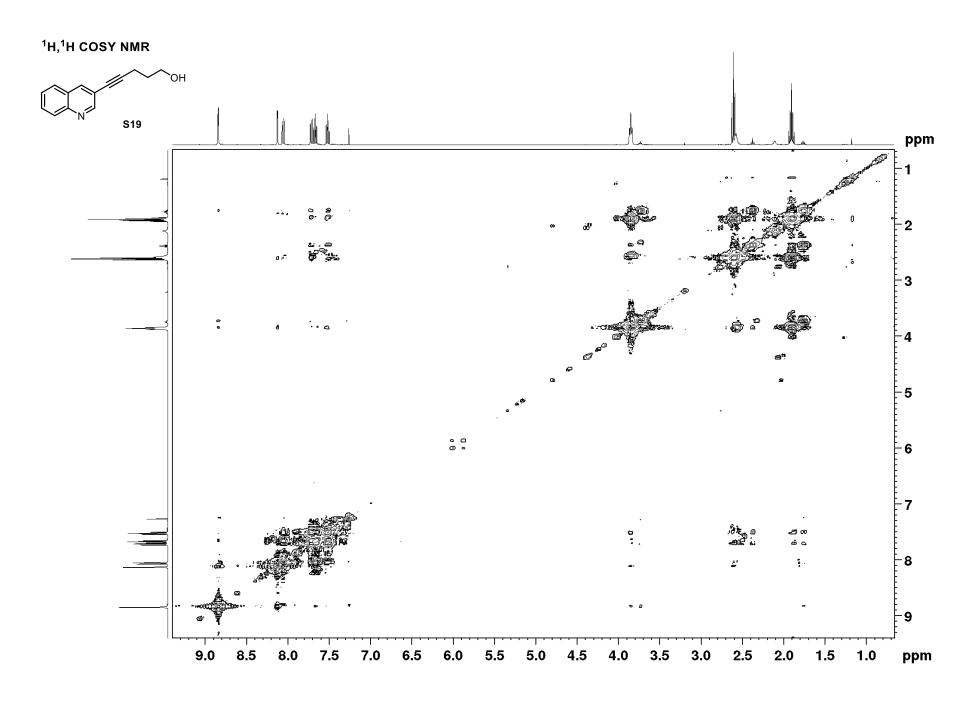


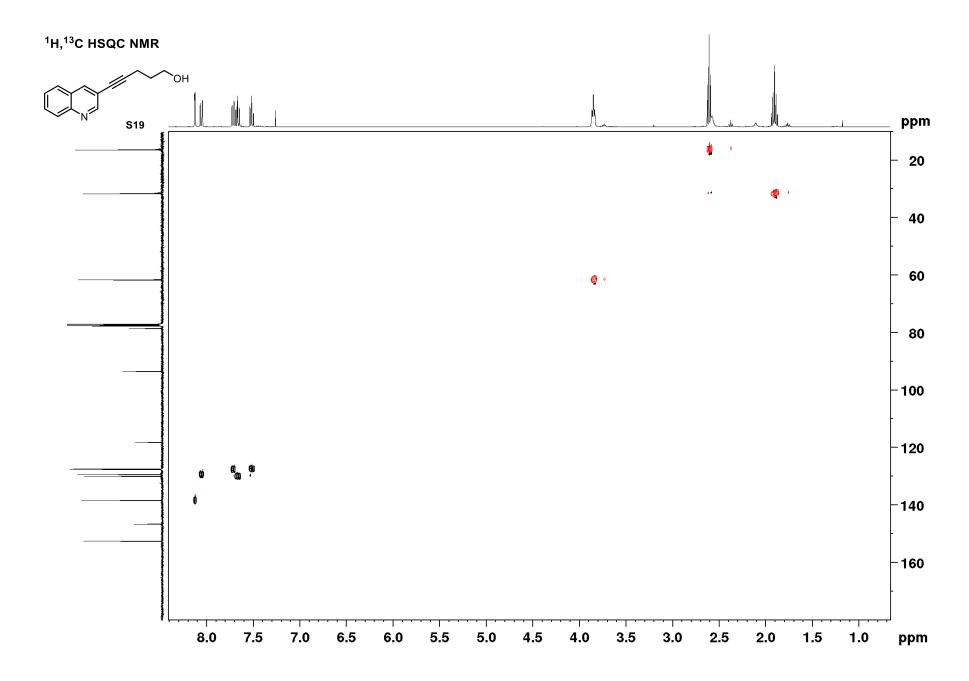


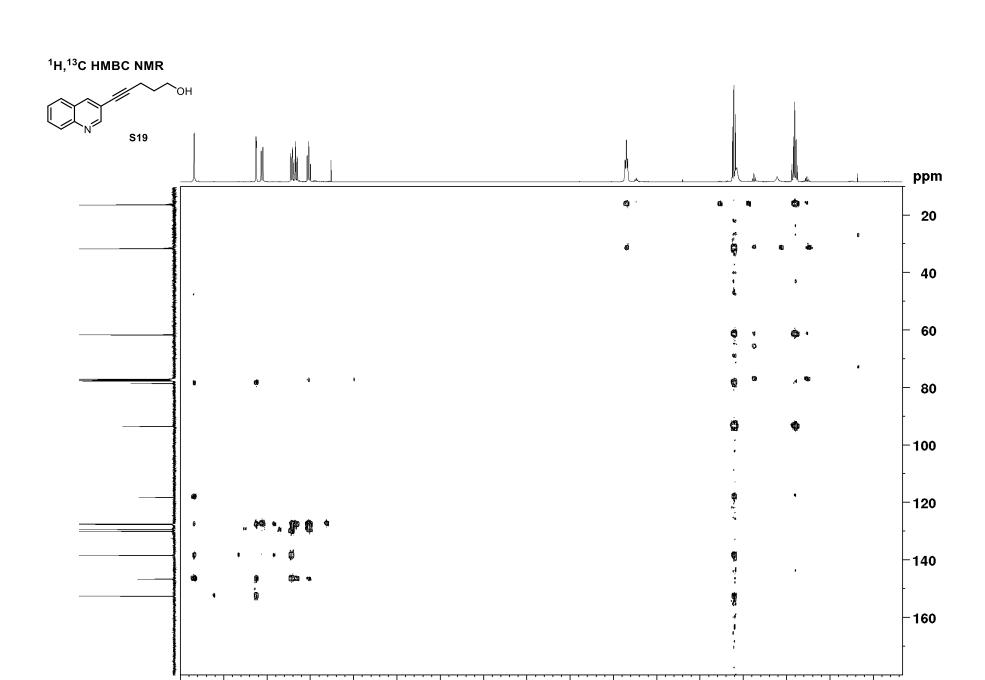












5.0

4.5

4.0

3.5

3.0

2.5

2.0

1.0

ppm

5.5

9.0

8.5

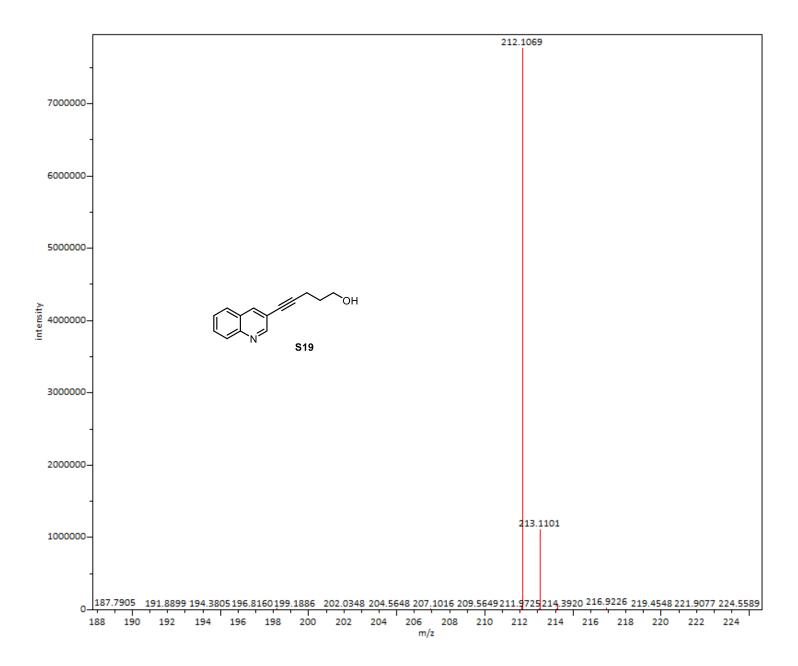
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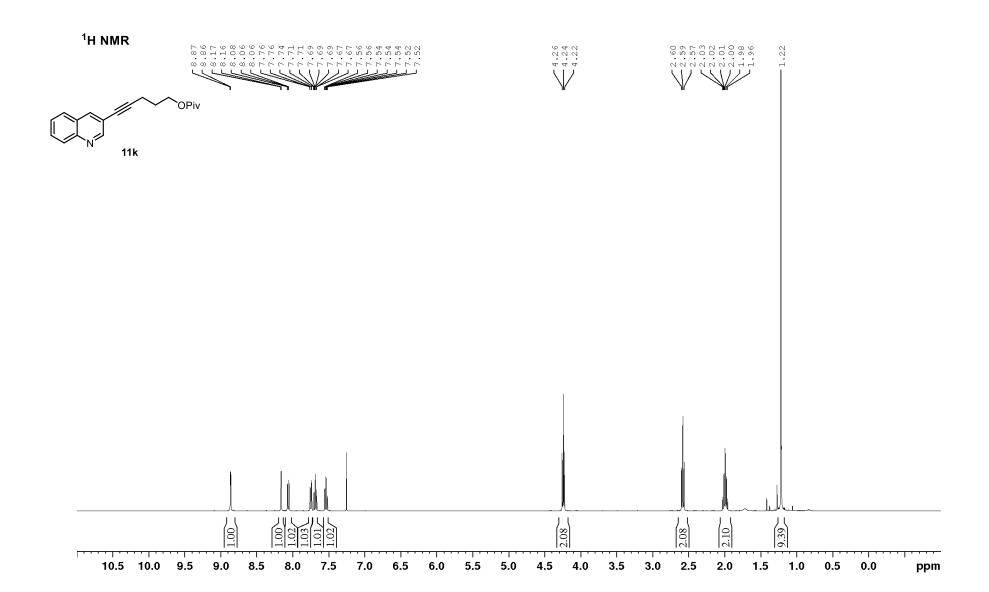
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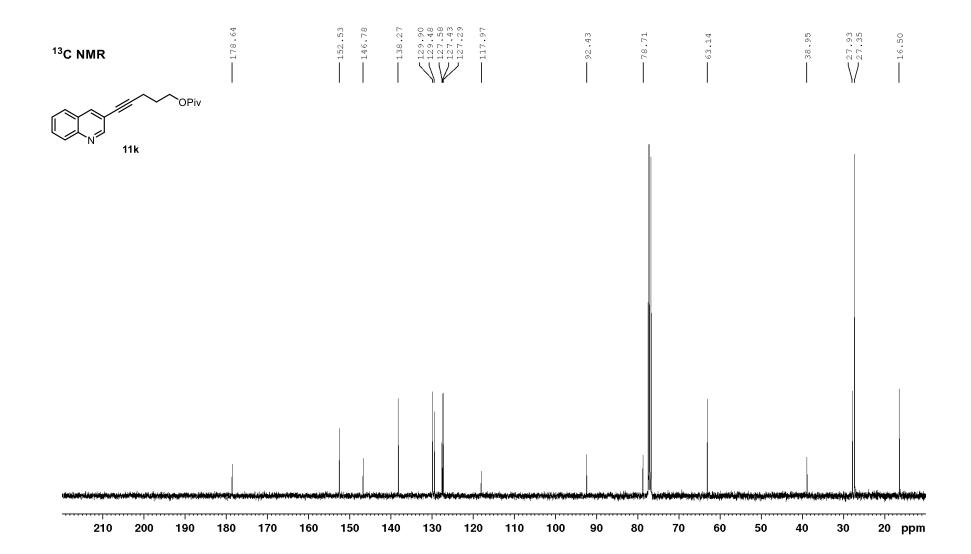
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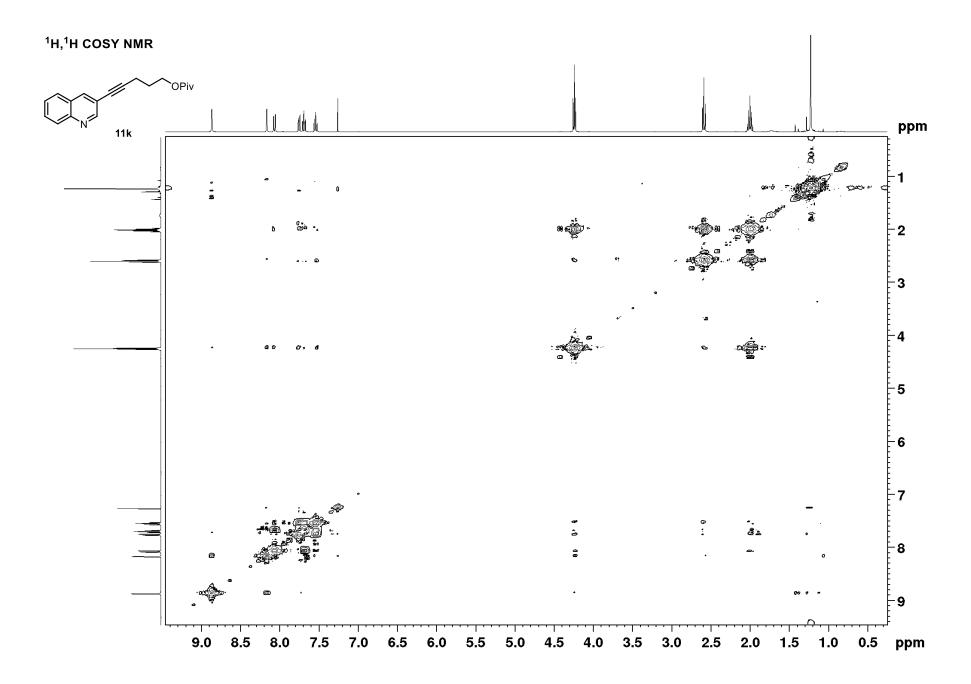
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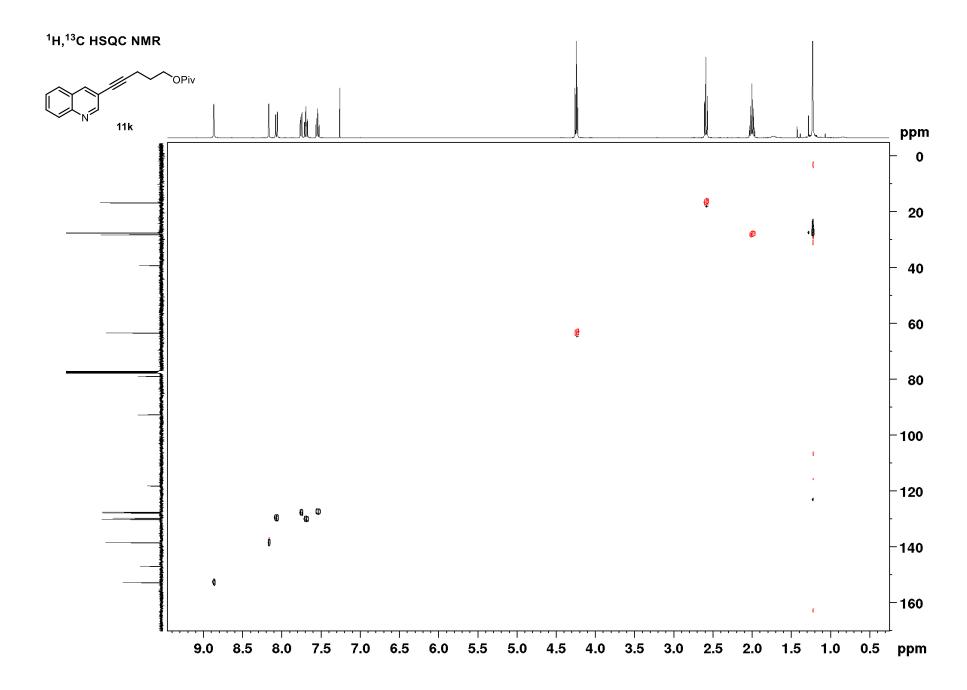
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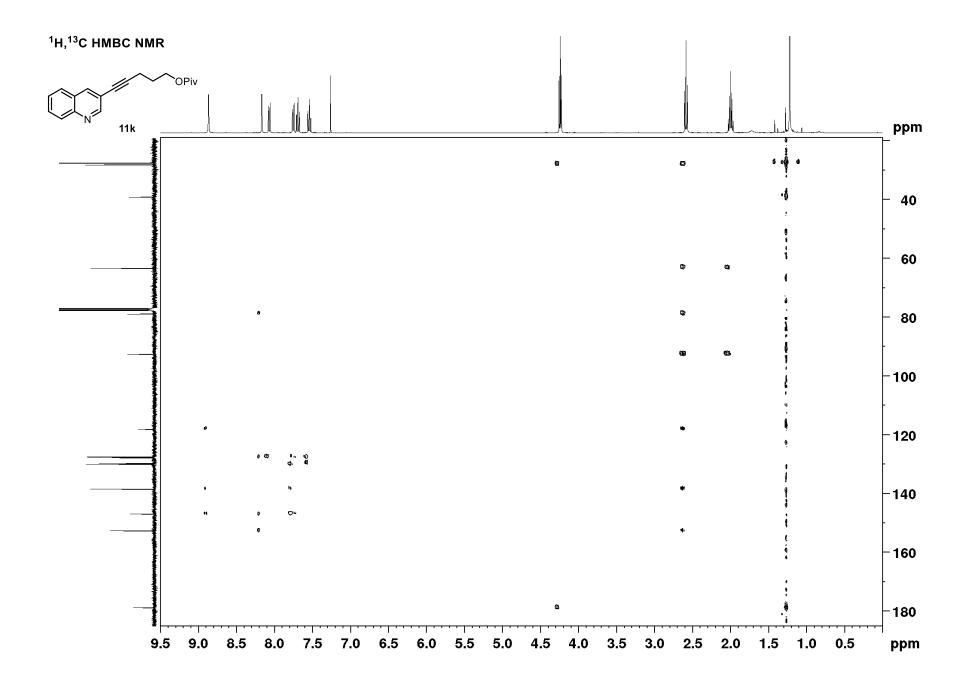


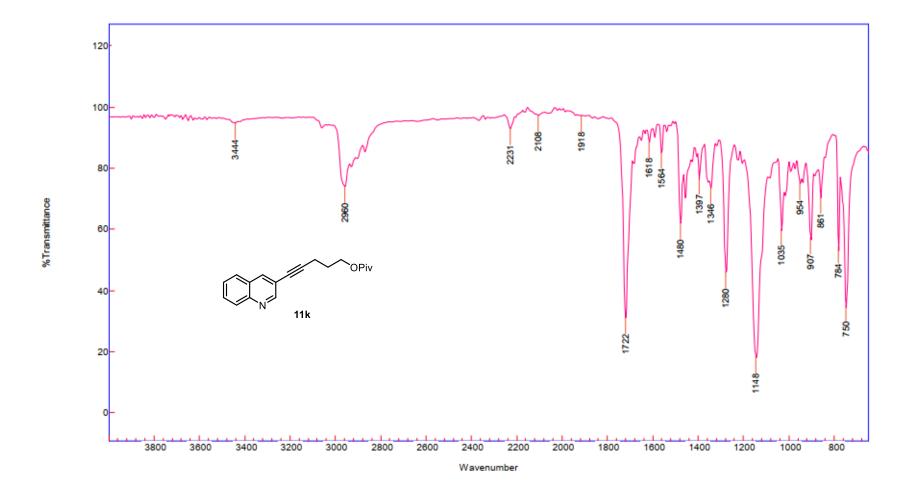


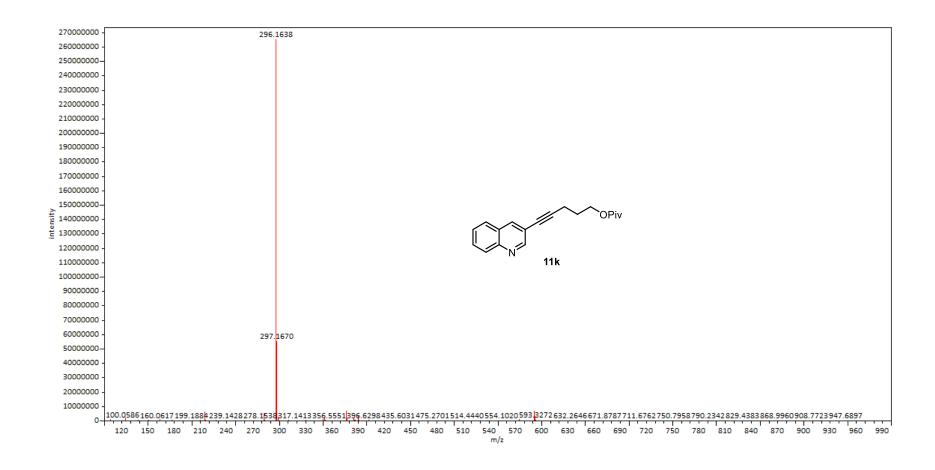


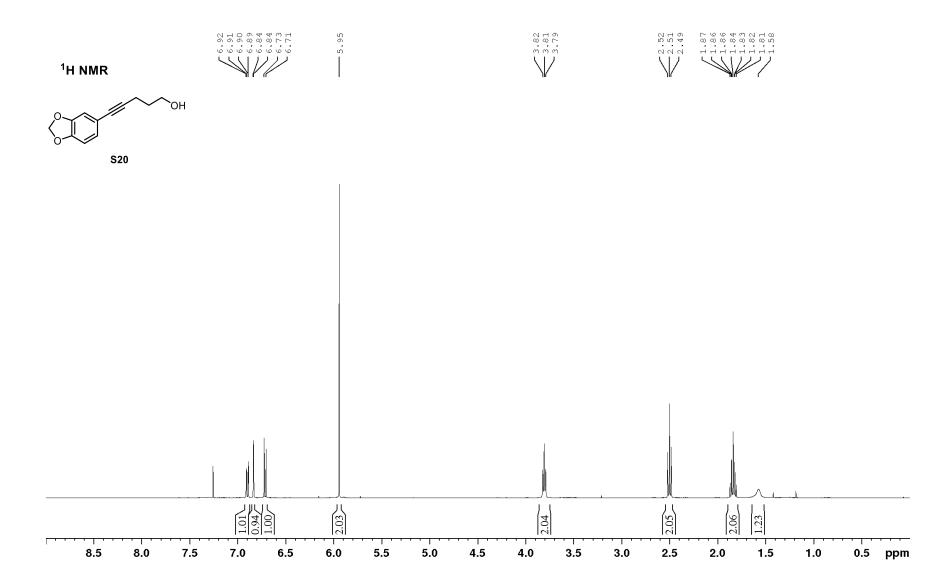


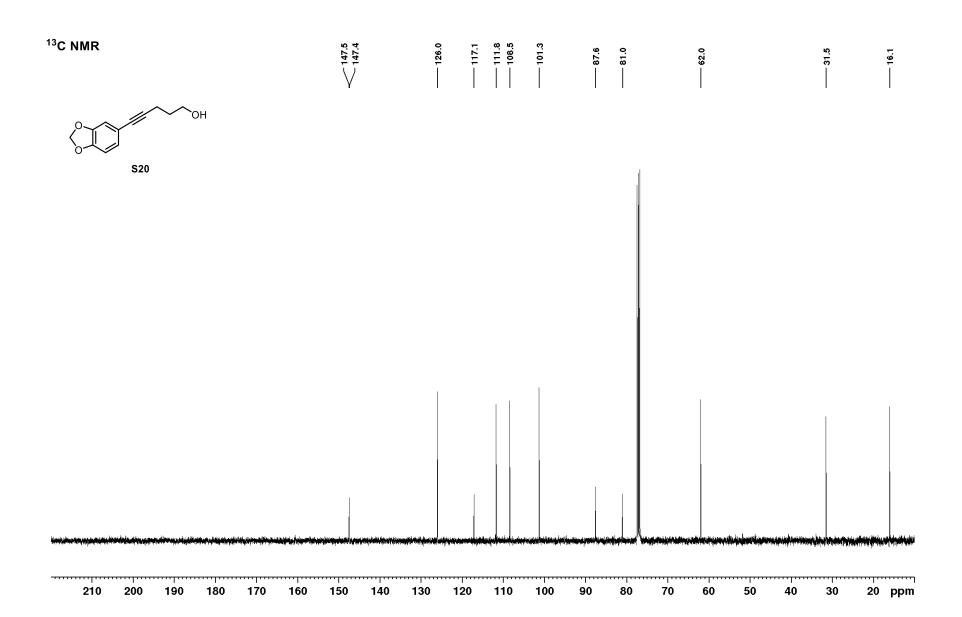


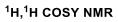


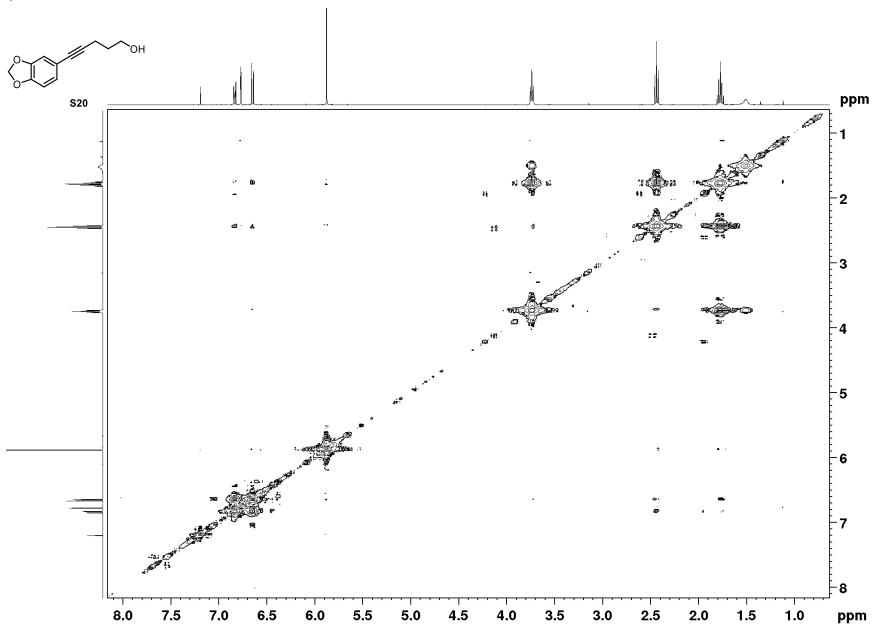


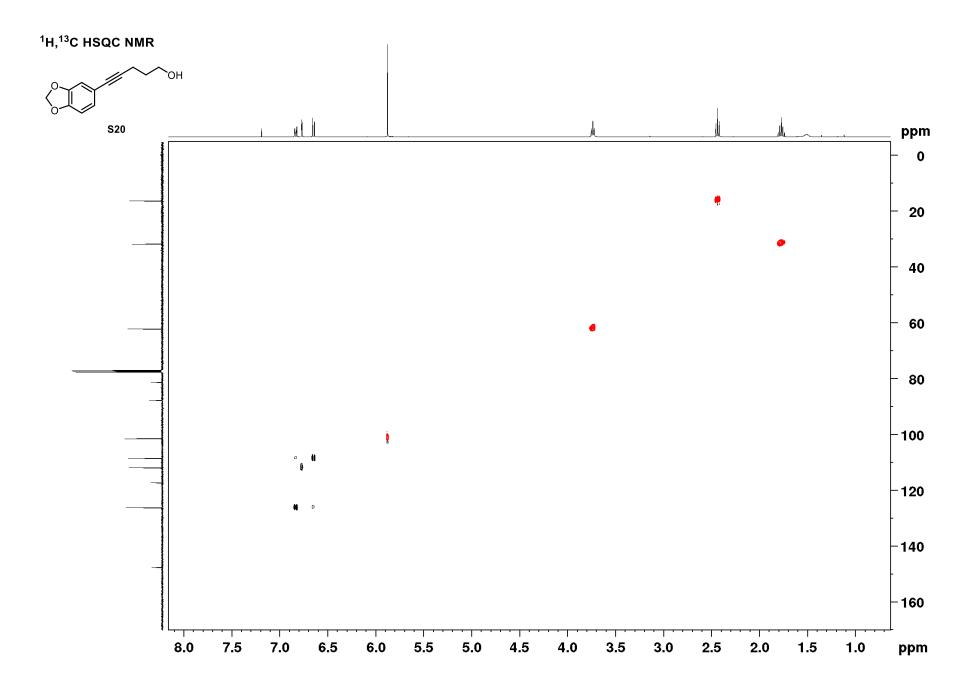


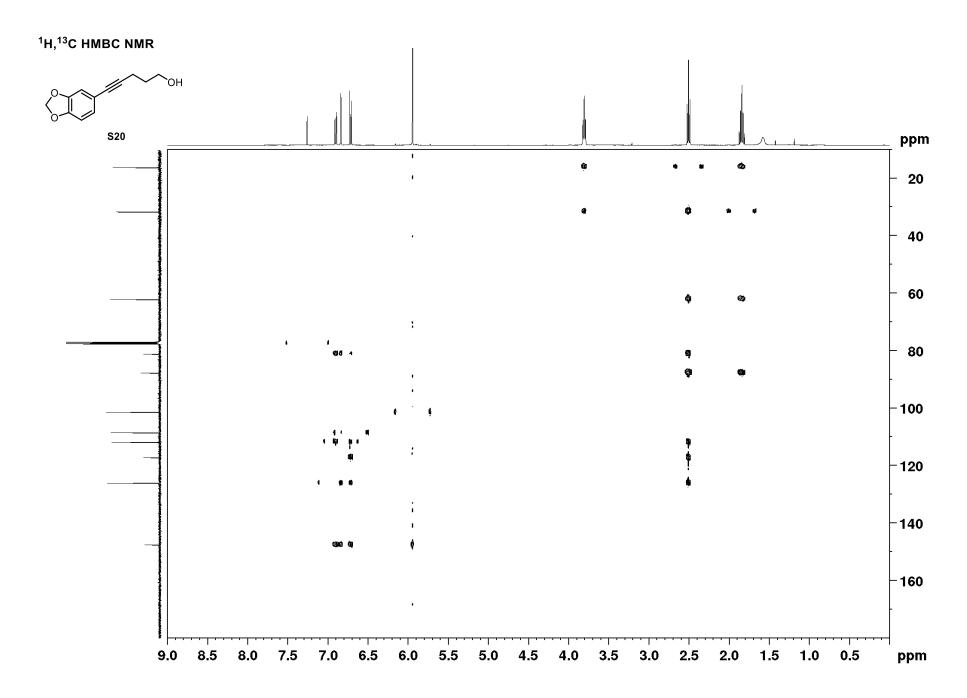


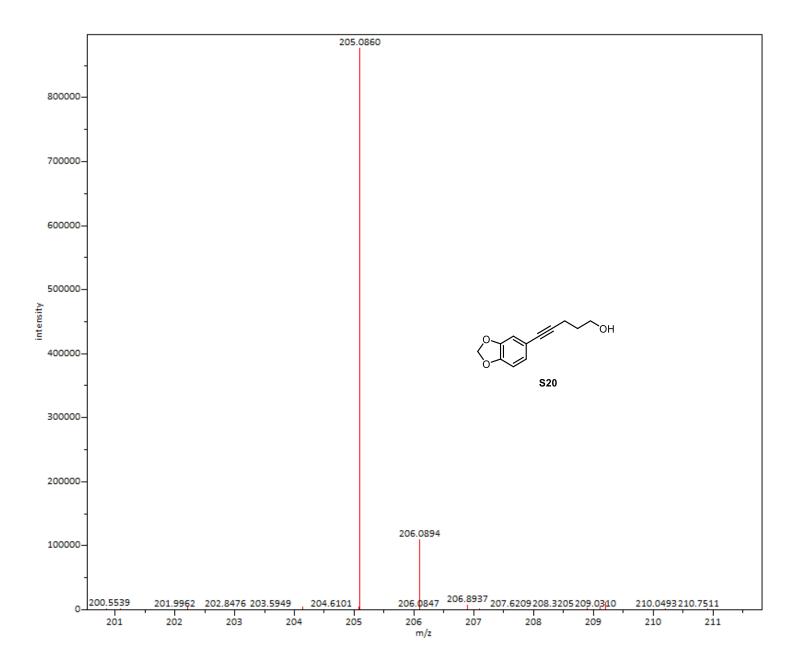




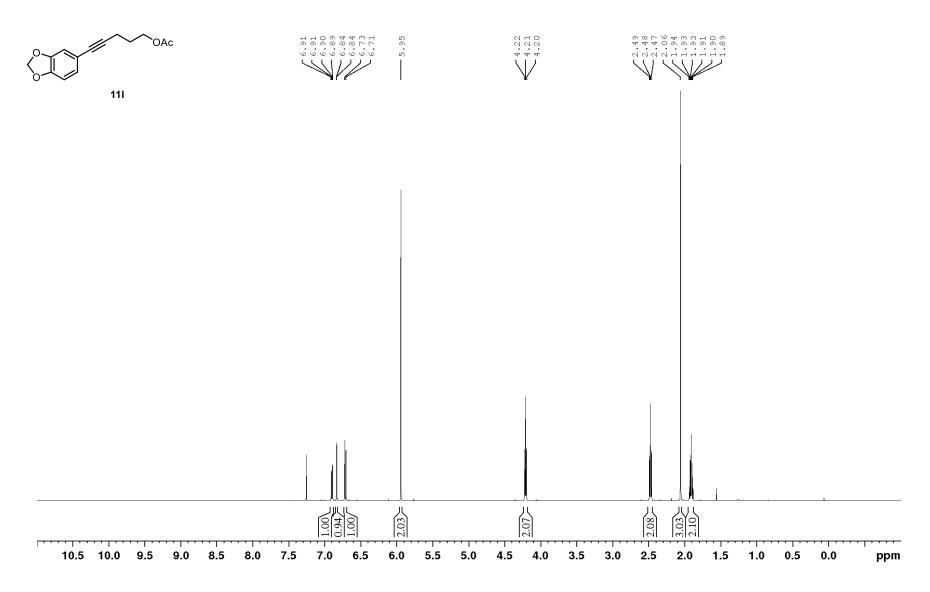


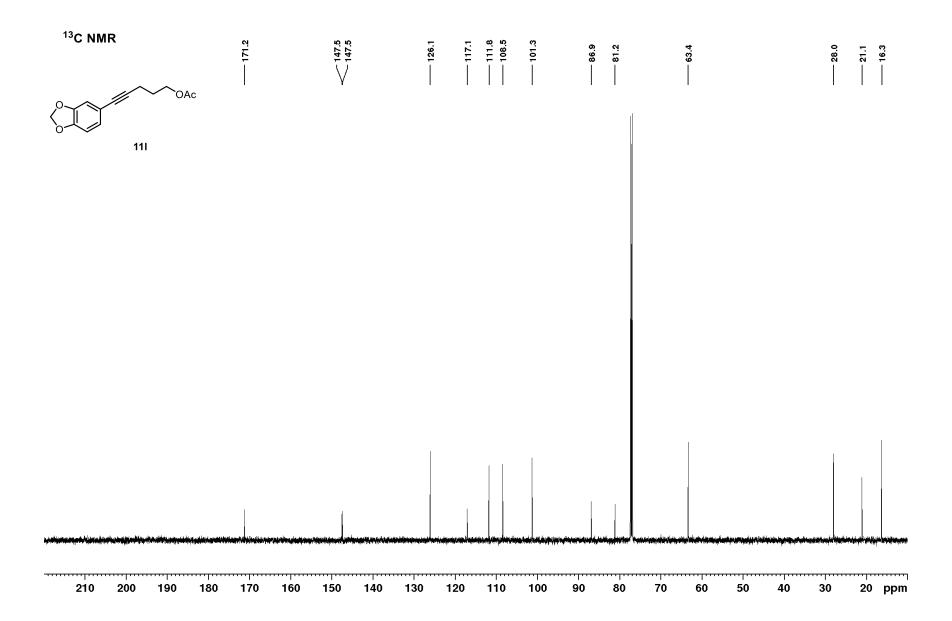


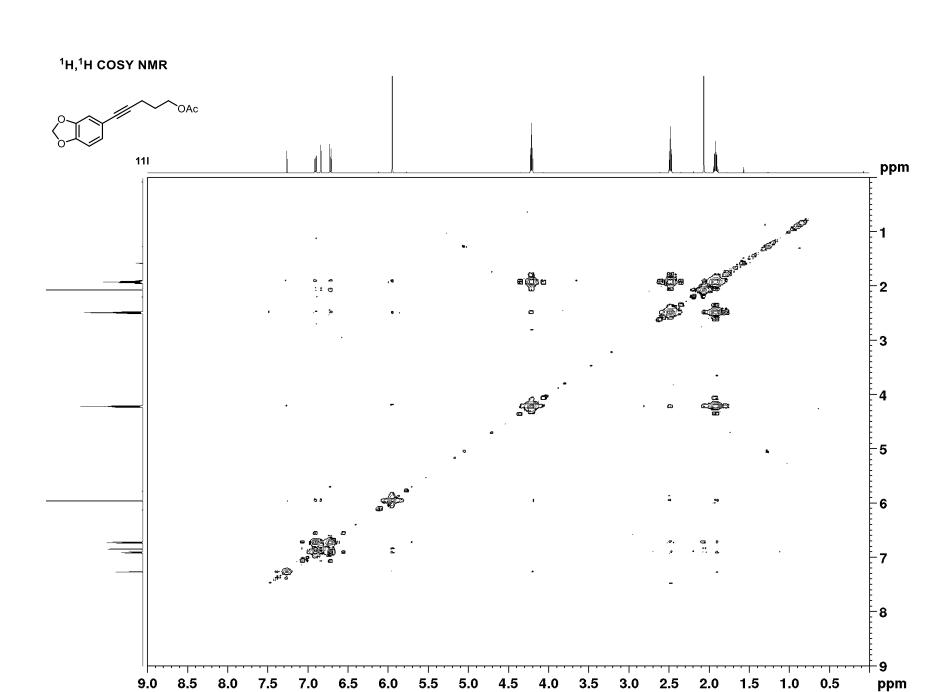


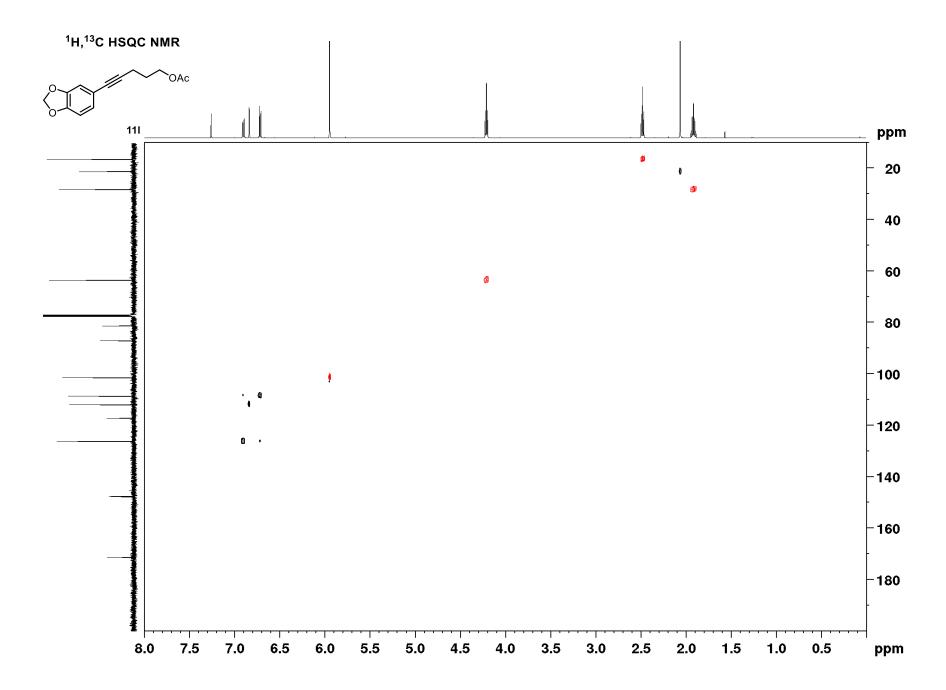


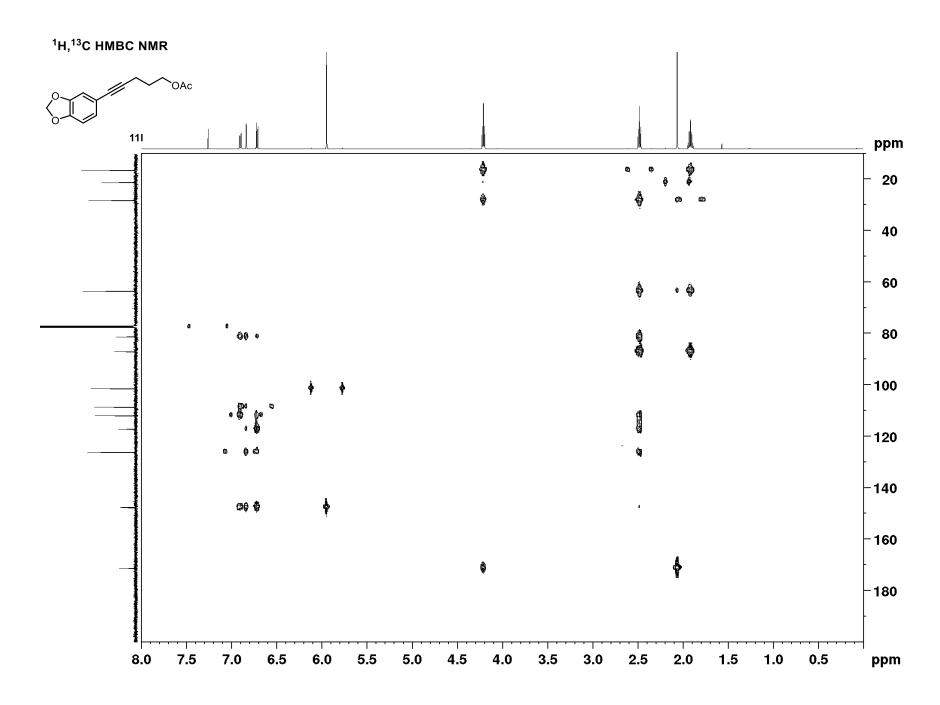


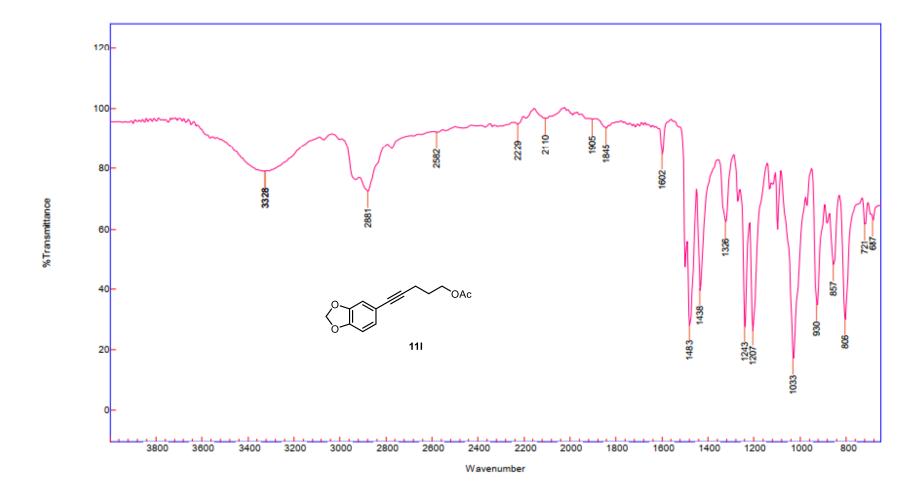


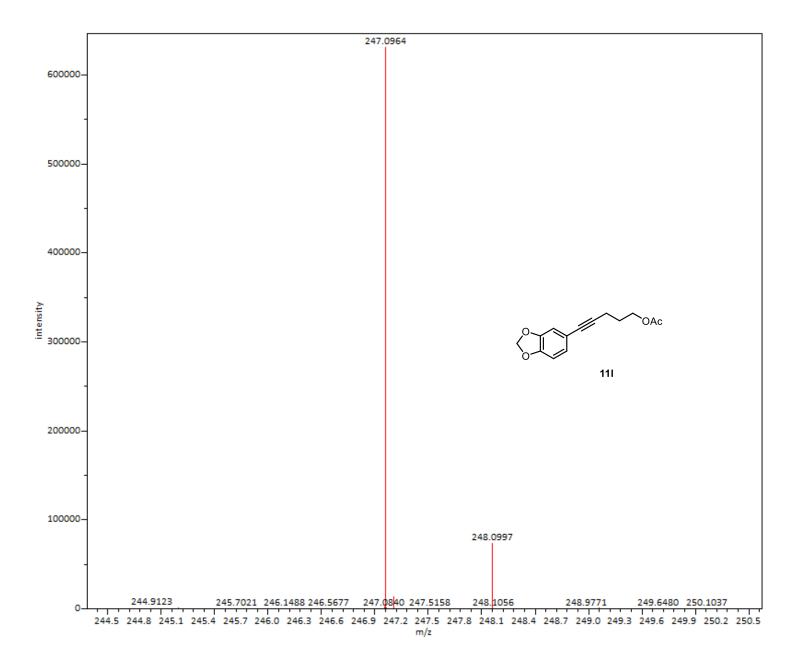




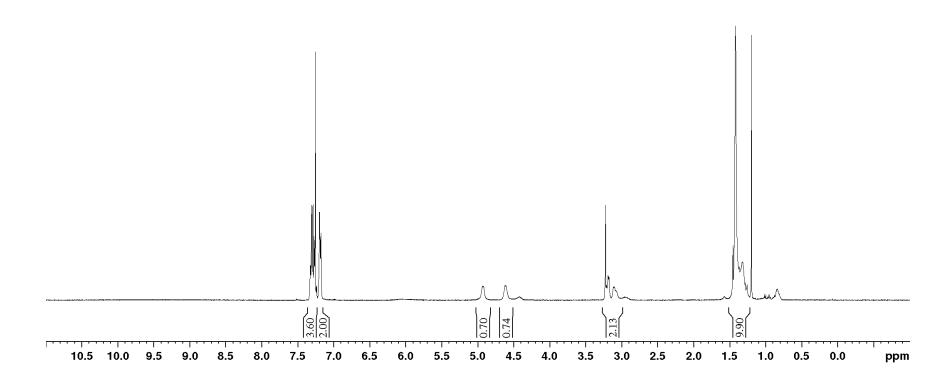


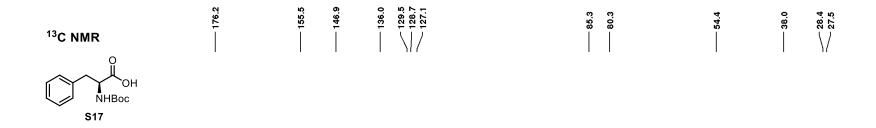


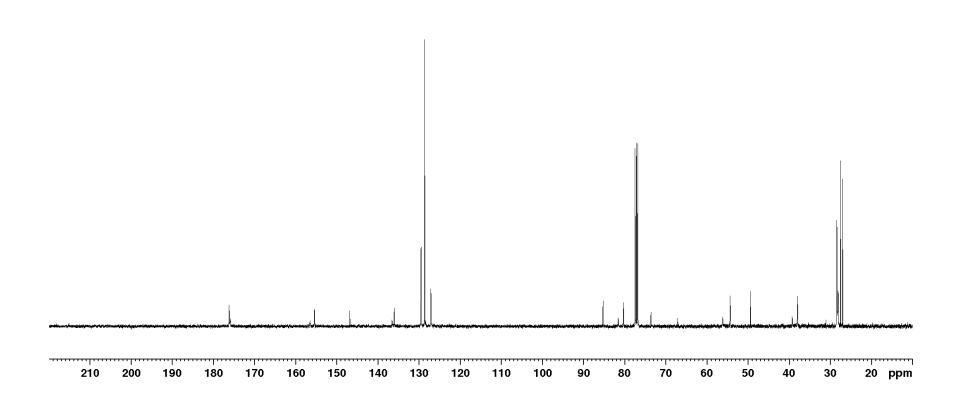


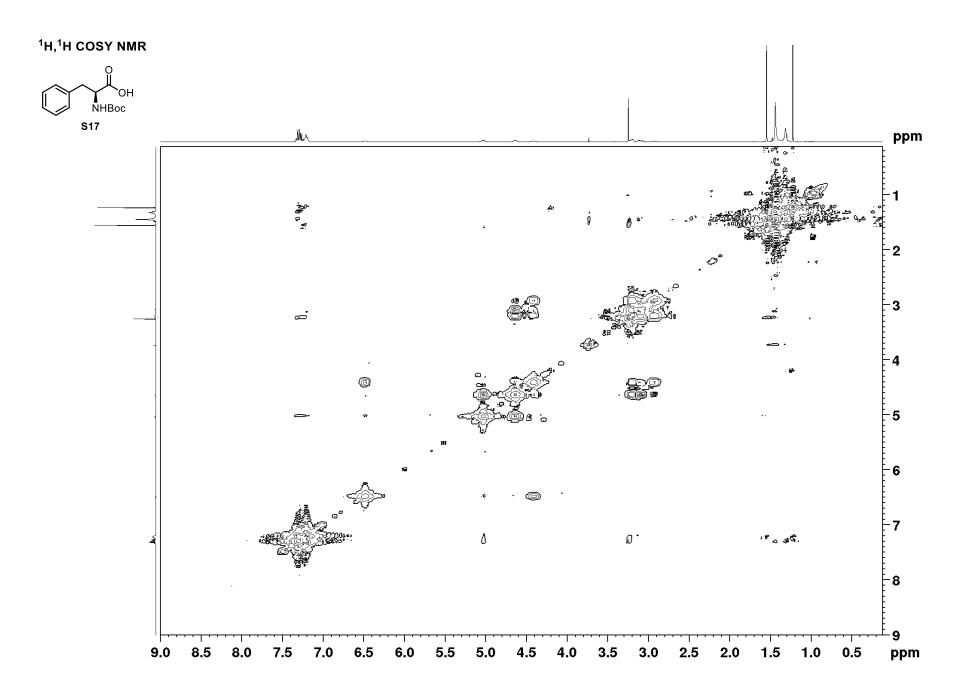


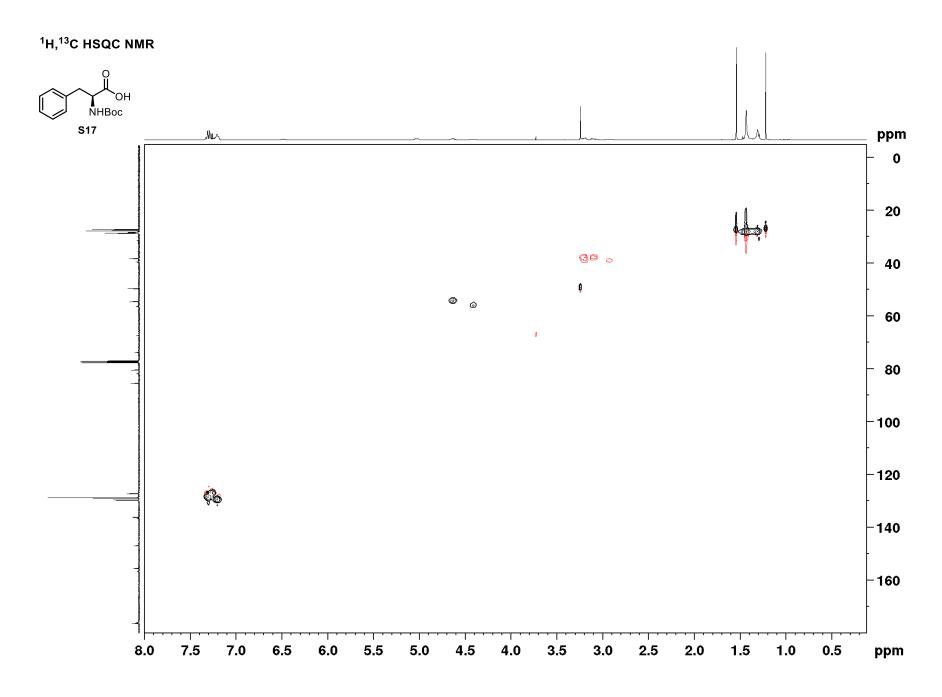


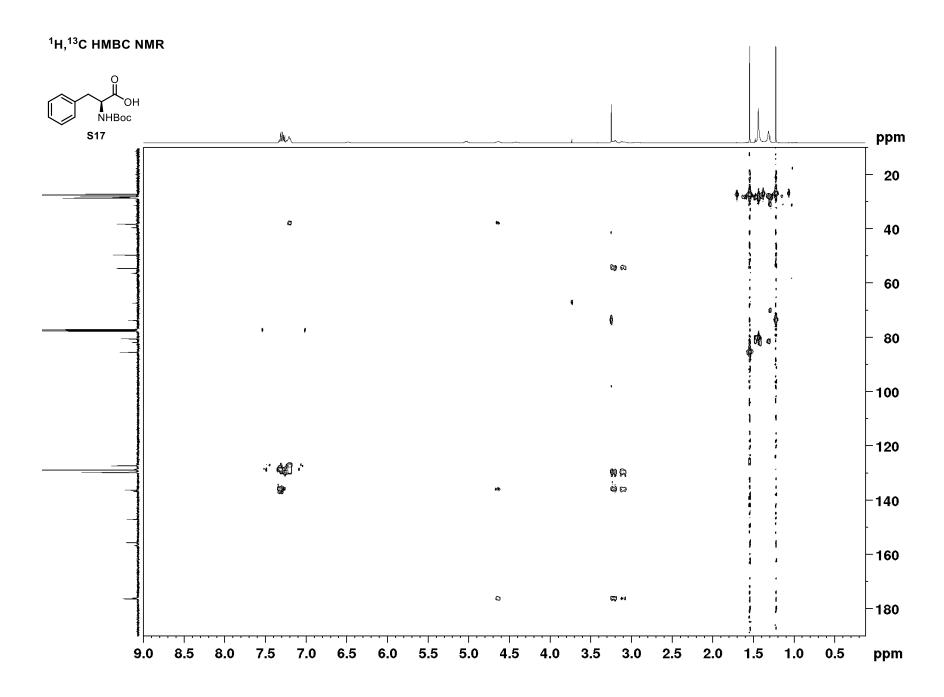


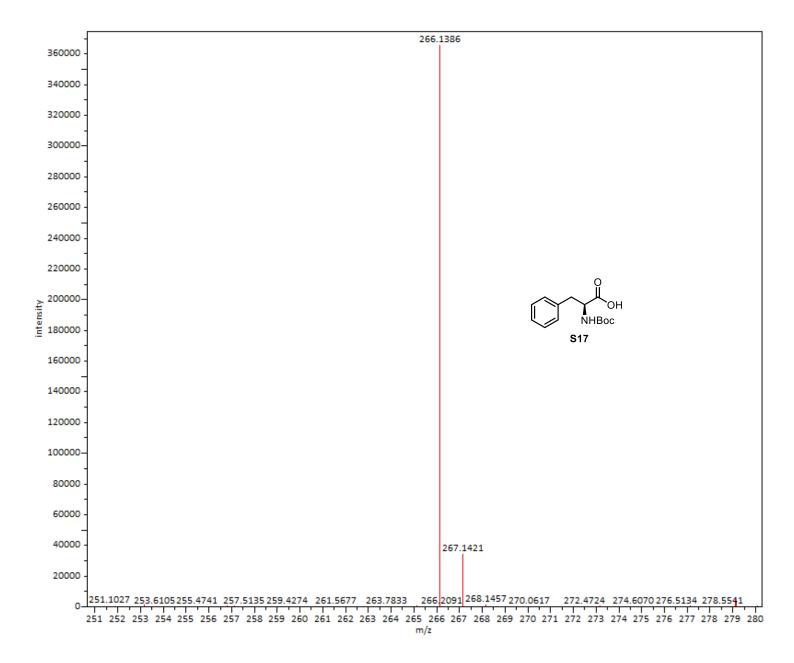




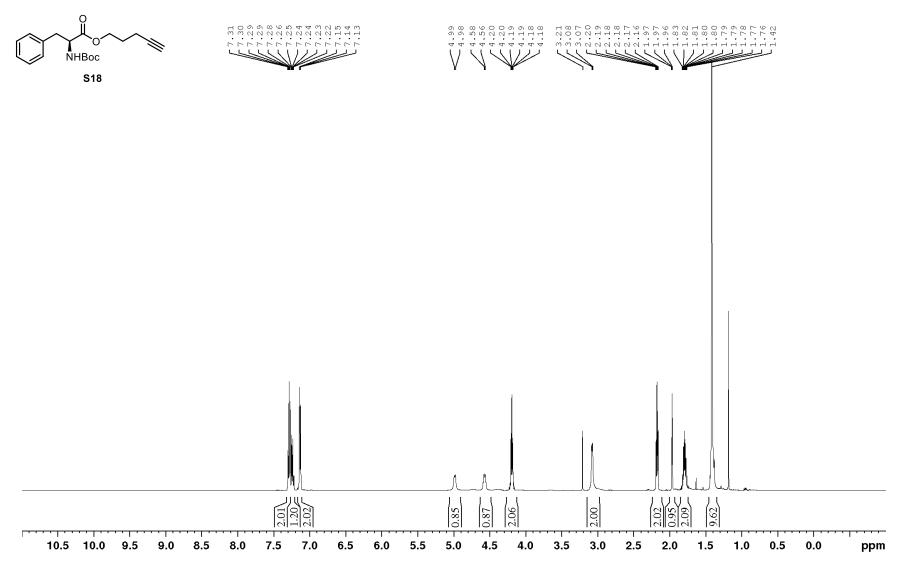


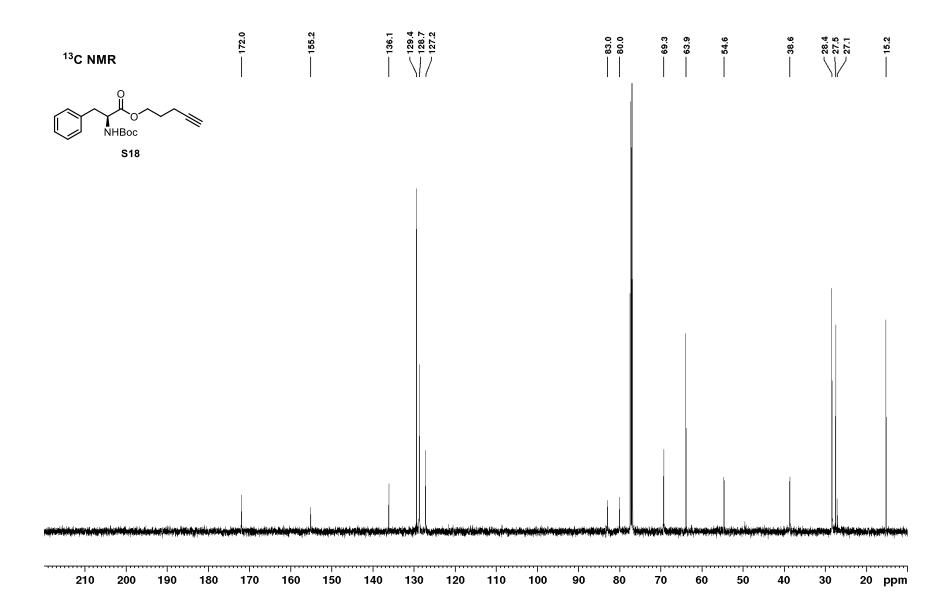


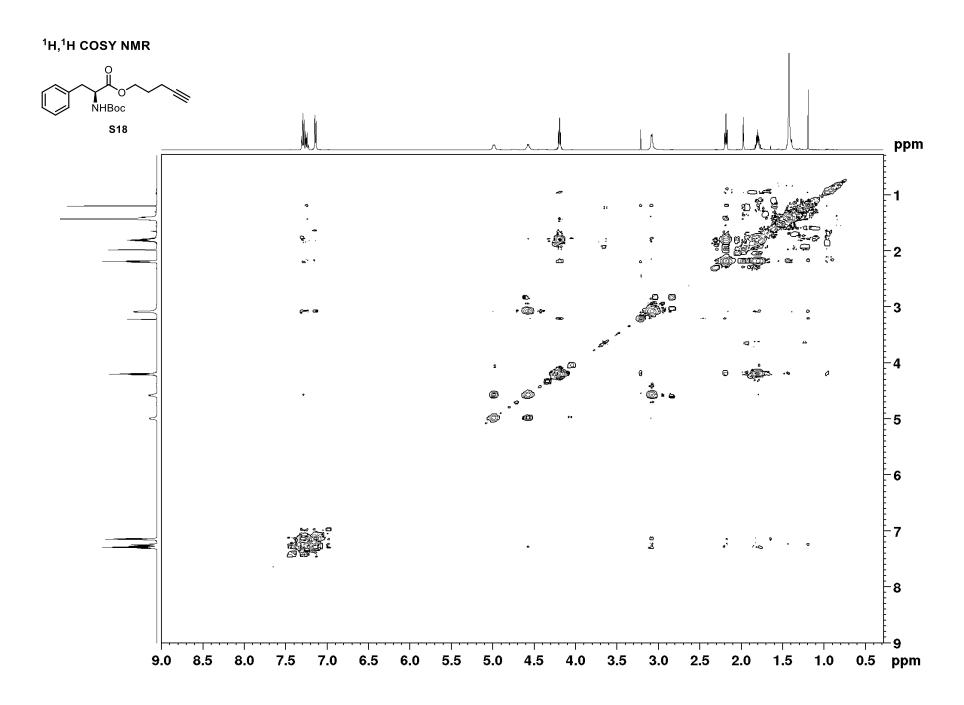




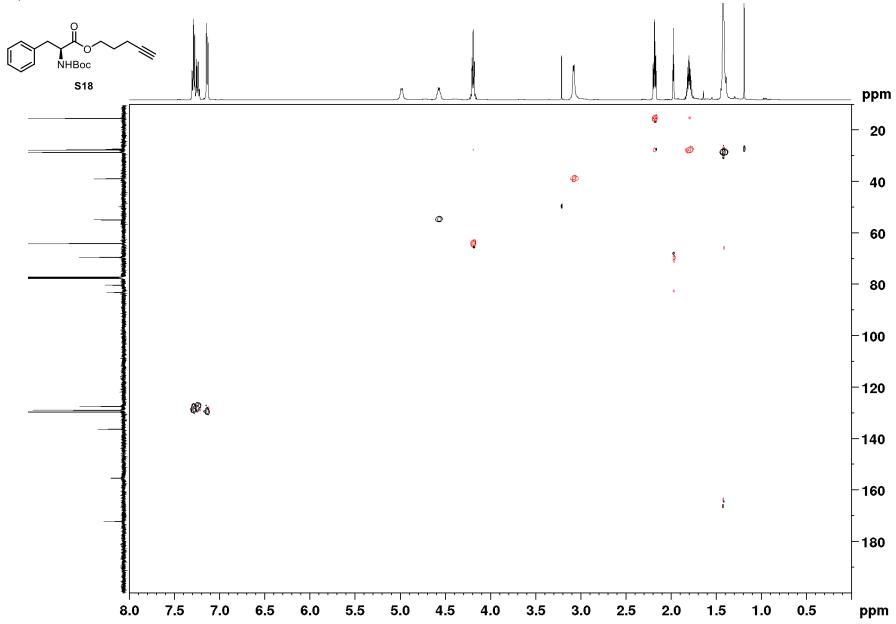




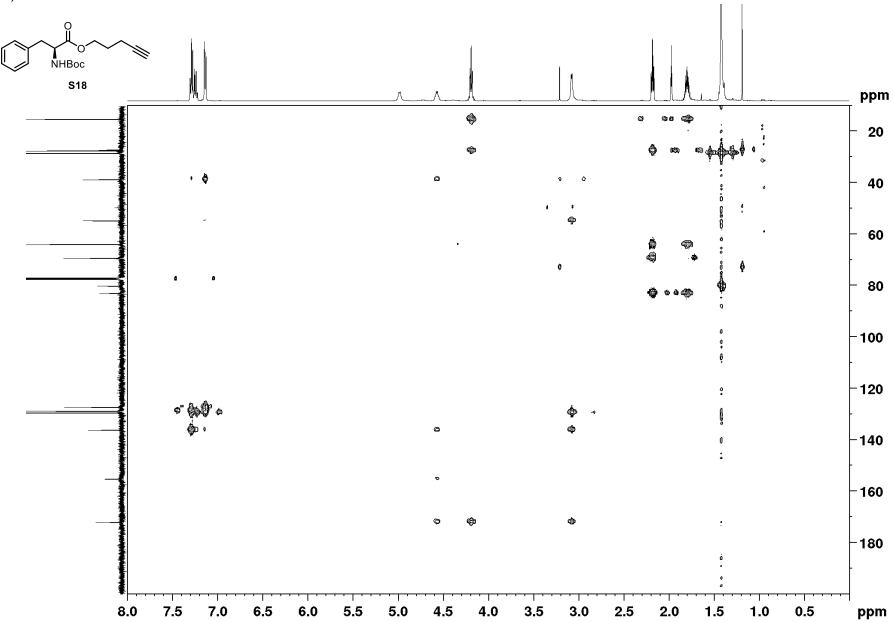


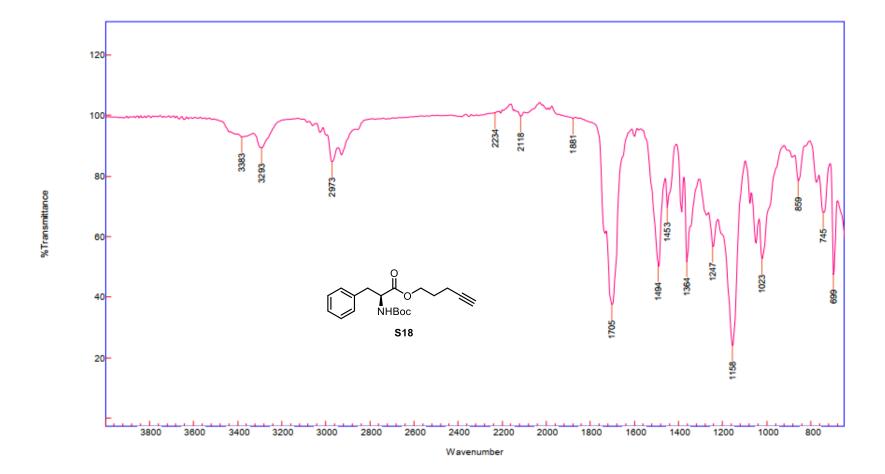


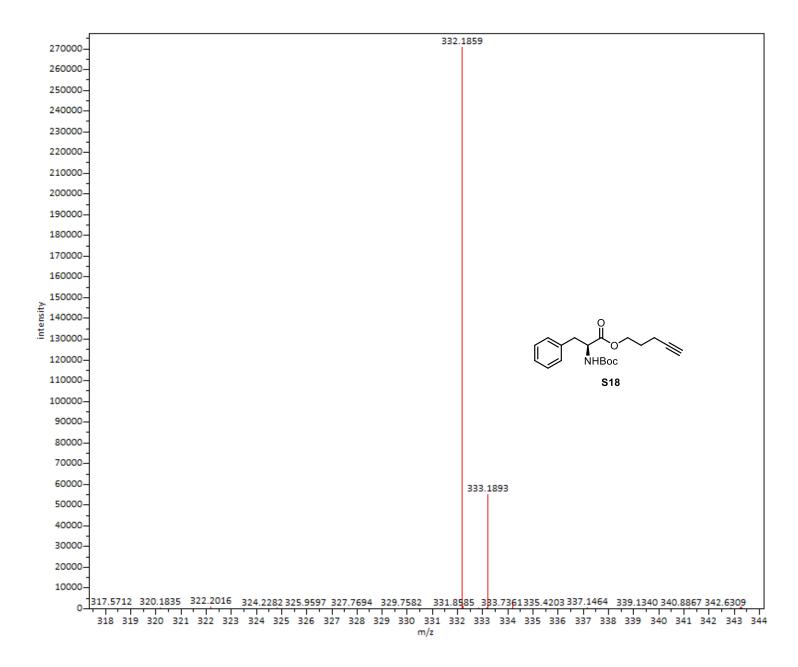


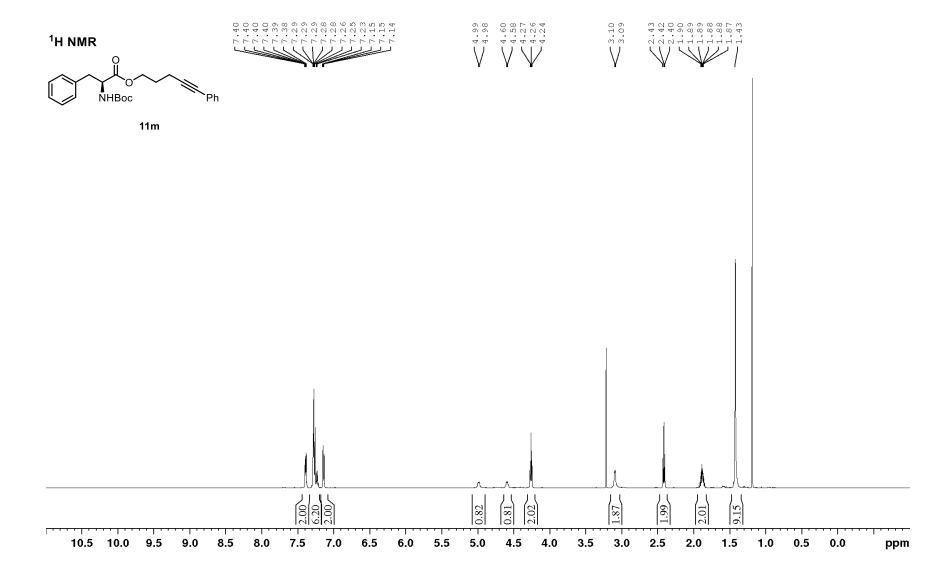


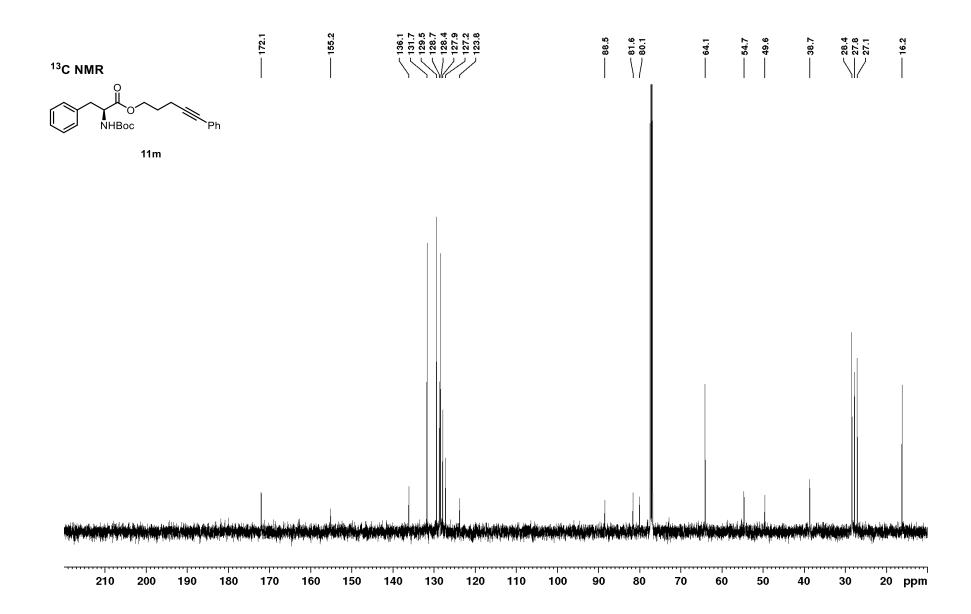


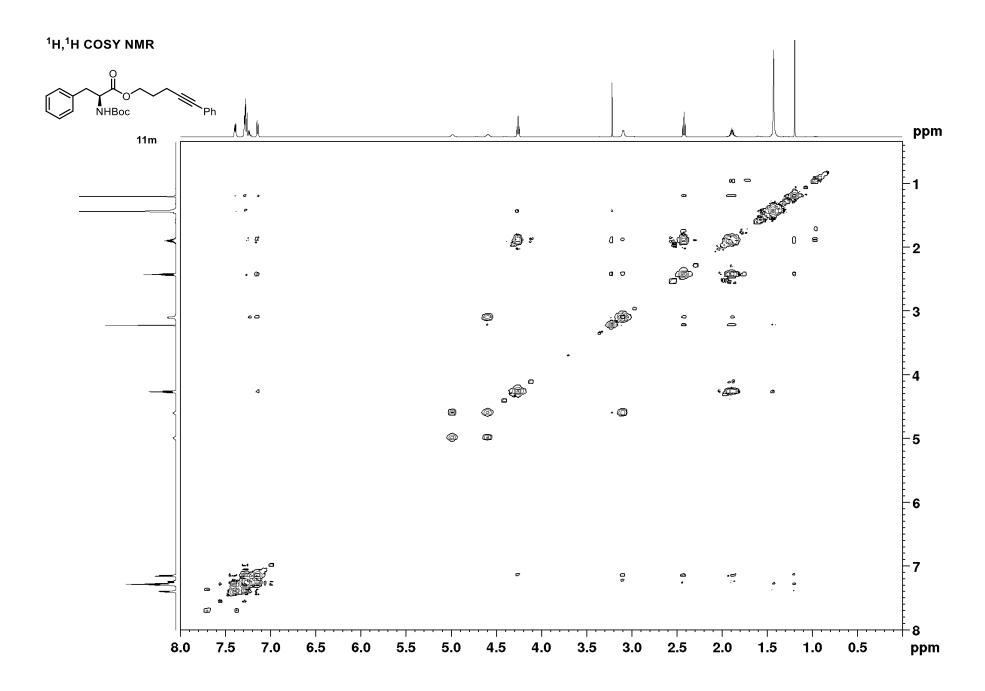




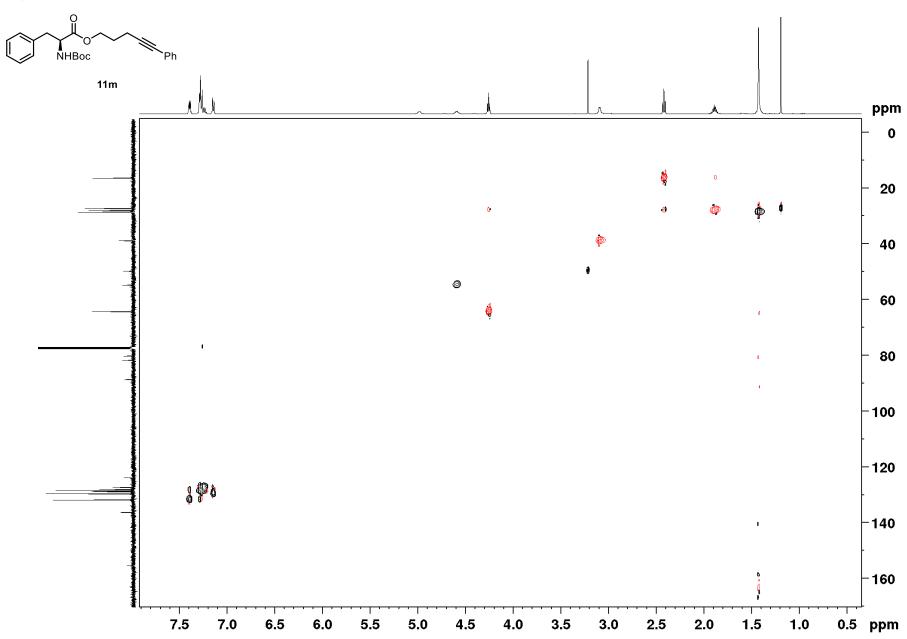


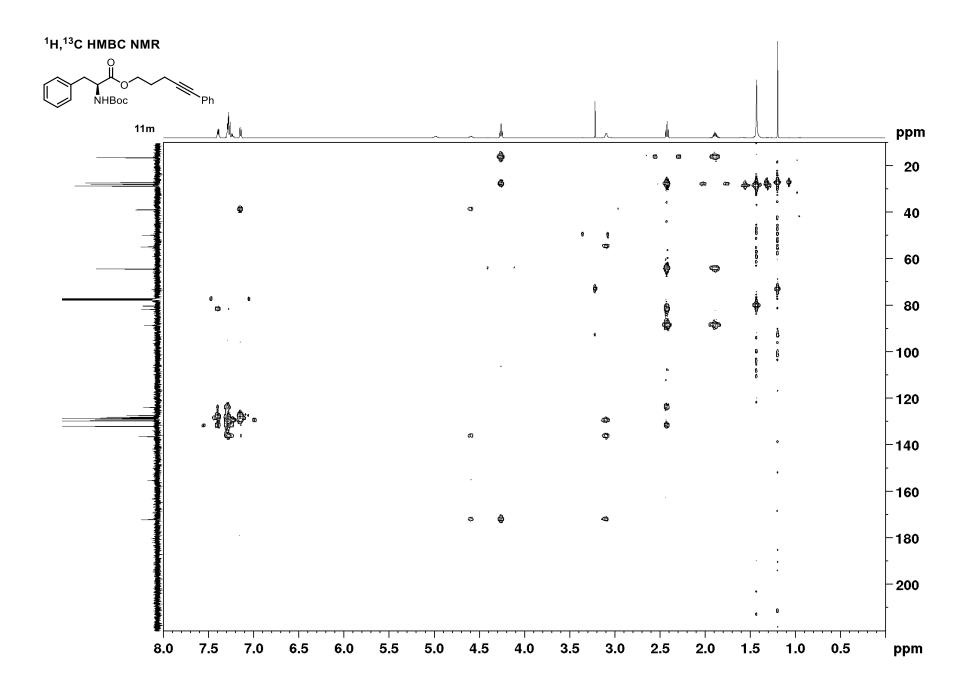


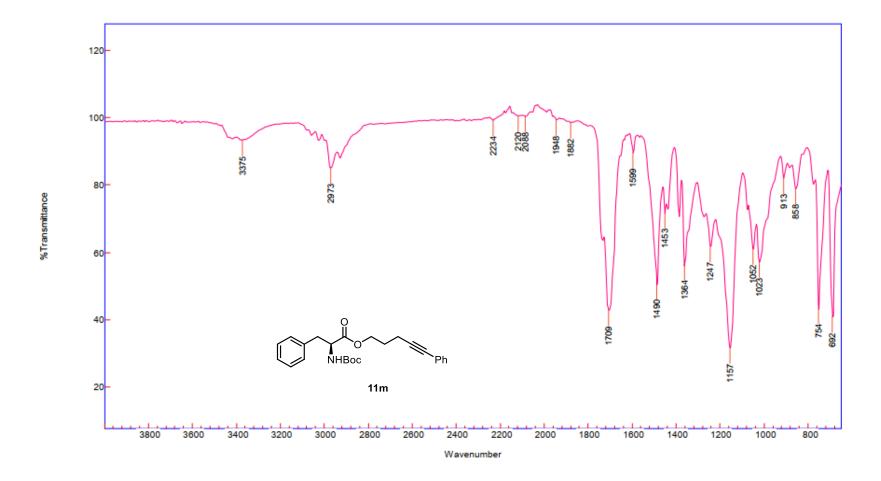


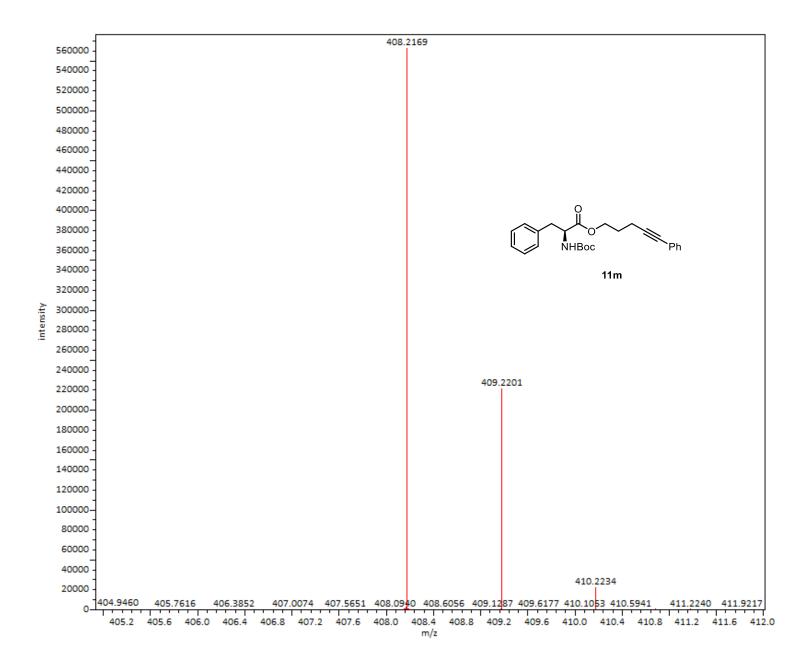


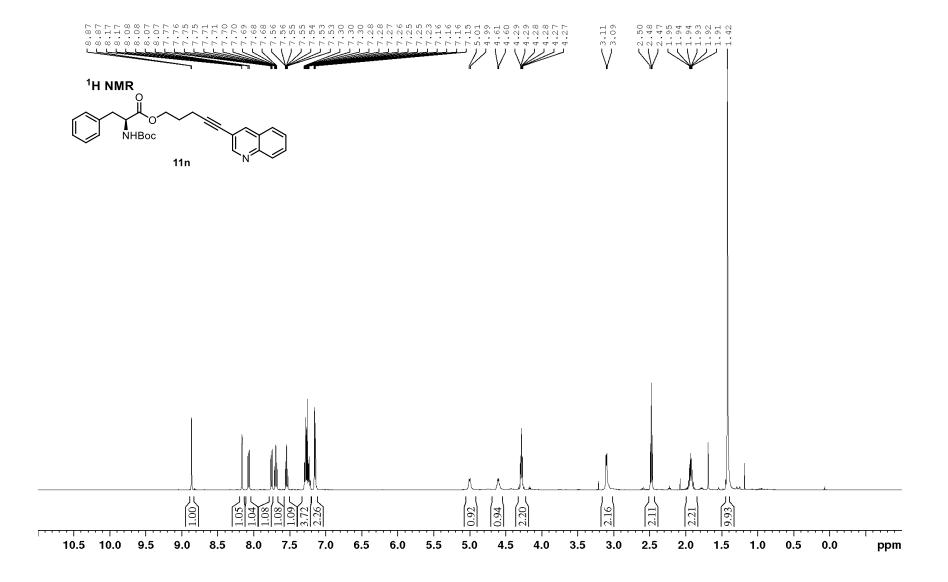


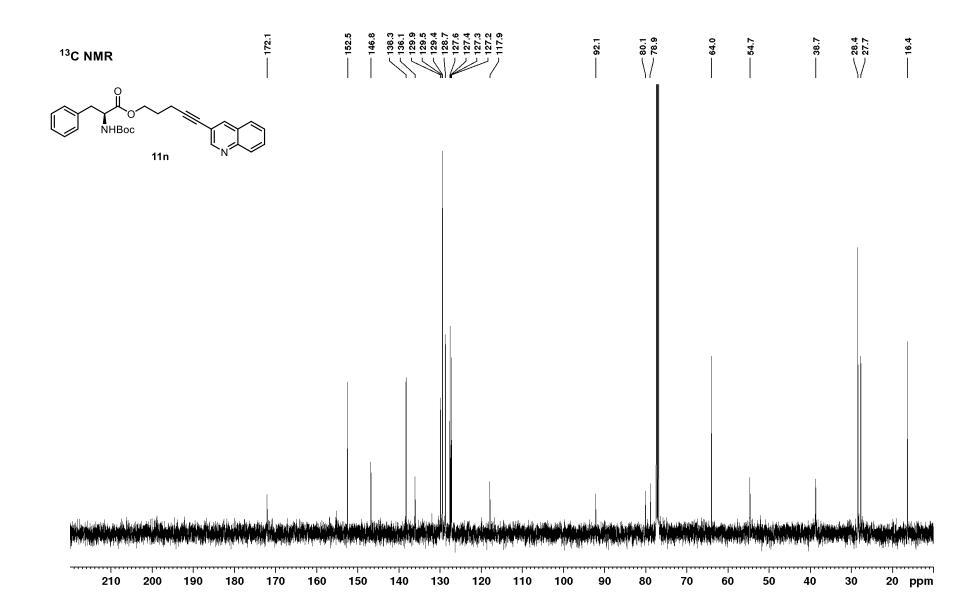




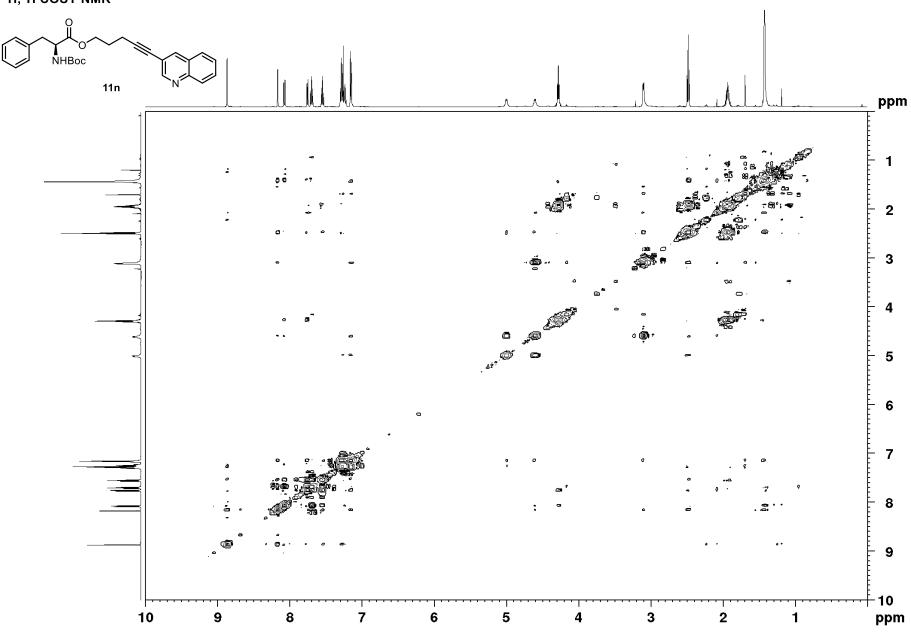




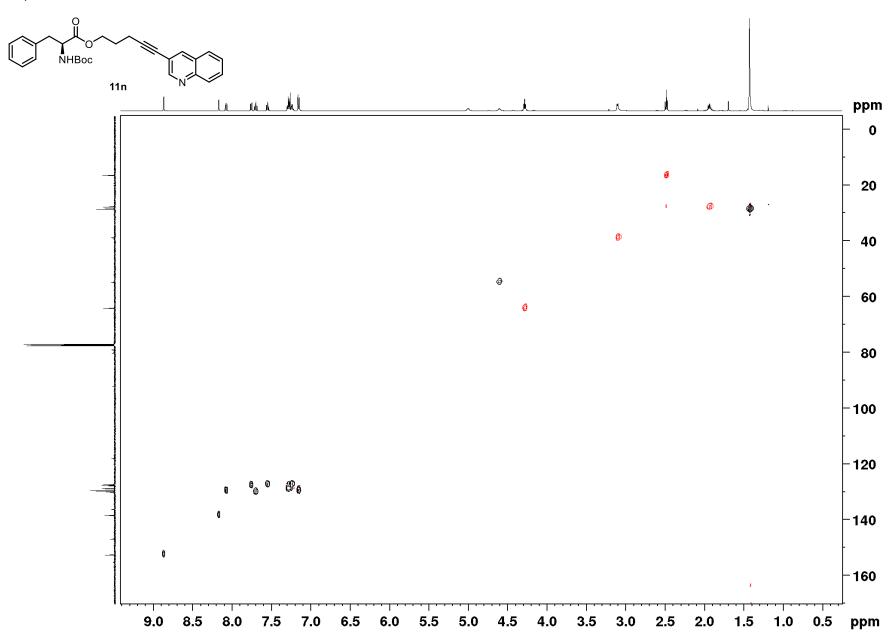


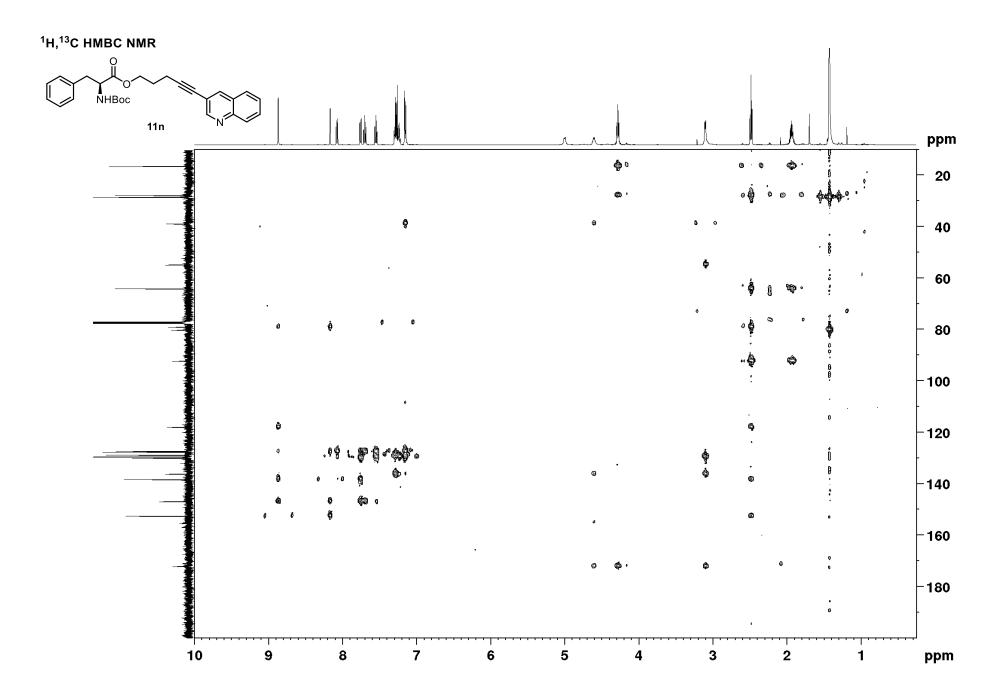


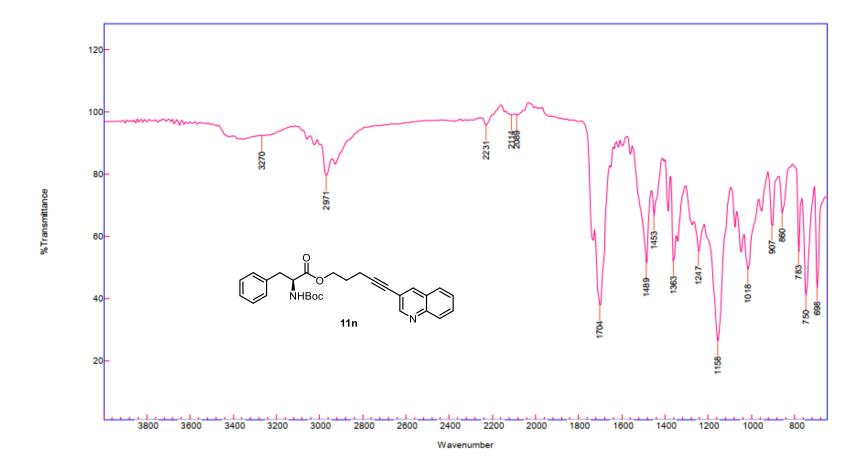


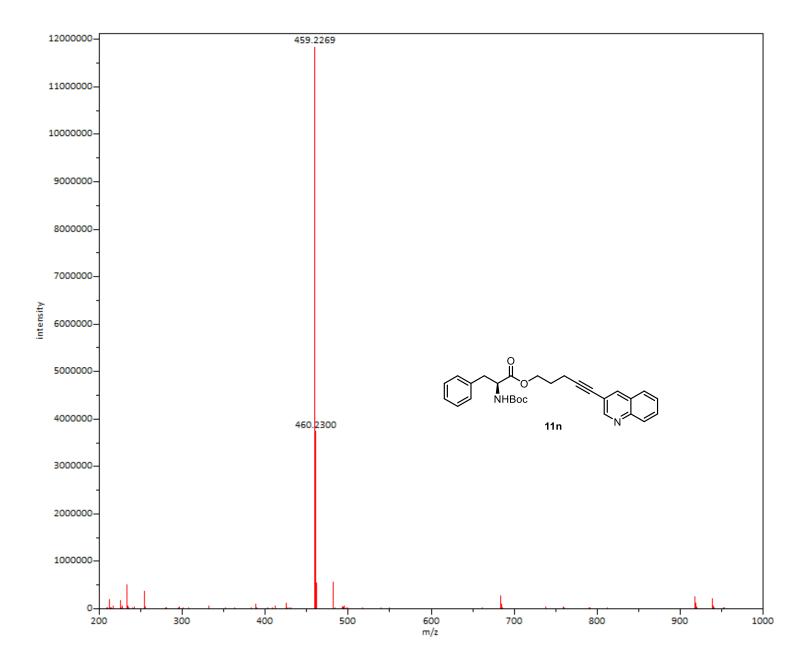


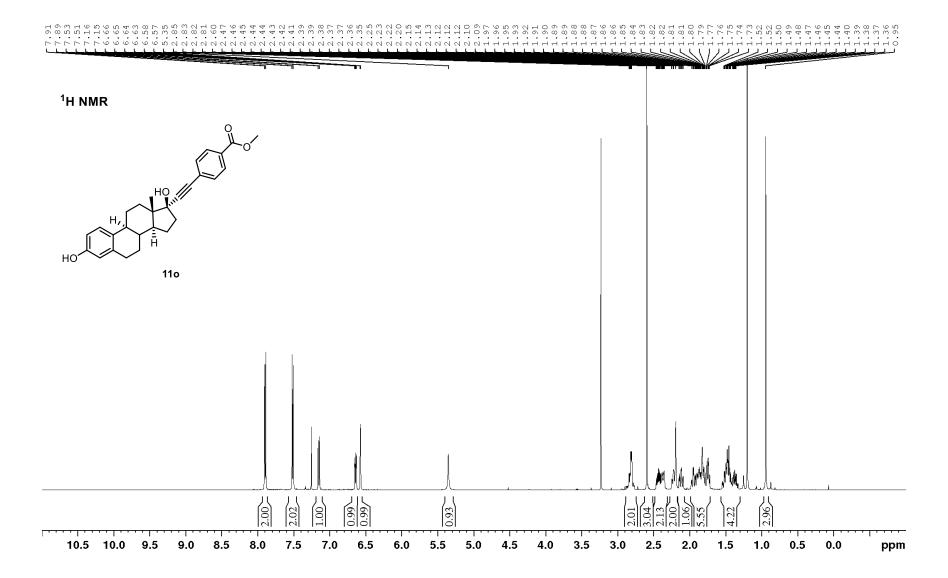


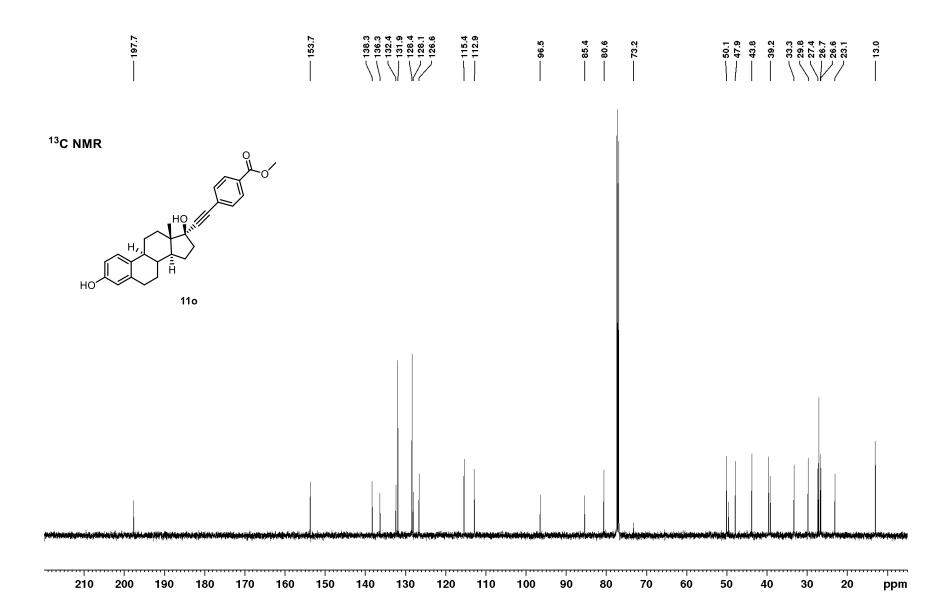


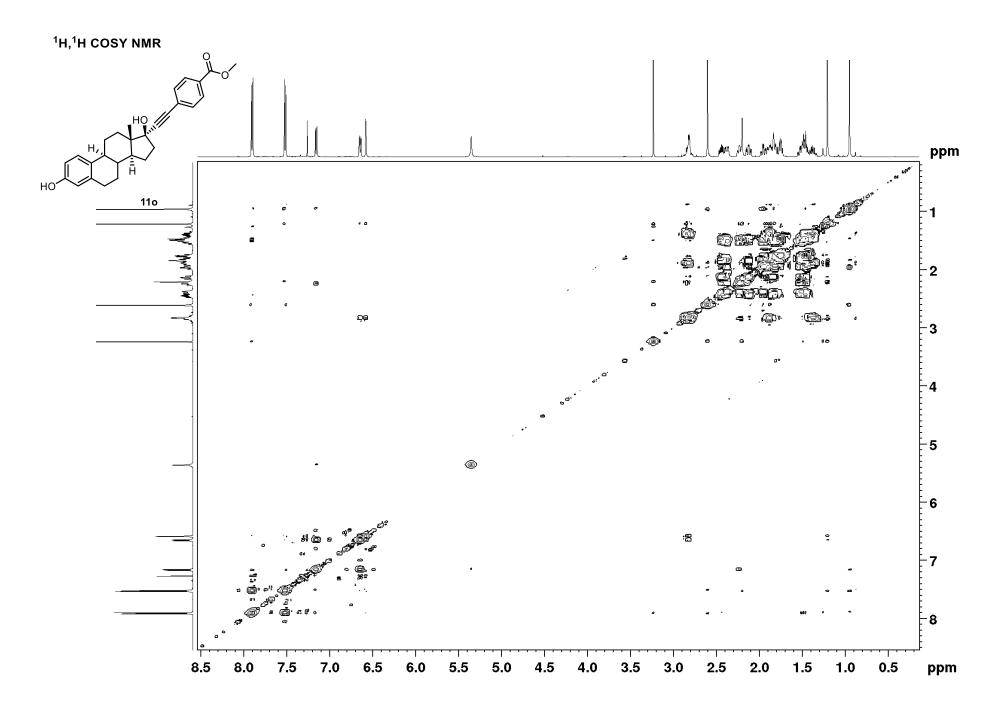


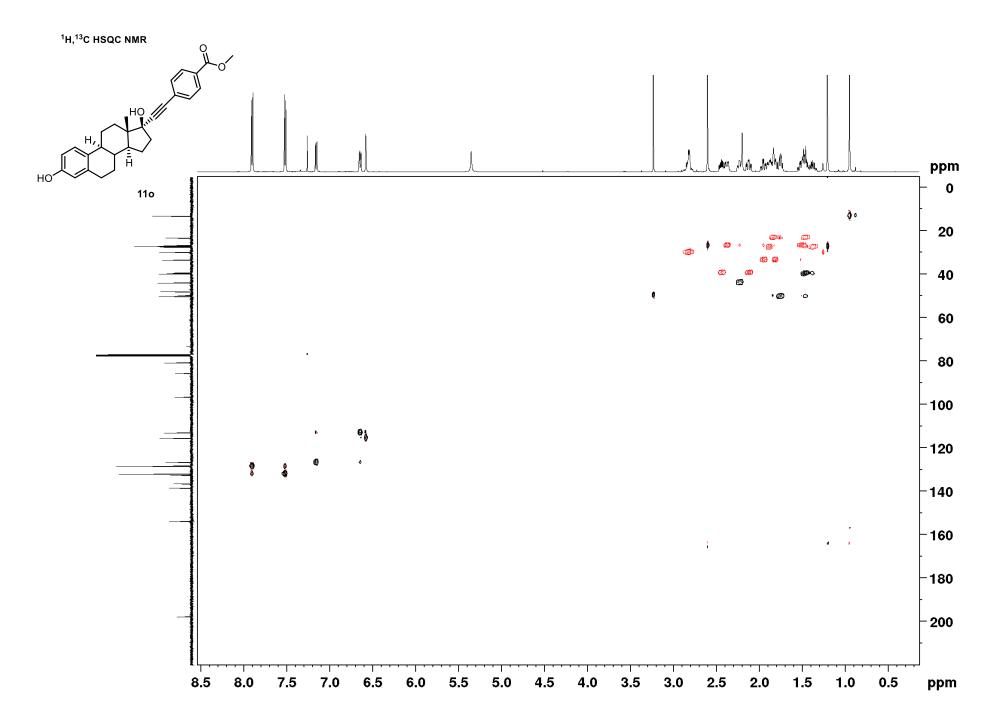


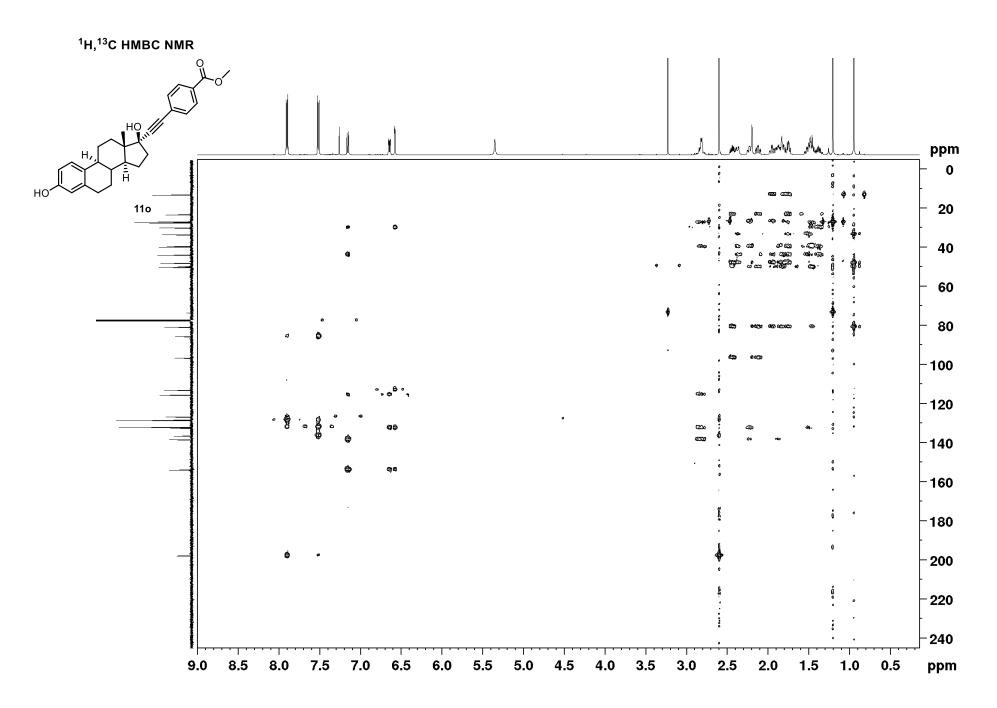


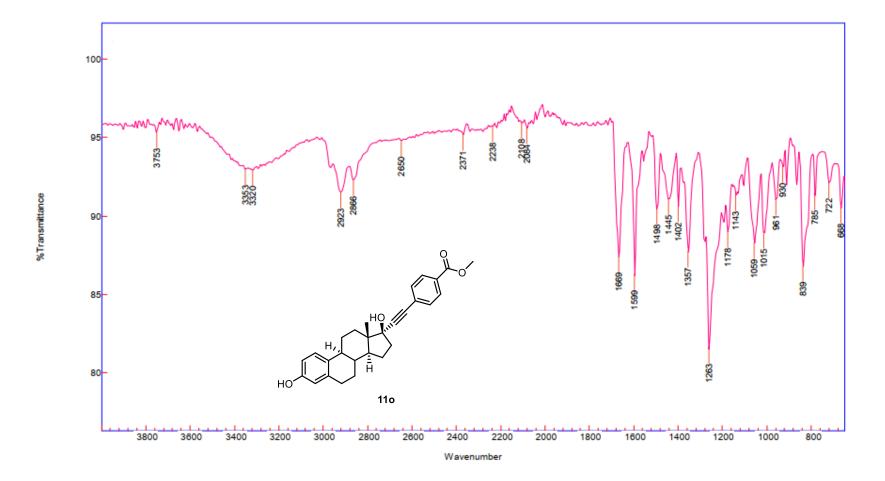


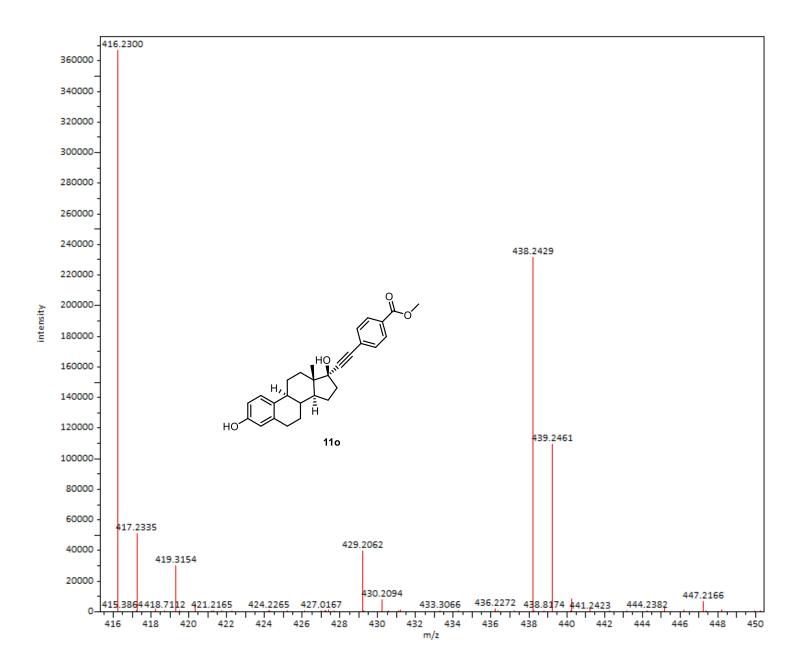


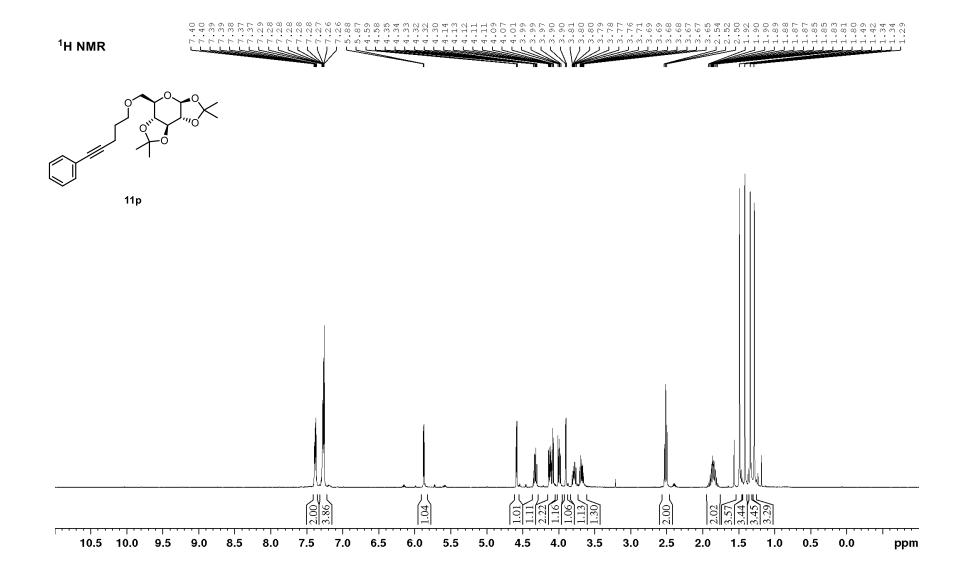


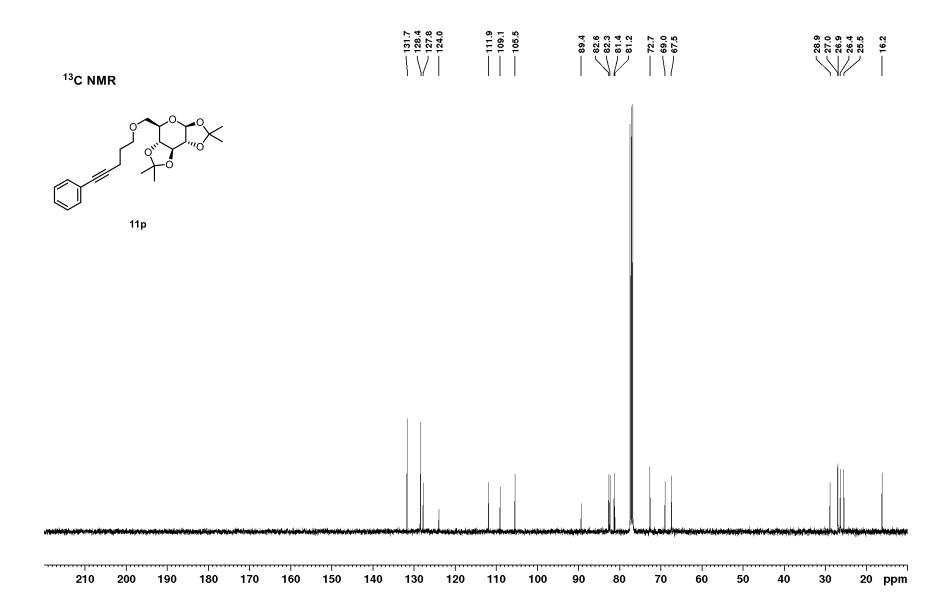




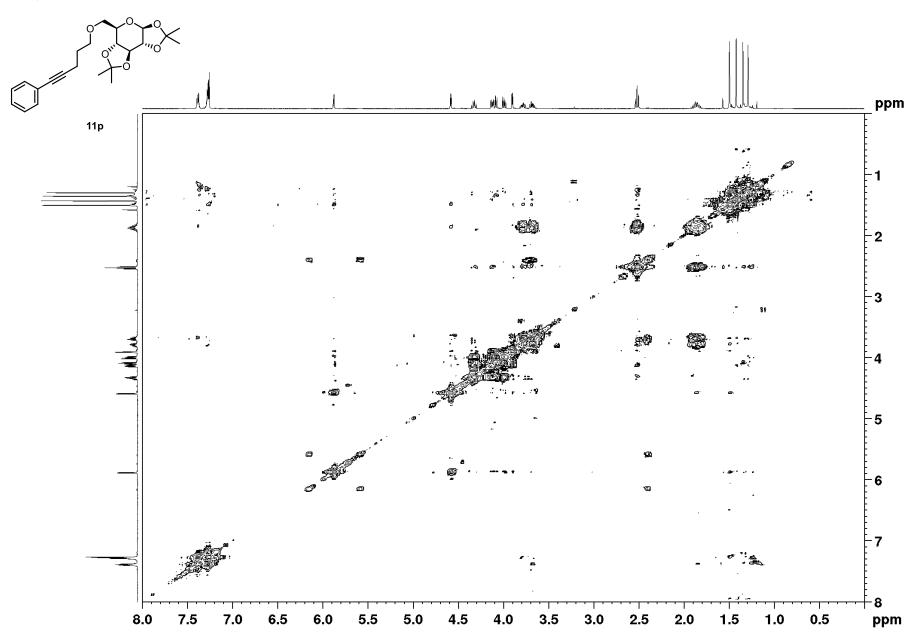




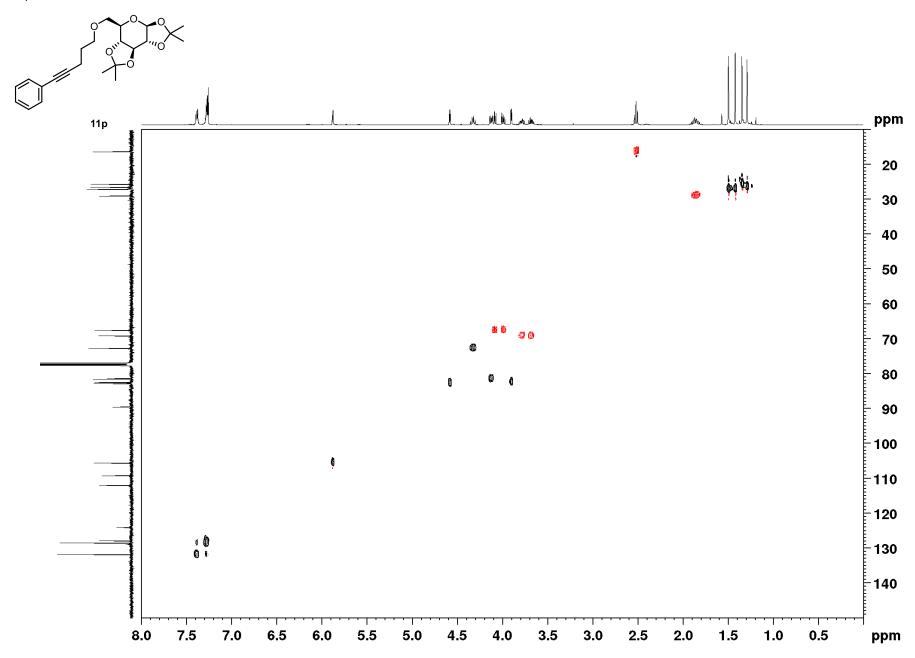




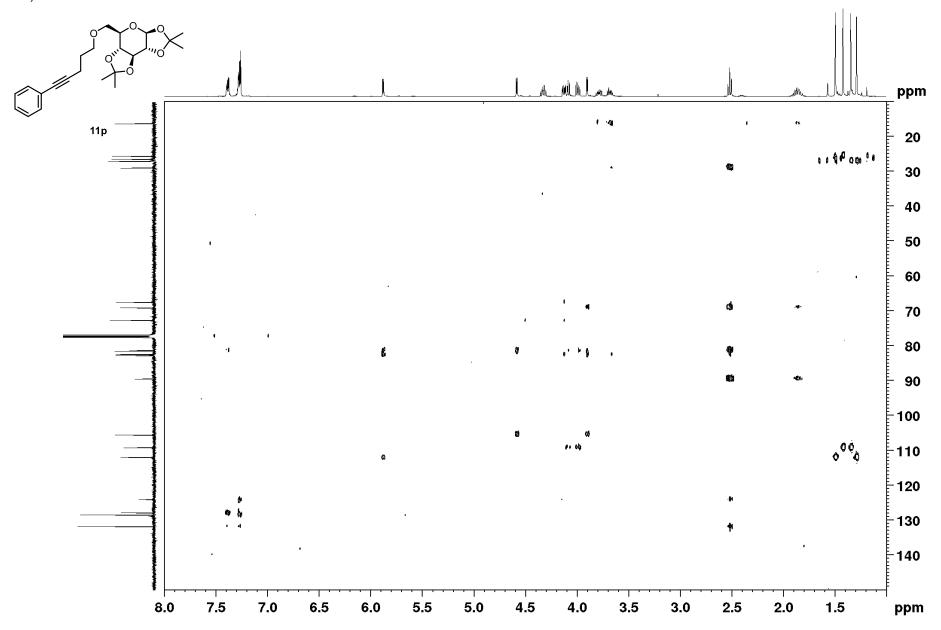


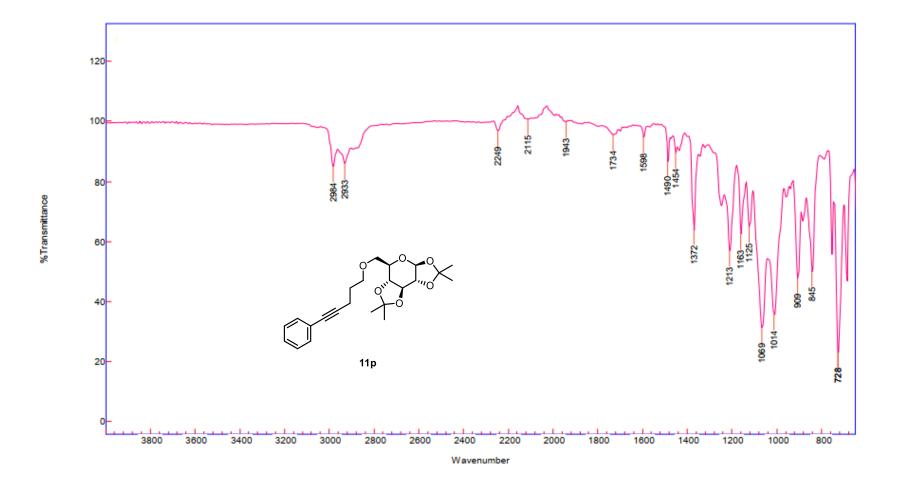


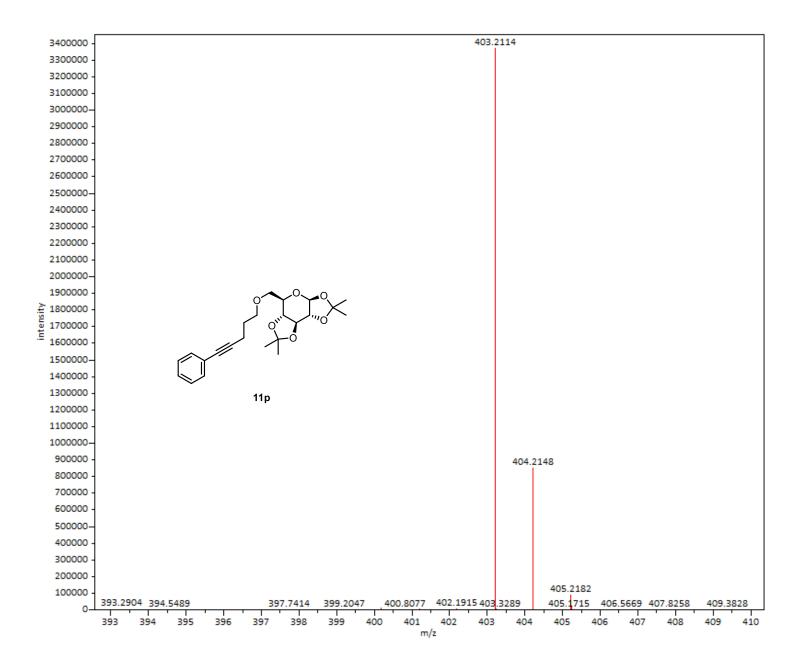




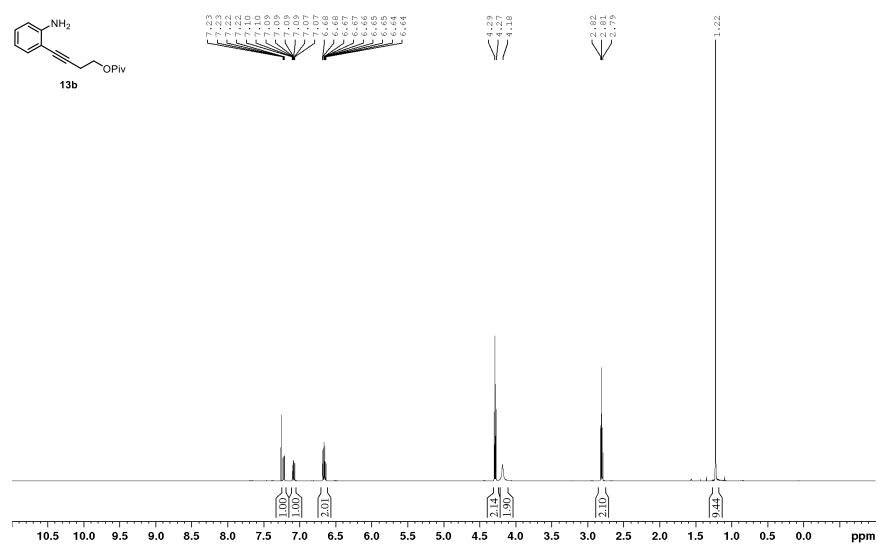
<sup>1</sup>H,<sup>13</sup>C HMBC NMR

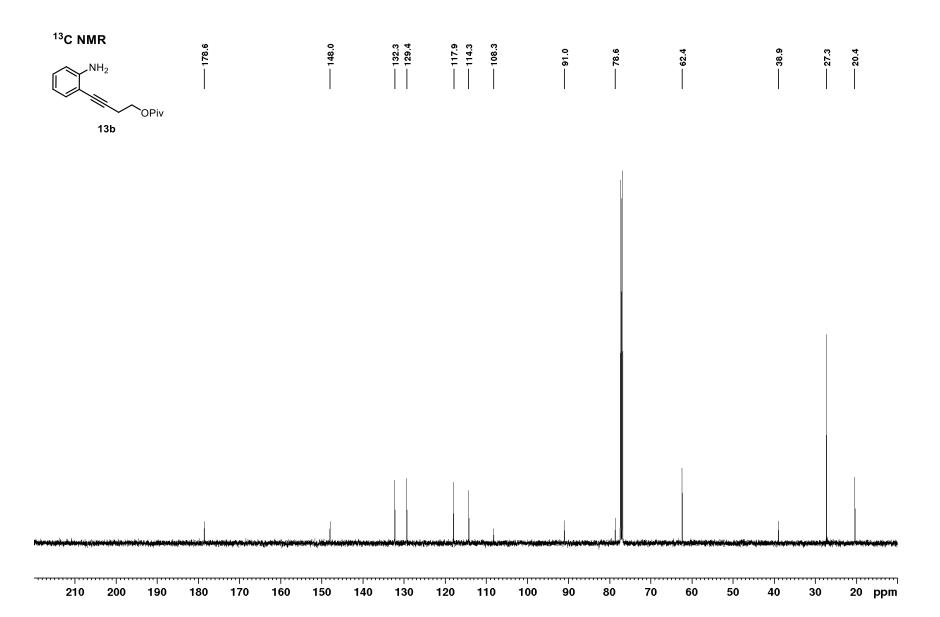




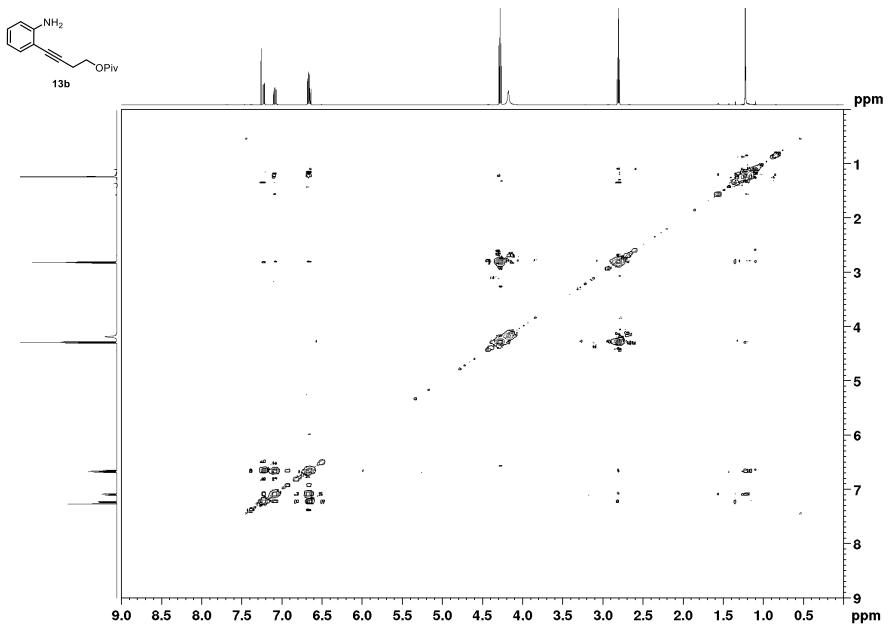


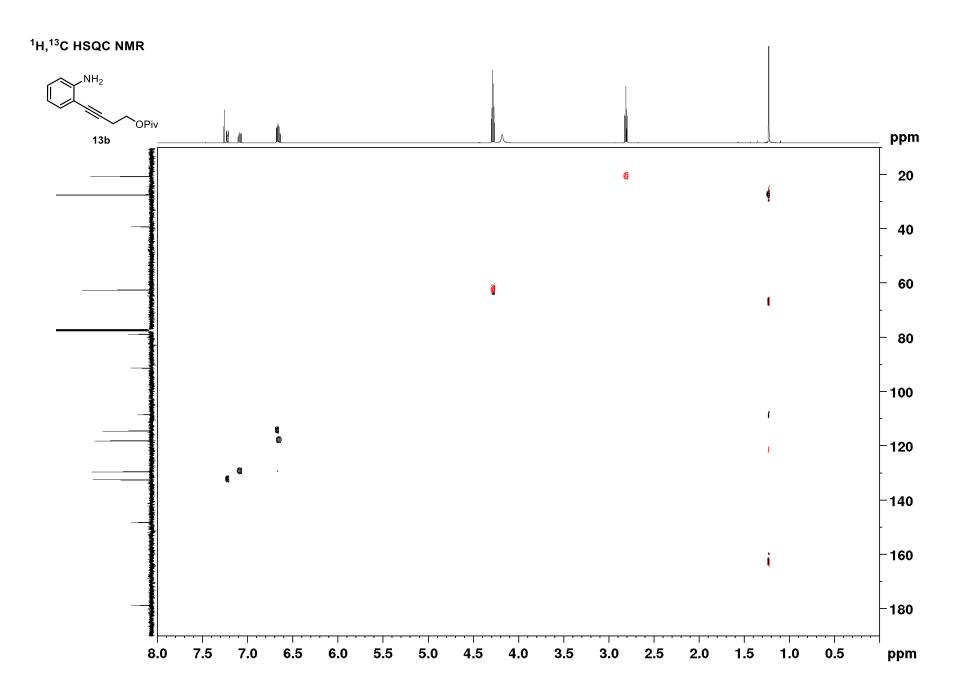


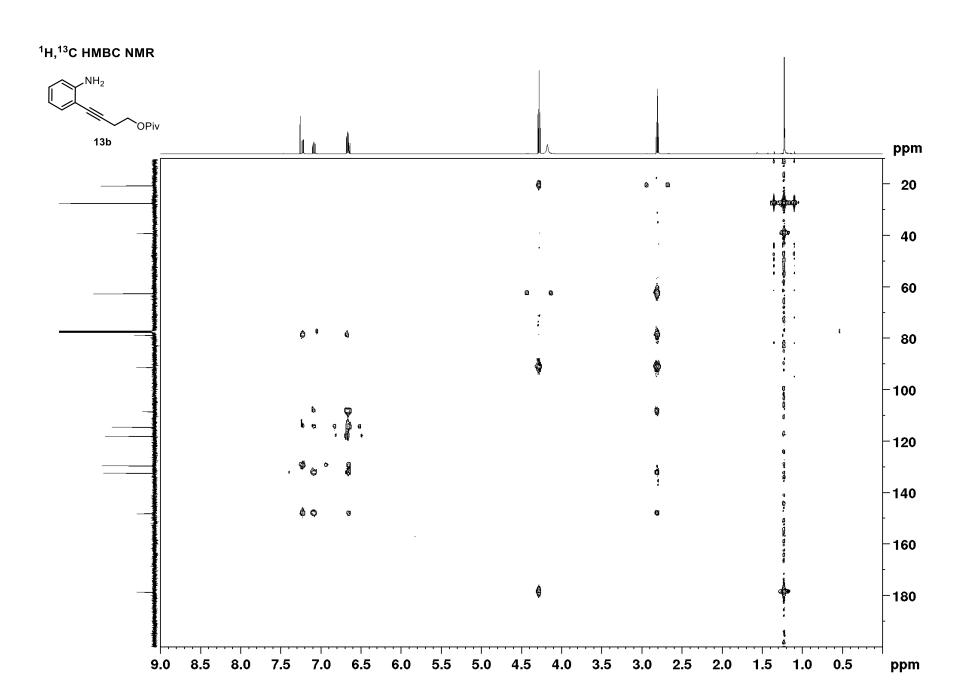


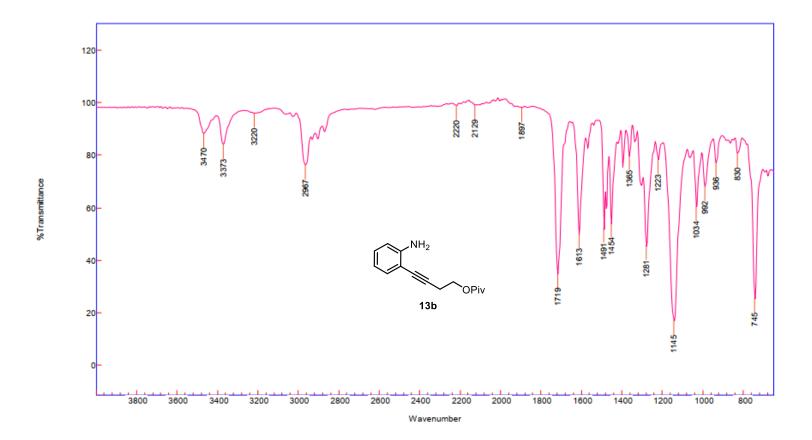


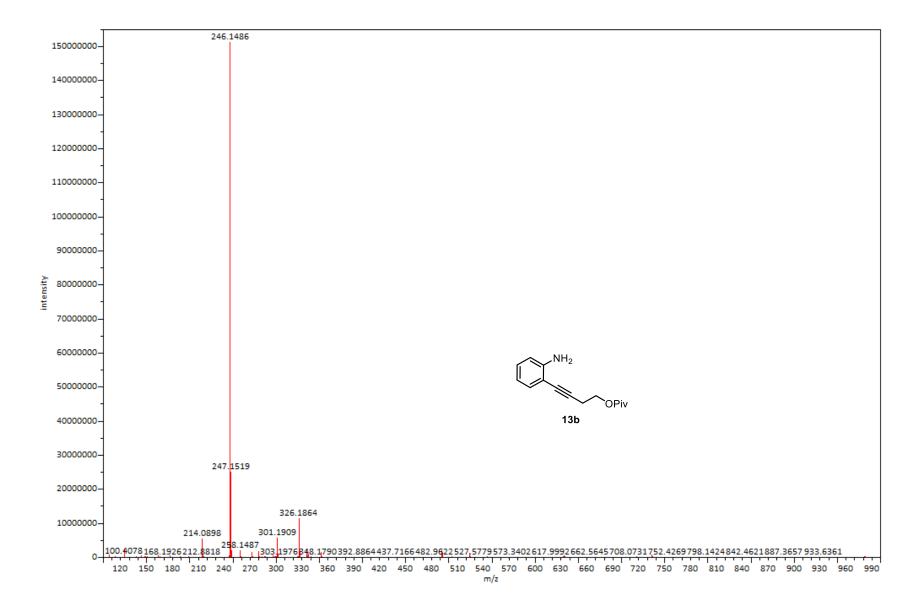


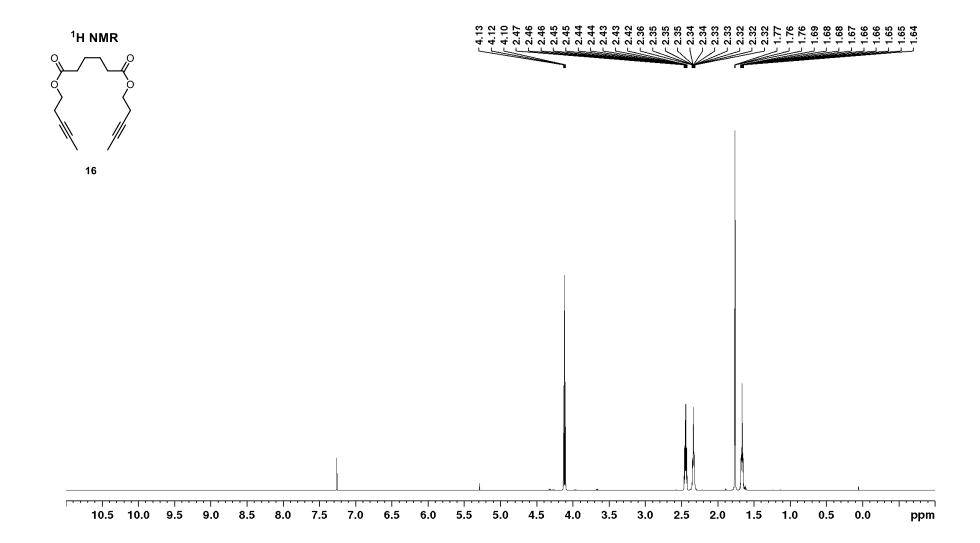


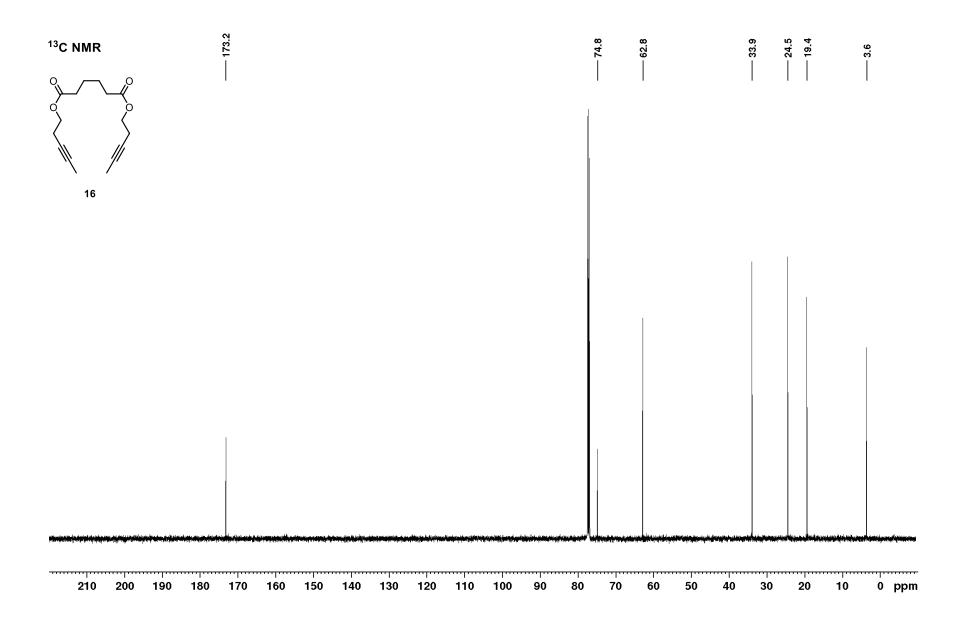




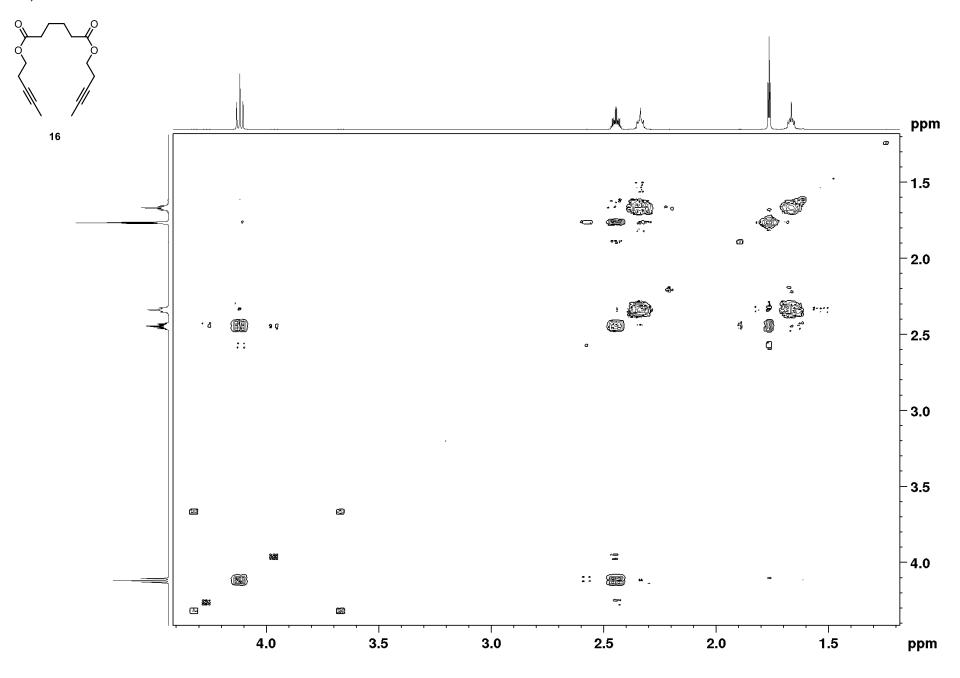




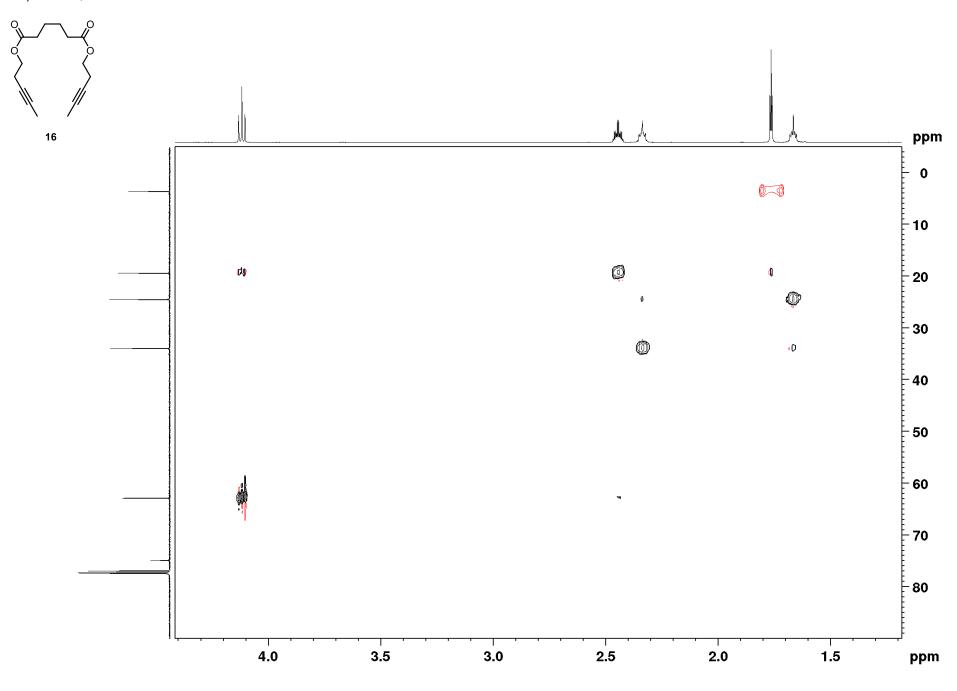




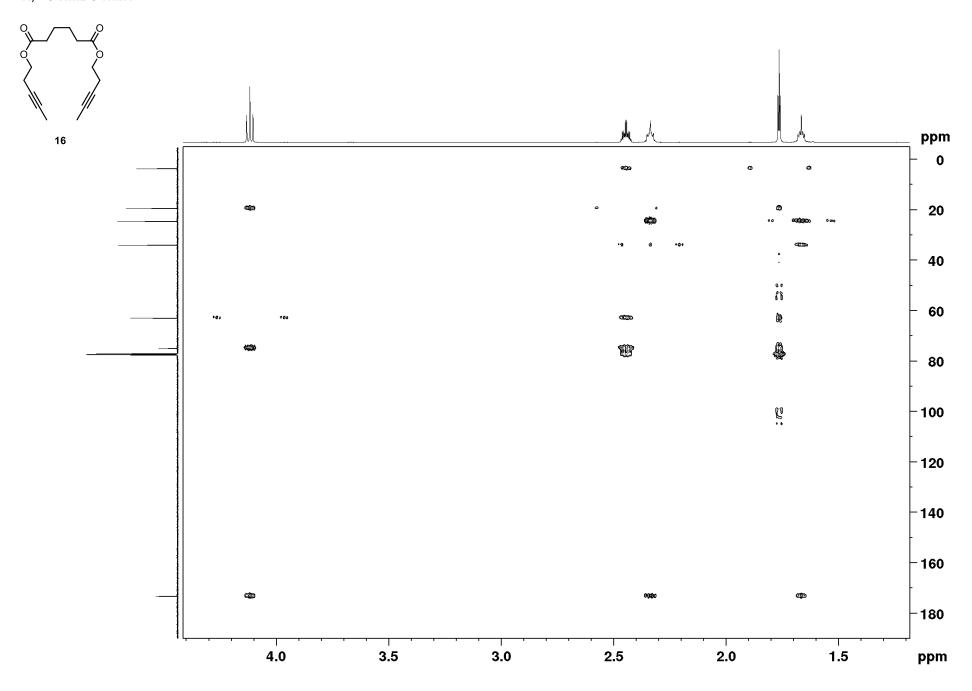


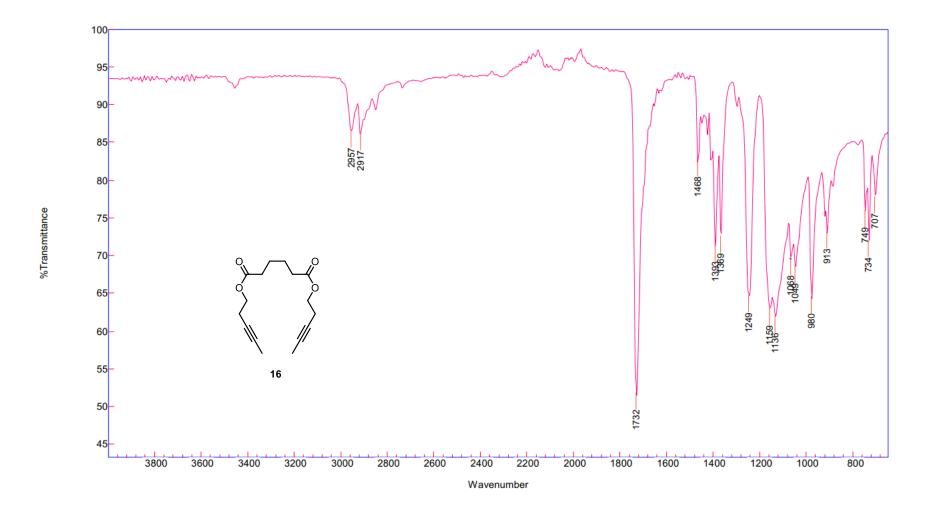


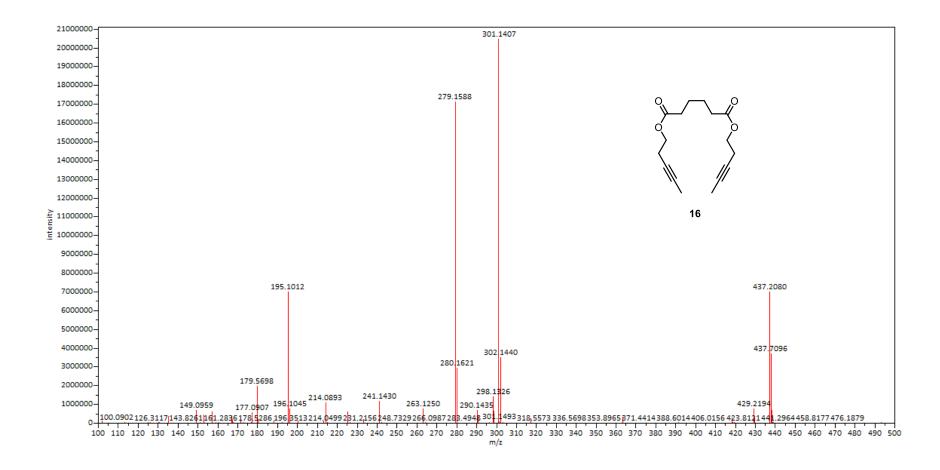


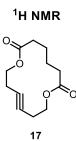


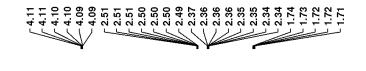
<sup>1</sup>H,<sup>13</sup>C HMBC NMR

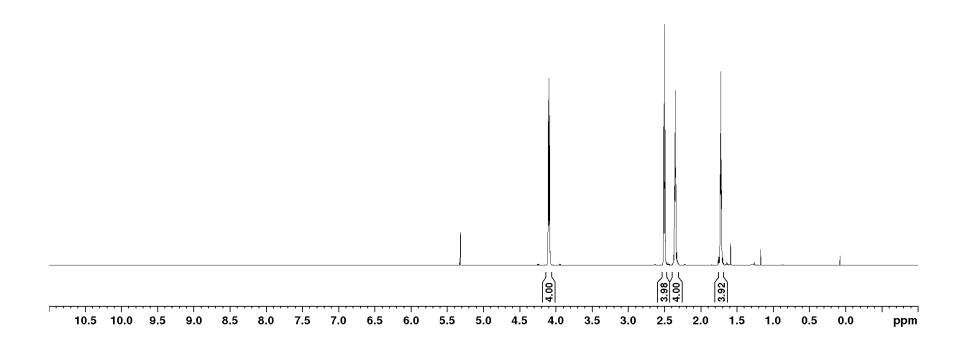


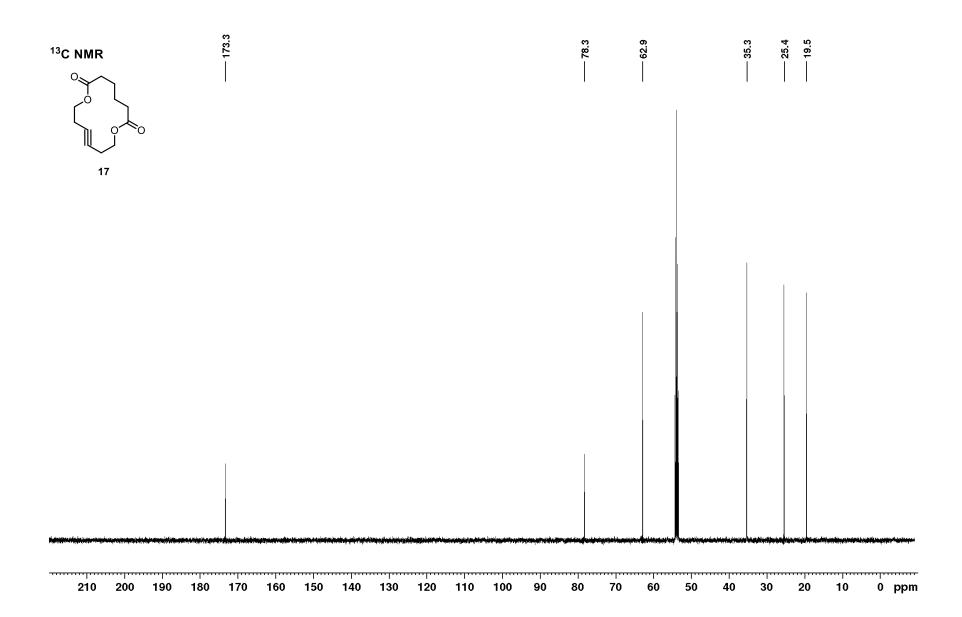




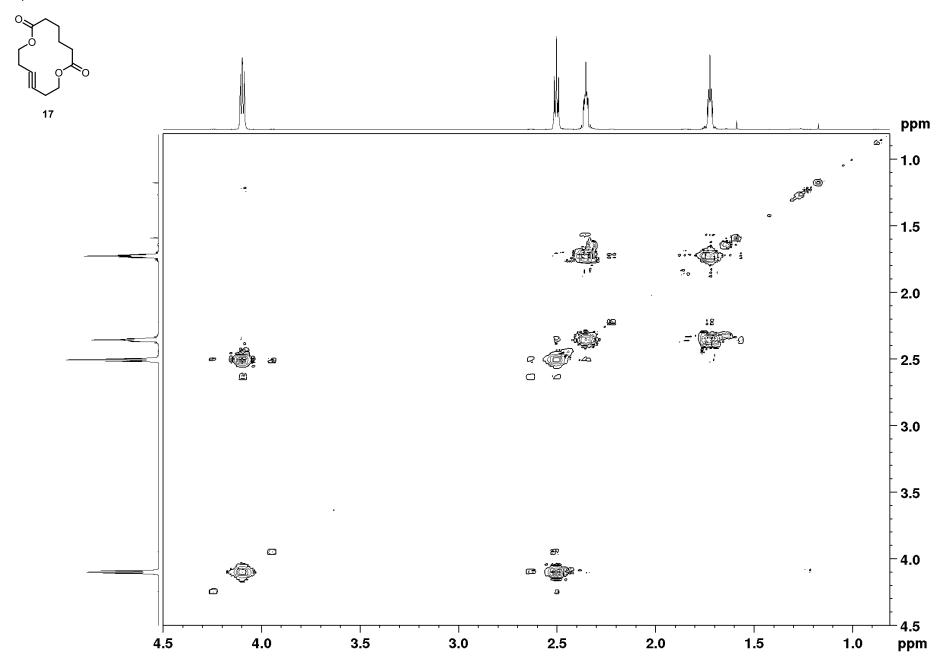


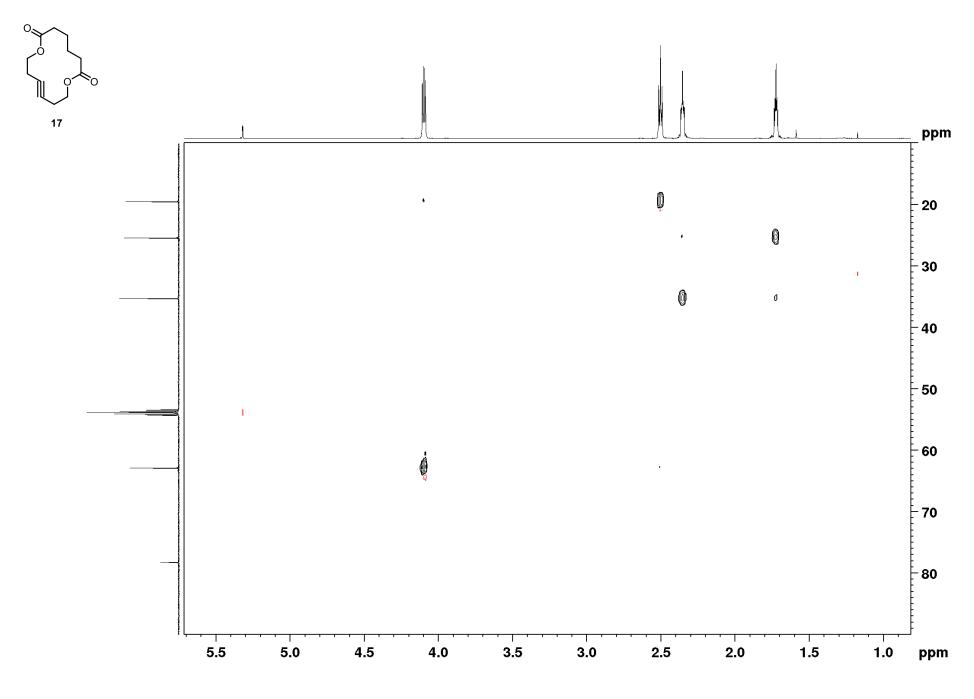




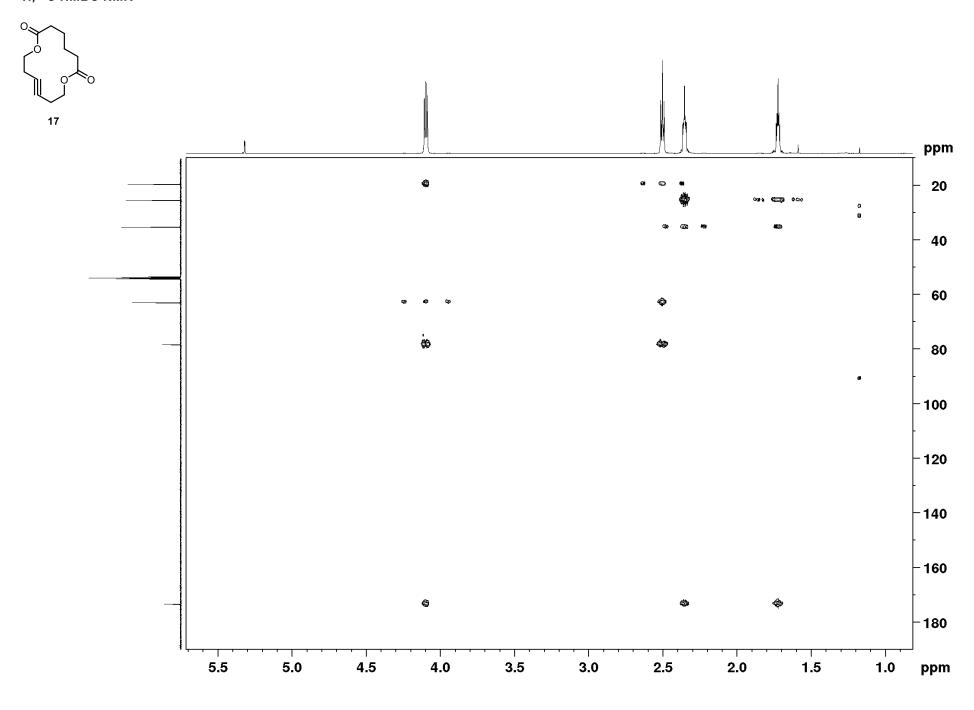


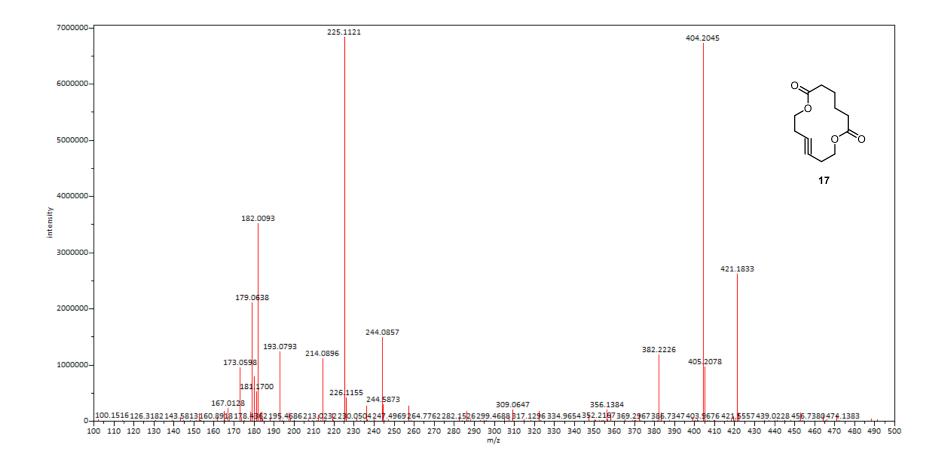


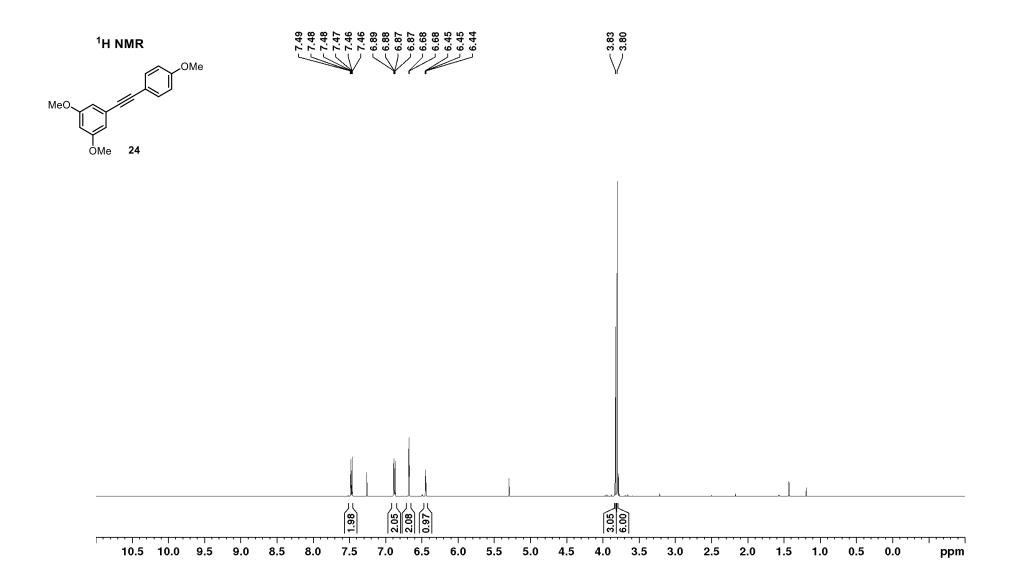


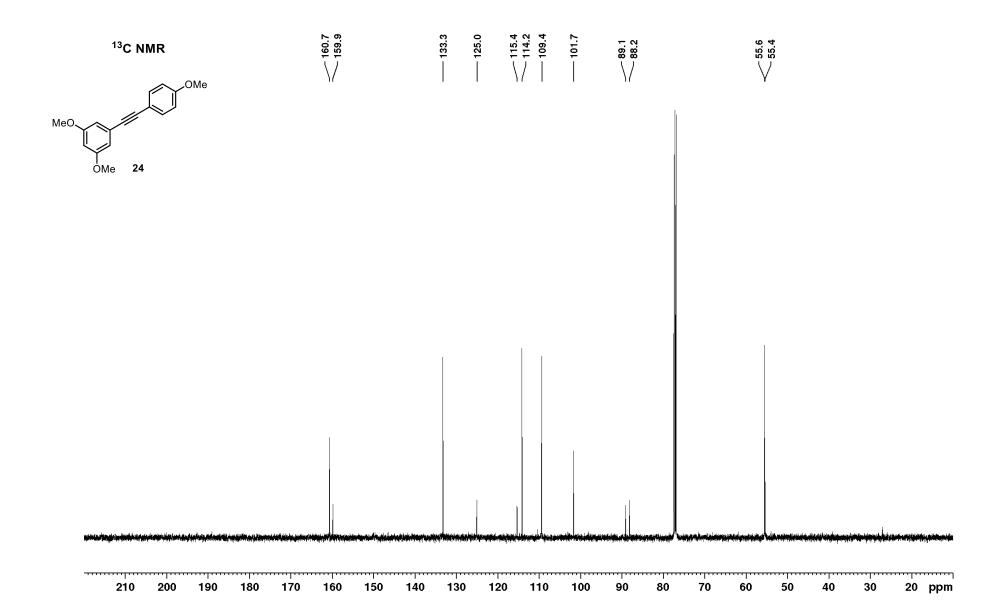




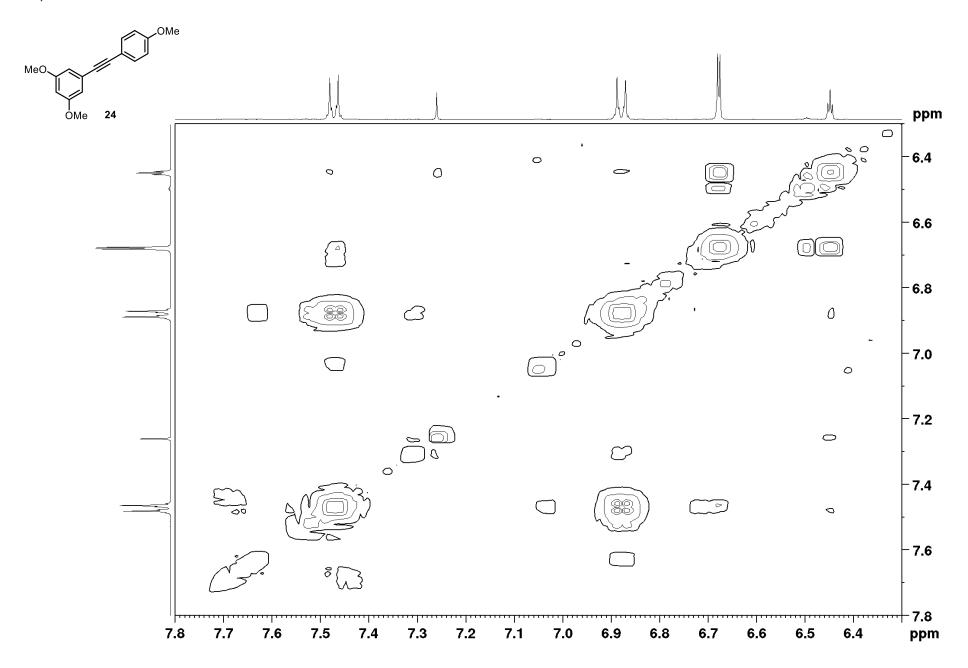


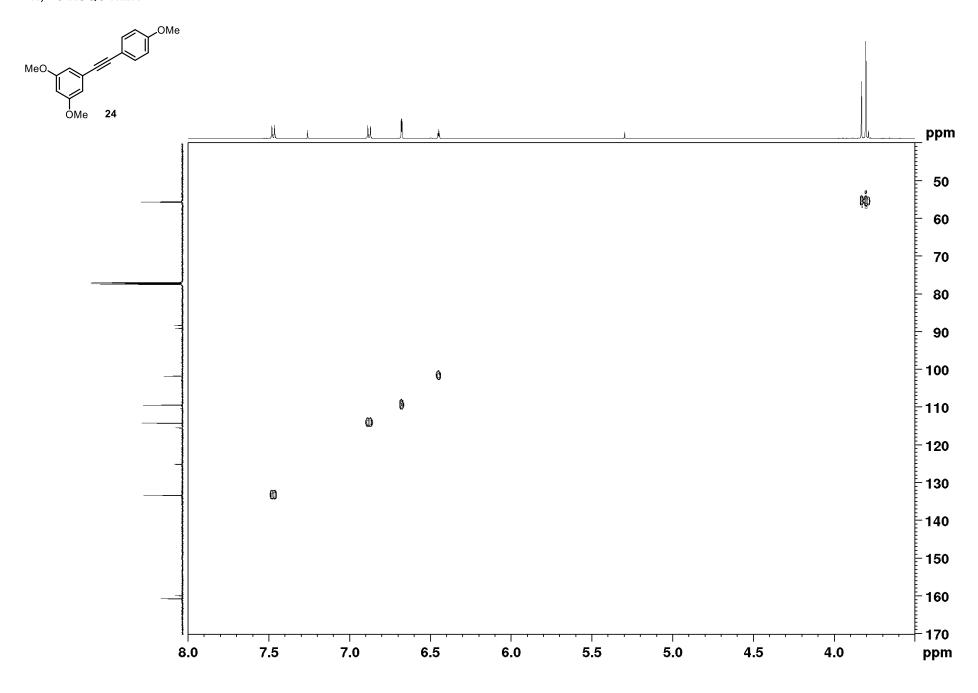




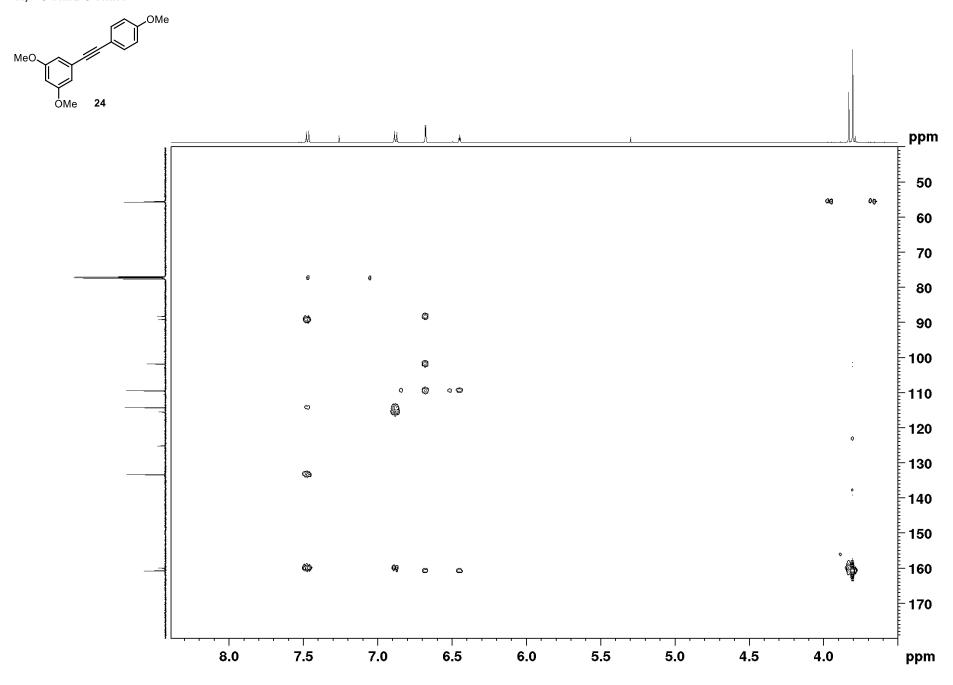


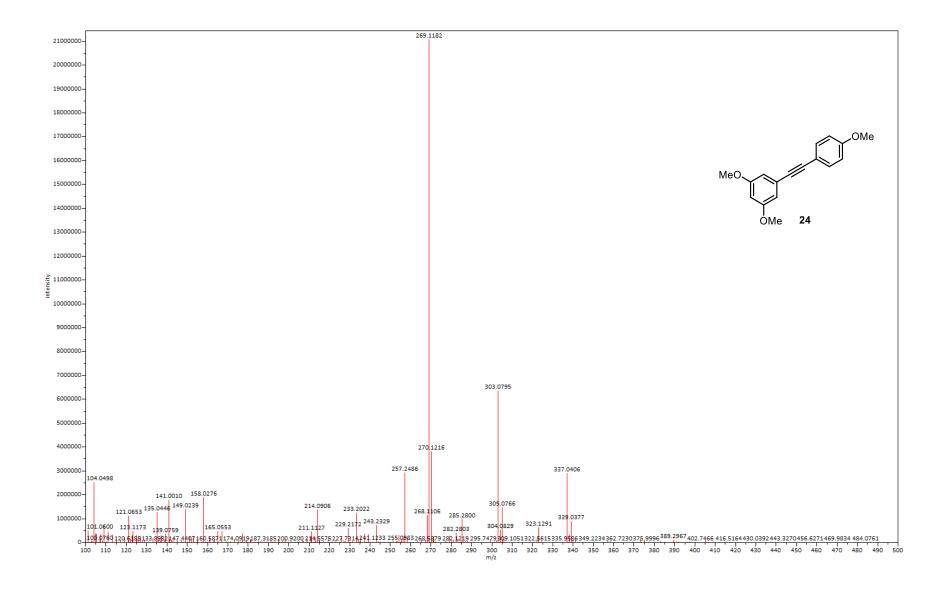
<sup>1</sup>H, <sup>1</sup>H COSY NMR











# Supporting Information for N. O. Thiel, B. Kaewmee, T. T. Ngoc, J. F. Teichert \*\*A Simple Nickel Catalyst Enables Broad E-Selective Alkyne Semihydrogenation\*

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	8.19	( <i>E</i> )-(5-Methylhex-1-en-1-yl)benzene ( <b>12f</b> )	58
	8.20	Methyl ( <i>E</i> )-5-phenylpent-4-enoate ( <b>12</b> g)	58
	8.21	( <i>E</i> )-(5-(Benzyloxy)pent-1-en-1-yl)benzene ( <b>12h</b> )	59
	8.22	(E)-Triisopropyl((4-phenylbut-3-en-1-yl)oxy)silane (12i)	60
	8.23	Methyl (E)-4-(4-acetoxybut-1-en-1-yl)benzoate (12j)	60
	8.24	( <i>E</i> )-5-(Quinolin-3-yl)pent-4-en-1-yl pivalate ( <b>12k</b> )	61
	8.25	( <i>E</i> )-5-(Benzo[ <i>d</i> ][1,3]dioxol-5-yl)pent-4-en-1-yl acetate ( <b>12l</b> )	62
	8.26	(E)-5-Phenylpent-4-en-1-yl (tert-butoxycarbonyl)-L-phenylalaninate (12m)	62
	8.27	(E)-5-(Quinolin-3-yl)pent-4-en-1-yl (tert-butoxycarbonyl)-L-phenylalaninate (12n)	63
	8.28	$17\alpha$ -20 <i>E</i> -21-(4-Methoxycarbonylyphenyl)-19-norpregna-1,3,5(10),20-tetraene-3,17,-diol (1.64)	<b>2</b> 0)
	8.29	(3 <i>aS</i> ,5 <i>aR</i> ,8 <i>aS</i> ,8 <i>bR</i> )-2,2,7,7-Tetramethyl-5-(((( <i>E</i> )-5-phenylpent-4-en-1-yl)oxy)-	
	meth	nyl)tetrahydro-5 <i>H</i> -bis([1,3]dioxolo)[4,5-b:4',5'-d]pyran ( <b>12p</b> )	65
	8.30	(E)-4-(2-Hydroxyphenyl)but-3-en-1-yl pivalate (14)	66
	8.31	2-(1 <i>H</i> -Indol-2-yl)ethyl pivalate ( <b>15</b> )	67
	8.32	(E)-1,8-Dioxacyclotetradec-11-ene-2,7-dione (18)	67
	8.33	(E)-1,3-Dimethoxy-5-(4-methoxystyryl)benzene (E-25)	68
	8.34	(E)-N,4-Dimethyl-N-(5-phenylpent-4-en-1-yl)benzenesulfonamide (28)	69
9	Fo	ormation of (Z)-1,3-Dimethoxy-5-(4-methoxystyryl)benzene (Z-25)	70
	9.1	(Z)-1,3-Dimethoxy-5-(4-methoxystyryl)benzene (Z- <b>25</b> )	70
10	0	Preparation of Resveratrol (26)	70
	10.1	(E)-5-(4-Hydroxystyryl)benzene-1,3-diol (26, Resveratrol)	70
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11.1	2-Allylnaphthalene ( <b>22</b> )	71
11.2	( <i>E</i> )-2-(Prop-1-en-1-yl)naphthalene ( <b>23</b> )	72
11.3	(E)-2-(Prop-1-en-1-yl)naphthalene- $d_1$ , (E)-2-(Prop-1-en-1-yl)naphthalene- $d_2$ , (E)-2-(Prop-1-en-1-yl)naphthalene- $d_3$ , (E)-2-(Prop-1-en-1-yl)naphthalene- $d_4$	n-
1-vI)na	aphthalene- $d_3$ (23- $d_1,d_2,d_3$ )	72

## 1 General Information

All reactions were carried out in flame dried glassware under a nitrogen atmosphere using standard Schlenk techniques. Glassware and stirring bars contaminated with transition metals were treated with agua regia (conc. HCl/conc. HNO<sub>3</sub> 3:1) prior to cleaning. For cleaning, glassware and stirring bars were kept in an iPrOH/KOH bath overnight, rinsed with H<sub>2</sub>O, kept in a citric acid/H<sub>2</sub>O bath overnight and finally rinsed with dest. H<sub>2</sub>O and dried at 120 °C. Solutions and reagents were added with nitrogen-flushed disposable syringes/needles. Solvents were added using glass syringes and stainless steel needles (stored at 120 °C). Analytical thin layer chromatography (TLC) was performed on silica gel 60 G/UV<sub>254</sub> aluminium sheets (Macherey-Nagel). Flash column chromatography was performed on silica gel Davisil LC60A (40-63 µm, pore size 60 Å, Grace) using the indicated solvents. NMR spectra were recorded on AVII 400, AVIII 500 or AVIII 700 NMR instruments (Bruker) at the Institut für Chemie of Technische Universität Berlin. Chemical shifts are reported in parts per million (ppm) relative to TMS or CCI₃F. For the calibration of the chemical shift the residual solvent resonance was used as the internal standard according to the standard literature. [1,2] 19F chemical shifts were calibrated using the unified scale. [2] Data are reported as follows: chemical shift, multiplicity (br s = broad singlet, s = singlet, d doublet. t triplet, = quartet, sept = septet, multiplet, q m m<sub>c</sub> = centrosymmetric multiplet), coupling constants (Hz), integration and - if possible - atom assignment. The assignment refers to the atom number shown in the corresponding molecule figure and was achieved by analysis of DEPT (DEPT 135) and 2D-NMR spectra (COSY, HSQC, HMQC, HMBC, NOESY). If a distinct assignment was not possible, atoms were marked with "\*" and can be interchanged. Melting points (m.p.) were determined using a Leica Galen III melting point apparatus (Wagner & Munz) and are reported as the meniscus melting point. [3] Infrared (IR) spectra were recorded on a Cary 630 FT-IR spectrometer equipped with an ATR unit (Agilent Technologies). Mass spectra (HRMS) were obtained from the Analytical Facility at the Institut für

Chemie at *Technische Universität Berlin* (ESI/APCI: LTQ Orbitrap XL, *Thermo Scientific*; EI: GC-system 5975C, HP-5MS, *Agilent Technologies*). Optical rotations were measured on a *Schmidt & Haensch Polartronic* H532 Polarimeter with  $\alpha_{\lambda}^{t}$  values reported in  $10^{-1}$  (° cm<sup>2</sup> g<sup>-1</sup>); with the concentration c in g/100 mL and  $\lambda$  indicated. In situ IR spectroscopy of the hydrogenation reactions was carried out using an autoclave equipped with an IR probe (ReactIR 15, Mettler Toledo).

All hydrogenation reactions were carried out in glass vials (50 x 14 mm, *Schütt*), equipped with a magnetic stirring bar, a rubber septum pinched with a needle (0.90 x 50 mm, *Braun*) in autoclaves BR-100 or BR-300 (including the appropriate heating blocks; *Berghof*).

## 1.1 Solvents

THF, toluene and 1,4-dioxane were dried over sodium/benzophenone and distilled under a N<sub>2</sub> atmosphere prior to use. Et<sub>3</sub>N and CH<sub>2</sub>Cl<sub>2</sub> were dried over CaH<sub>2</sub> and distilled under a N<sub>2</sub> atmosphere prior to use. Benzene (puriss., absolute) was purchased from *Sigma Aldrich*. Solvents (technical grade) for extraction/chromatography (cyclohexane, CH<sub>2</sub>Cl<sub>2</sub>, *tert*-butyl methyl ether and *n*-pentane) were distilled under reduced pressure prior to use.

# 1.2 Chemicals

The following chemicals were purchased and used without further purification: 1,2-diphenylethyne (11a, Sigma-Aldrich), ethynylbenzene (Sigma-Aldrich), 1-hexyne (Sigma-Aldrich), 1-(4bromophenyl)ethan-1-one (Sigma-Aldrich), methyl 4-iodobenzoate (Sigma-Aldrich), bromobenzonitrile (Sigma-Aldrich), 1-chloro-4-iodobenzene (Sigma-Aldrich), iodobenzene (Sigma-Aldrich), 4-bromobenzaldehyde (Sigma-Aldrich), 1-iodo-4-nitrobenzene 2-iodothiophene (Sigma-Aldrich), 4-iodophenol (Sigma-Aldrich), (Sigma-Aldrich), bromopyridine (Sigma-Aldrich), 3-bromopyridine (Sigma-Aldrich), 4-iodopyridine (Sigma-Aldrich), hydrazine hydrate (Sigma-Aldrich), 1-iodo-4-methoxybenzene (Sigma-Aldrich), but-3-yn-1-ol (ABCR), 1-iodo-2-methoxybenzene (Sigma-Aldrich), 1-iodo-3-methoxybenzene (Sigma-Aldrich), 1-iodo-3-(trifluoromethyl)benzene (Sigma-Aldrich), 3-phenylprop-2-yn-1-ol (S1, Sigma-Aldrich), pivaloyl chloride (Sigma-Aldrich), adipic acid (Merck), pent-3-yn-1-ol (Sigma-Aldrich), N,Ndicyclohexylcarbodiimide (DCC, Fluka), 4-(dimethylamino)pyridine (DMAP, Sigma-Aldrich), tritert-butoxy(2,2-dimethylpropylidyne)tungsten (ABCR), phthalic acid (Sigma-Aldrich), nickel(II) iodide (Aldrich), 1,1'-bis(diphenylphosphino)ferrocene (dppf, TCI), 2,2'-bipyridine (Sigma-Aldrich),

2-(bromomethyl)naphthalene (*Sigma-Aldrich*), vinylmagnesium bromide solution (1.0M, *Sigma-Aldrich*).

The following chemicals were synthesized according to the corresponding literature procedure: (5-(benzyloxy)pent-1-yn-1-yl)benzene (11h),  $^{[1]}$  1-(phenylethynyl)-4-(trifluoromethyl)benzene (9d),  $^{[2]}$  1-methoxy-4-(phenylethynyl)benzene (9e),  $^{[2]}$  1-Chloro-4-(phenylethynyl)benzene (9f),  $^{[3]}$  4-Phenylbut-3-yn-1-ol (S2),  $^{[4]}$  Methyl 1-ethynyl-3,5-dimethoxybenzene (S3),  $^{[5]}$  [IPrCuOH],  $^{[6]}$  Hept-6-en-1-yn-1-ylbenzene (20),  $^{[7]}$   $((3aS,5R,5aR,8aS,8bR)-2,2,7,7-tetramethyltetrahydro-5H-bis([1,3]dioxolo)[4,5-b:4',5'-d]pyran-5-yl)methano, <math>^{[8]}$  5-phenylpent-4-yn-1-yl-4-methylbenzene-sulfonate,  $^{[9]}$  *N*-methyl-p-toluenesulfonamide  $^{[10]}$ .

# 2 Optimization

In the case of aryl alkyl alkynes investigations showed that a wide bite angle is crucial for stereo-(E/Z) and chemoselectivity (competing overreduction to the alkane). Best results were observed using dppf as ligand (table 1, entry 11). In further investigations, dppf was used as ligand.

Table 1: Optimization for aryl alkyl alkynes. Screening of ligands.[a]

Entry	[Ni]	Conversion [%] <sup>[b]</sup>	12h [%] <sup>[b]</sup>	E/Z	S4 [%] <sup>[b]</sup>
1	[(Ph <sub>3</sub> P) <sub>2</sub> NiCl <sub>2</sub> ]	0	0	_	0
2	$[(Ph_3P)_2NiBr_2]$	0	0	_	0
3	$[(dppe)_2NiCl_2]$	0	0	-	0
4	$[(dppp)_2NiCl_2]$	17	17	35:65	0
<b>5</b> <sup>[c]</sup>	5 mol% Nil <sub>2</sub>	70	43	77:23	25
3.7	10 mol% Ph₃P	70	43	11.23	25
<b>6</b> <sup>[c]</sup>	5 mol% Nil <sub>2</sub>	0	0	_	0

Entry	[Ni]	Conversion [%] <sup>[b]</sup>	12h [%] <sup>[b]</sup>	E/Z	<b>S4 [%]</b> <sup>[b]</sup>
	5 mol% dppm				
<b>7</b> [c]	5 mol% Nil <sub>2</sub>	0	0		0
<i>,</i>	5 mol% dppe	U	U	_	U
<b>8</b> [c]	5 mol% Nil <sub>2</sub>	22	20	53:47	2
Q <sub>r⊲1</sub>	5 mol% dppp	32	26		
<b>9</b> [c]	5 mol% Nil <sub>2</sub>	0	0	_	0
9[∾]	5 mol% dppb				
40[0]	5 mol% Nil <sub>2</sub>	0	0	-	0
<b>10</b> <sup>[c]</sup>	5 mol% dppbz				
<b>11</b> <sup>[c]</sup>	5 mol% Nil <sub>2</sub>	0.4		85:15	4
11™	5 mol% dppf	24	20		
	5 mol% Nil <sub>2</sub>				
<b>12</b> <sup>[c]</sup>	10 mol%	39	24	75:25	15
	<i>t</i> BuPh₂P				

[a] Reactions were conducted with **11h** (0.13 mmol) in THF (1 mL). [b] Determined by GC and <sup>1</sup>H NMR Analysis. [c] 14 h reaction time.

When using the optimized conditions (see above) on substrate **11h**, we found that other ligand types did not allow for the desired transformation. Employing Nil<sub>2</sub>/dppf as catalyst, we detected aldehyde **S5**, most probably stemming from preliminary benzyl deprotection and subsequent alkene isomerization/keto-enol tautomerization. We therefore decided to use another alcohol protecting group (see below).

Table 2: Screening of other ligand types.[a]

Entry		Conversion 12h/isomers		E/Z	S4/S5 [%]	
Entry	L	[%]	[%]	E/Z	O-1/03 [70]	
1	dppf	100	68/2	90:10	14/16	
2	10 mol% <i>t</i> Bu₃P	3	3/0	-	0	
3	1,10-phen	0	0	_	0	
4	5 mol% IPr·HCl 5 mol% <i>n</i> BuLi	0	0	-	0	
5	dtbpf	0	0	_	0	

<sup>[</sup>a] Reactions were conducted with 11h (0.13 mmol) in THF (1 mL). [b] Determined by GC and <sup>1</sup>H NMR Analysis.

Screening of protecting groups showed that the pivaloyl ester protecting group was the best alcohol protecting group (table 3, entry 4). In further investigations, pivaloyl ester was used as protecting group of choice.

Table 3: Screening of alcohol protecting groups.[a]

Entry	R	Conversion [%]	S7/Isomers [%] <sup>[b]</sup>	E/Z	S8/S9/S10 [%] <sup>[b]</sup>
1	H ( <b>S2</b> )	100	33/3	91:9	15/1 + unknown species
2	Tips ( <b>11i</b> )	99	67/1	95:5	24/7
3	Ac ( <b>S11</b> )	99	72/1	95:5	27/0
4	Piv ( <b>6</b> )	100	84/1	95:5	12/0/3

<sup>[</sup>a] Reactions were conducted with **S6** (0.13 mmol) in 1,4-dioxane (1 mL). [b] Determined by GC and <sup>1</sup>H NMR Analysis.

The screening of solvents revealed 1,4-dioxane as best solvent for reactivity and stereoselectivity.

Table 4: Screening of solvents.[a]

Entry	Solvent	Conversion	7/isomers	E/Z	8/S10 [%] <sup>[b]</sup>	
Entry	Solvent	[%]	[%] <sup>[b]</sup>	<b>E/Z</b>	0/310[/0]**	
1	1,4-dioxane	89	72/3	93:7	11/3	
2	DMF	0	0	-	0	
3	chlorobenzene	4	2/2	50:50	0	
4	<i>n</i> hexane	0	0	_	0	
5	toluene	94	73/3	89:11	16/2	
6	1,2- dichoroethane	0	0	-	0	
7	<i>s</i> BuOH	85	62/3	89:11	15/5	
8	DMSO	0	0	_	0	

[a] Reactions were conducted with 6 (64 µmol) in solvent (0.75 mL). [b] Determined by GC and <sup>1</sup>H NMR Analysis.

The reaction conditions were optimized using internal alkyne  $\bf 6$  as model substrate. Applying 15 bar H<sub>2</sub> pressure and 100 °C temperature showed the best results in case of reactivity and selectivity (table 5, entry 3).

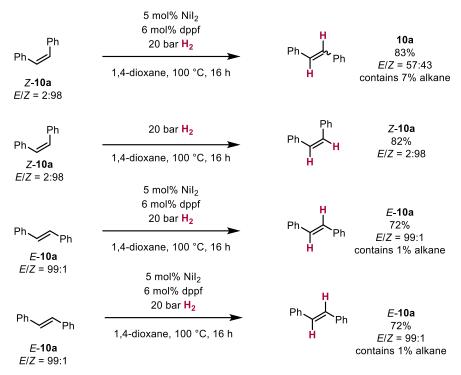
Table 5: Optimization of pressure and temperature.[a]

Entry	Pressure	Temperature	Conversion [%]	<b>7/isomers [%]</b> [b]	E/Z	8/S10 [%]
1	20	80	48	87:1 48 39/3	87:1	6/0
•	_0	00	.0	33/3	3	
2	20	95	100	79/3	95:5	15/3
3	20	100	100	84/1	95:5	12/3
3	15	100	100	85/1	95:5	11/3
4	15	105	100	82/2	95:5	13/3
5	10	100	84	63/2	95:5	17/2

<sup>[</sup>a] Reactions were conducted with 6 (0.13 mmol) in 1,4-dioxane (1 mL). [b] Determined by GC and <sup>1</sup>H NMR Analysis.

# 3 Isomerization Studies – Indication for Nickel Hydride Intermediates

To prove the hypothesis that an isomerization process is involved in the reported E-selective alkyne semihydrogenation the following experiments were conducted: First Z-10a was subjected to the reaction conditions giving E/Z-stilbene (E/Z=57:43) and 7% of the alkane (scheme 1, top). This result underlines an isomerization process mediated by a nickel hydride. The substantial amount of alkane (7%) is noteworthy since the reaction with tolane (9a) gave no overreduction. The reaction with Z-stilbene (Z-10a) under the same conditions but without the presence of the nickel catalyst shows no isomerization of Z-10a excluding a thermal isomerization process as reason for the observed E-selectivity (Scheme 1, middle). Last E-10a was subjected to the reaction conditions leading to no loss of stereoselectivity and negligeable amounts of overreduction to the alkane (1%, scheme 1, bottom). This indicates that the catalyst system differentiates between Z-10a and E-10a in terms of reactivity.



Scheme 1. Isomerization experiments with tolane (9a), Z-stilbene (Z-10a) and E-stilbene (E-10a)

When adding 10 mol% tolane (**9a**) to *Z*-stilbene (*Z*-**10a**), the selectivity changes in favor of *E*-**10a** when compared to the result *without* the addition of tolane (**9a**) (see Scheme 1, first reaction). This indicates an active role of the added alkyne (**9a**) in the catalytic cycle. When 10 mol% of *E*-stilbene (*E*-**10a**) were added instead of the alkyne **9a**, no change in selectivity was observed (Scheme 2, second reaction). The addition of TEMPO (1.0 equiv) shut down the reaction completely. This is possibly due to coordination and/or redox chemistry of TEMPO with the nickel precursor before the actual catalytic transformation. The addition of TEMPO was accompanied by a change in color which was not observed in any other case. When 2 equivalents of methyl acrylate (**19**) where added, no change in the original selectivity was observed.

Scheme 2. Isomerization experiments with tolane (9a), Z-stilbene (Z-10a) and E-stilbene (E-10a).

To investigate whether the current process could in principle run via a prior Z-selective alkyne semihydrogenation followed by a (necessarily rapid) Z-E-isomerization sequence ultimately favouring the thermodynamically more stable E-alkene we used 2-allylnaphthalene (22, Scheme 4) as mechanistic probe. When 22 was subjected to the standard reaction conditions (5 mol% Nil<sub>2</sub>, 6 mol% dppf, 20 bar H<sub>2</sub>, 1,4-dioxane, 100 °C), we found complete isomerization towards *E*propenyl-naphthalene 23 (67% yield). This result is an indication for the presence of nickel hydride intermediates, which could facilitate this isomerization through a hydronickelation/β-hydride elimination. It should be noted that in the absence of nickel(II) iodide and also in the absence of dppf, no conversion of 22 was observed, indicating the crucial role of the ligand for H2 activation and/or isomerization. To exclude that possibly formed HI could permit an Brønstedt-acid catalyzed isomerization, we carried out the same isomerization (22 to 23) in the presence of 10 mol% base (2,6-di-tert-butylpyridine). This additive did not hinder the isomerization, indicating the absence of acid-catalyzed processes (Scheme 4, middle). Finally, application of the standard conditions but utilizing deuterium gas showed a pattern of partial deuteration at all three side chain carbon atoms (17% to 36% deuterium incorporation, Scheme 4, bottom). Especially the presence of partial deuterium labelling at the quasi-benzylic position (17% D) hints towards a re-insertion of a putative nickel deuteride into the alkene already in conjugation to the aromatic ring. Therefore, for the

present nickel–catalyzed alkyne semihydrogenation we suggest a mechanism similar to the E-selective alkyne semihydrogenation with iron and cobalt complexes (Scheme 1), namely a primary Z-selective alkene formation followed by an efficient Z/E-isomerization by hydronickelation and  $\beta$ -hydride elimination.

Scheme 3. Indication for nickel hydride intermediates.

To study a possible alkene isomerization along carbon chains (chain-walking), N-propargylic tosylamide **S12** was treated in the presence of 10 mol% Ni(OTf)<sub>2</sub>, 12 mol% dppf, 30 bar H<sub>2</sub>. We found the *E*-**27** was formed as a minor product in the ratio *E*-**27**/*E*-**28** = 25:75. The result shows that indeed chain-walking can proceed through putative nickel hydride intermediate *via* hydronickelation/ $\beta$ -hydride elimination along the carbon chain to the thermodynamically more stable position forming a styrene derivative as a major product. See spectra below.

Equation 1 Indication for nickel hydride intermediate (chain-walking).

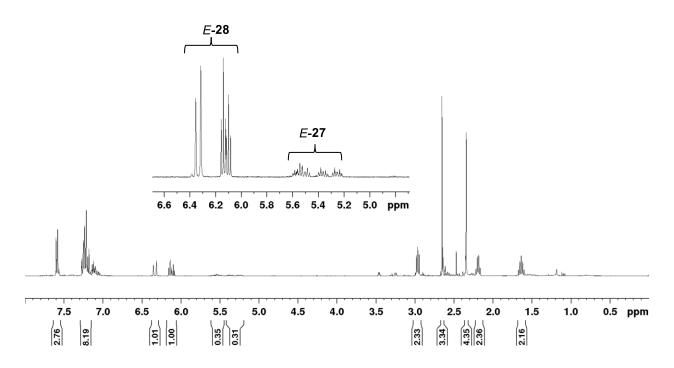


Figure 1. <sup>1</sup>H NMR spectrum of isomerized product mixtures *E*-27 and *E*-28.

To investigate whether a radical process is involved, enyne **20** was subjected to the standard alkyne semihydrogenation reaction conditions. After 16 h, we found full conversion of **20**, along with the formation of a variety of products (see <sup>1</sup>H NMR spectrum of the purified mixture, eq. 1).

In the isolated product mixture, we were able to identify cyclized products *E*-21 and *Z*-21 along with *E*-29. The products 21 and S13 could be characterized unequivocally by 1D TOCSY NMR experiments, and comparison to literature data. See spectra below.

Equation 2: Enyne 20 subjected to the catalysis protocol.

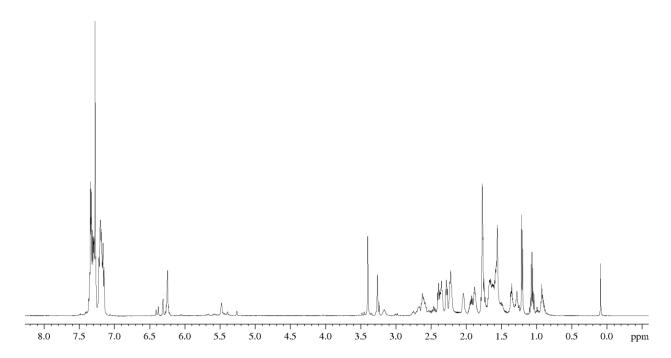


Figure 2. <sup>1</sup>H NMR spectrum of purified reaction mixture.

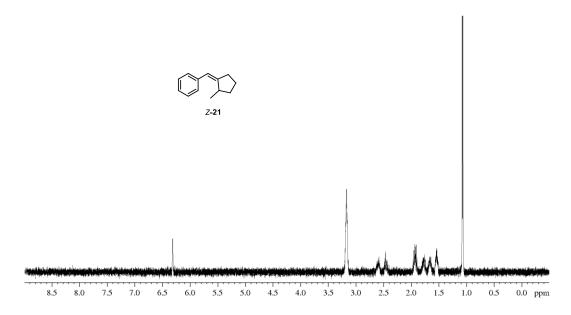


Figure 3. 1D TOCSY NMR with irradiation at 3.16 ppm.

The spectroscopic data is in accordance with the literature (a mixture of E-21 and Z-21 is reported). [11] (Note: In the literature, [11] the ratio of stereoisomers is given as Z/E = 2:3, with the major component bearing the doublet at ~1.1 ppm. In our case, the component with the doublet at ~1.2 ppm is the major product. In comparison to what has been claimed to be the pure E product, [12] either the assignment in literature reference [11] or reference [12] is mistaken. We have opted to follow the pure isolated product from reference [12] to assign the stereochemistry of product 21 in our cases.)

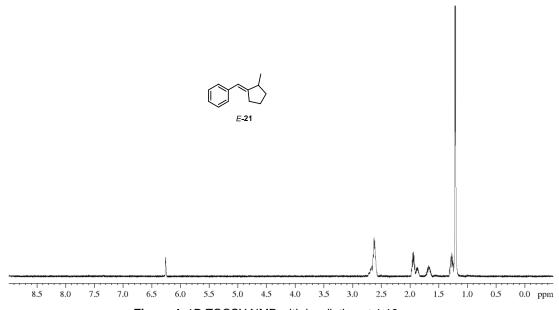


Figure 4. 1D TOCSY NMR with irradiation at 1.19 ppm.

The spectroscopic data is in accordance with the literature.<sup>[12]</sup>



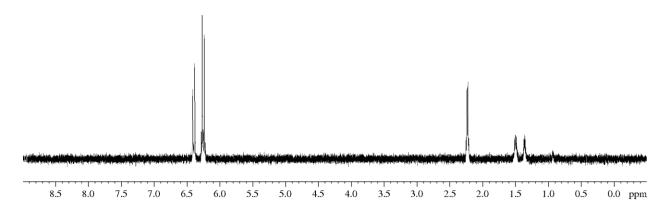


Figure 5. 1D TOCSY NMR with irradiation at 6.38 ppm.

The spectroscopic data is in accordance with the literature.<sup>[13]</sup>

# 4 Experiments with Propargylic Ester **S14**

**Equation 1**. Reaction of propargylic ester **S14** under the optimized conditions. The reaction was done with **S14** (0.13 mmol) in 1,4-dioxane (1 mL).

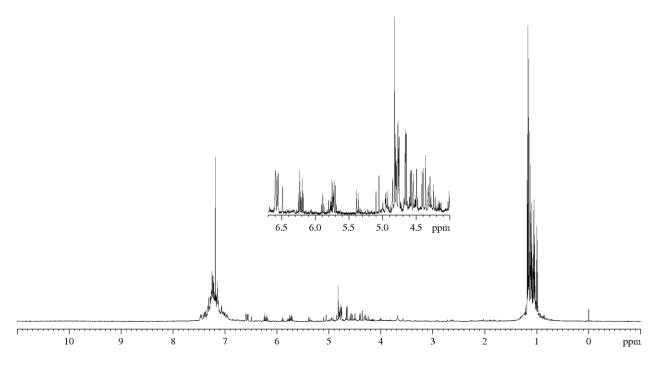


Figure 1. Reaction outcome by <sup>1</sup>H NMR of **S14** under the optimized conditions.

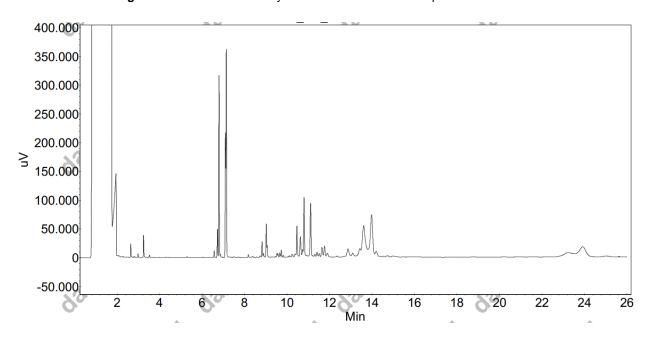


Figure 1. Reaction outcome by GC of S14 under the optimized conditions.

## 5 General Procedures

## 5.1 General Procedure – Sonogashira Coupling (**GP1**)

In a flame-dried Schlenk-flask the terminal alkyne (1.0–1.2 equiv) is added to a stirred mixture of [(Ph<sub>3</sub>P)<sub>2</sub>PdCl<sub>2</sub>] (1.0–2.0 mol%), Cul (1.0–2.0 mol%) and the corresponding aryl halide (1.0–1.2 equiv) in Et<sub>3</sub>N (0.2M, unless noted otherwise) at 0 °C. The mixture is allowed to warm to rt or heated to 50 °C and is stirred until full conversion of the starting material is detected (TLC or <sup>1</sup>H NMR). After quenching with H<sub>2</sub>O (5 mL/mmol) the reaction is extracted with *tert*-butyl methyl ether (3 x 5 mL/mmol). The combined organic phases are washed with sat. aq. NH<sub>4</sub>Cl (5 mL/mmol), brine (5 mL/mmol) and dried over MgSO<sub>4</sub>. Filtration and removal of all volatiles under reduced pressure affords the crude product which is purified as stated for each product.

## 5.2 General Procedure – Acylation of Alcohols (**GP2**)

R = Alkyl, Aryl

2.00 equiv DMAP

1.2 equiv acyl halide

$$R' = Methyl, tBu$$

In a flame-dried Schlenk flask, the alcohol (1.0 equiv) and 4-(dimethylamino)pyridine (DMAP, 2.0 equiv) are dissolved in CH<sub>2</sub>Cl<sub>2</sub> (4 mL/mmol). The corresponding acyl halide (1.2 equiv) is added dropwise. The reaction is stirred overnight at room temperature and is quenched by addition of H<sub>2</sub>O (5 mL/mmol). The aqueous phase is extracted with *tert*-butyl methyl ether (3 x 5 mL/mmol), the combined organic layers are washed with brine (5 mL/mmol) and dried over MgSO<sub>4</sub>. Filtration and removal of all volatiles under reduced pressure affords the crude product which is purified as stated for each product.

#### 5.3 General Procedure – Esterification (GP3)

In a flame-dried Schlenk flask, the corresponding carboxylic acid (1.0 equiv), 4-(dimethylamino)pyridine (DMAP, 10 mol%) and DCC (1.05 equiv per intended coupling) are dissolved in CH<sub>2</sub>Cl<sub>2</sub> (10 mL/mmol). Pent-3-yn-1-ol (1.0 equiv per intended coupling) is added dropwise. The reaction is stirred overnight at room temperature. After detecting of full conversion (TLC) the reaction mixture is filtered through a plug of silica (SiO<sub>2</sub>, 2 cm) and eluted with *tert*-butyl methyl ether (2 x 3 mL/mmol), the filtrate is concentrated under reduced pressure to afford the crude product which is purified as stated for each product.

#### 5.4 General Procedure – Pivalation (**GP4**)

1.20 equiv PivCl  
5 mol% DMAP  
1.20 equiv Et<sub>3</sub>N

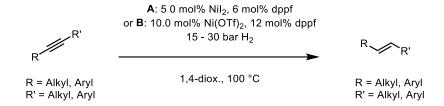
OPiv  

$$CH_2Cl_2$$
, rt

 $n = 0,1$ 

In a flame-dried Schlenk flask corresponding alcohols (1.00 equiv), 4-(dimethylamino)pyridine (DMAP, 5 mol%) and Et<sub>3</sub>N (1.20 equiv) are dissolved in CH<sub>2</sub>Cl<sub>2</sub> (1.6 mL/mmol). To this mixture pivaloyl chloride (1.20 equiv) is added dropwise at room temperature. The reaction is stirred overnight at room temperature and is quenched by the addition of H<sub>2</sub>O (1.6 mL/mmol). The aqueous layer is extracted with *tert*-butyl methyl ether (3 x 0.5 mL/mmol) and the combined organic layers are washed with brine (1 mL/mmol) and dry over MgSO<sub>4</sub>. Filtration and removal of all volatiles under reduced pressure affords the crude product which is purified as stated for each product.

## 5.5 General Procedure – *E*-Selective Hydrogenation (**GP5**)



All reactions were prepared as following: A hydrogenation vial was charged with condition **A**: Nil<sub>2</sub> (5 mol%), and dppf (6 mol%) or condition **B**: Ni(OTf)<sub>2</sub> (10 mol%) and dppf (12 mol%), the corresponding substrate (if solid, 1.0 equiv), a magnetic stirrer and a septum. The charged hydrogenation vial was evacuated and repressurized with nitrogen gas using a Schlenk line. Then the corresponding amount of solvent was added. Substrates (1.0 equiv) which are liquid at room temperature were added dropwise via syringe after the solvent was added. After addition of all components the reactions were stirred at room temperature for 2 min.

The autoclave was purged with  $N_2$  (1 x 1 bar, 3 x 10 bar) before the reaction vessels were placed in the autoclave under a counterflow of  $N_2$ , afterwards the autoclave was purged with  $N_2$  (3 x 10 bar) and  $H_2$  (3 x 10 bar) before the appropriate  $H_2$  pressure was applied (pressure is given as initial pressure before heating). The heating block was pre-heated to the temperature given before the autoclave was placed inside. After the reported reaction time the autoclave was allowed to cool to room temperature and  $H_2$  was released. The autoclave was purged with  $N_2$  (3 x 10 bar) before the reaction vessels were taken out. The reaction mixture was concentrated under reduced pressure, diluted with  $CH_2CI_2$  and filtered through a small plug of silica (2 cm, 2 mL,  $CH_2CI_2$  as eluent), and all volatiles were removed under reduced pressure. Reactions were subsequently analyzed either by GC or  $^1H$  NMR. The crude mixture was then subjected to purification as indicated with the appropriate substrates.

# 6 Preparation of Alkynyl Pivalate (**\$15**)

# 6.1 But-3-yn-1-yl pivalate (**\$15**)

3 4 0 515 C<sub>9</sub>H<sub>14</sub>O<sub>2</sub>

Mw = 154.21 g/mol

Prepare from but-3-yn-1-ol (3.78 mL, 50.0 mmol, 1.00 equiv), 4-(dimethylamino)pyridine (DMAP, 305 mg, 2.50 mmol, 5 mol%) and  $Et_3N$  (8.34 mL, 60.0 mmol, 1.20 equiv) were dissolved in  $CH_2Cl_2$  (100 mL). To this mixture pivaloyl chloride (7.35 mL, 60.0 mmol, 1.20 equiv) was added

dropwise at room temperature according to **GP4**. After 23 h the reaction was quenched, purification of the crude product *via* flash chromatography using cyclohexane/*tert*-butyl methyl ether = 30:1 as eluent giving **S15** (4.29 g, 27.2 mmol, 54%) as a colorless oil.

 $\mathbf{R}_f = 0.40$  (cyclohexane/tert-butyl methyl ether = 10:1).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.21 (s, 9H), 1.97 (t, <sup>4</sup>J = 2.7 Hz, 1H), 2.52 (td, <sup>3</sup>J = 6.8 Hz, <sup>4</sup>J = 2.7 Hz, 2H), 4.16 (t, <sup>3</sup>J = 6.8 Hz, 2H) ppm.

<sup>13</sup>**C NMR** (126 MHz, CDCl<sub>3</sub>):  $\delta$  = 19.1, 27.3, 38.9, 62.0, 69.8, 80.2, 178.4 ppm.

**HRMS** (ESI) calcd for  $C_9H_{15}O_2^+$  [(M+H)<sup>+</sup>]: 155.1067, found 155.1065.

**IR** (ATR) v = 3296 (w), 2964 (m), 1725 (s), 1480 (m), 1398 (w), 1365 (w), 1282 (s), 1149 (s), 1037 (m), 939 (w) cm<sup>-1</sup>.

# Pent-4-yn-1-yl pivalate (\$16)

1 2 3 5 0 6 7 8

 $C_{10}H_{16}O_2$ Mw = 168.24 g/mol

Prepared from pent-4-yn-1-ol (0.93 mL, 10.0 mmol, 1.00 equiv), 4-(dimethylamino)pyridine (DMAP, 61 mg, 0.50 mmol, 5 mol%) and  $Et_3N$  (1.40 mL, 12.0 mmol, 1.20 equiv) were dissolved in  $CH_2Cl_2$  (15 mL). To this mixture pivaloyl chloride (1.50 mL, 12.0 mmol, 1.20 equiv) was added dropwise at room temperature according to **GP4**. After 15 h the reaction was

the reaction was quenched, purification of the crude product *via* flash chromatography using cyclohexane/*tert*-butyl methyl ether = 30:1 as eluent giving **S16** (1.65 g, 27.2 mmol, 99%) as a pale yellow oil.

 $\mathbf{R}_f = 0.32$  (pentane).

<sup>1</sup>**H NMR** (400 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.19 (s, 9H, H-8), 1.86 (p, <sup>3</sup>*J* = 6.9 Hz, 2H, H-4), 1.96 (t, <sup>3</sup>*J* = 2.6 Hz, 1H, H-5), 2.28 (td, <sup>3</sup>*J* = 6.9 Hz, <sup>4</sup>*J* = 2.6 Hz, 2H, H-3), 4.15 (t, <sup>3</sup>*J* = 6.9 Hz, 2H) ppm.

<sup>13</sup>**C NMR** (101 MHz, CDCl<sub>3</sub>):  $\delta$  = 15.3, 27.1, 27.3, 27.8, 38.9, 63.0, 69.1, 83.2, 178.6 ppm.

**HRMS** (ESI) calcd for  $C_{10}H_{17}O_2^+$  [(M+H)+]: 169.1223, found 169.1222.

The analytic data is in accordance with the literature.[14]

# 7 Preperation of Internal Alkynes

#### 7.1 4-Phenylbut-3-yn-1-yl pivalate (6)

Prepared from 4-phenylbut-3-yn-1-ol ( $\mathbf{S2}$ , 439 mg, 3.00 mmol, 1.00 equiv) and pivaloyl chloride (434 mg, 3.60 mmol, 1.20 equiv) using DMAP (733 mg, 6.00 mmol, 2.00 equiv) in CH<sub>2</sub>Cl<sub>2</sub> (12 mL) at room temperature according to **GP2**. After 16 h the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-

pentane/tert-butyl methyl ether = 60:1 as eluent gave **6** (495 mg, 2.15 mmol, 72%) as a slightly yellow oil.

 $\mathbf{R}_f = 0.50$  (cyclohexane/tert-butyl methyl ether = 20:1).

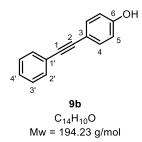
<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.23 (s, 9H), 2.75 (t, <sup>3</sup>*J* = 6.8 Hz, 2H), 4.25 (t, <sup>3</sup>*J* = 6.8 Hz, 2H), 7.28–7.31 (m, 3H), 7.38–7.40 (m, 2H) ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>):  $\delta$  = 20.1, 27.3, 38.9, 62.3, 82.0, 85.7, 123.6, 128.0, 128.4, 131.7, 178.5 ppm.

**HRMS** (ESI) calcd for  $C_{15}H_{19}O_2^+$  [(M+H)+]: 231.1380, found 231.1373.

The analytic data is in accordance with the literature. [15]

# 7.2 4-(Phenylethynyl)phenol (9b)



Prepared from ethynylbenzene (490 mg, 4.80 mmol, 1.20 equiv) and 4-iodophenol (880 mg, 4.00 mmol, 1.00 equiv) using [(PPh<sub>3</sub>)<sub>2</sub>PdCl<sub>2</sub>] (28 mg, 40  $\mu$ mol, 1.0 mol%) and CuI (7.6 mg, 40  $\mu$ mol, 1.0 mol%) in Et<sub>3</sub>N (30 mL) according to **GP1**. After 16 h the reaction was quenched, purification of the crude product *via* flash chromatography using cyclohexane/*tert*-butyl methyl ether = 3:1 as eluent followed by

recrystallization from n-pentane/CH $_2$ Cl $_2$  gave **9b** (556 mg, 2.86 mmol, 72%) as a shiny brown solid.

 $\mathbf{R}_f = 0.35$  (cyclohexane/tert-butyl methyl ether = 2:1).

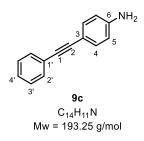
<sup>1</sup>**H NMR** (500 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 5.12 (br s, 1H, O*H*), 6.84 (m, 2H), 7.32–7.38 (m, 3H), 7.44 (m, 2H), 7.50–7.53 (m, 2H) ppm.

<sup>13</sup>C NMR (126 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 88.3, 89.5, 115.9, 115.9, 123.9, 128.5, 128.8, 131.8, 133.6, 156.3 ppm.

**HRMS** (EI) calcd for  $C_{14}H_{10}O^+$  [(M)+]: 194.0726, found 194.0728.

The analytic data is in accordance with the literature. [16]

#### 7.3 4-(Phenylethynyl)aniline (9c)



Following a modified literature procedure [17] 2-(4-(phenylethynyl)phenyl)isoindoline-1,3-dione (1.24 g, 3.83 mmol, 1.00 equiv) was dissolved in EtOH/CH<sub>2</sub>Cl<sub>2</sub> (v/v = 5:1, 12 mL) and hydrazine hydrate (65 wt%, 589 mg, 7.65 mmol, 2.00 equiv) was added. The mixture was stirred at room temperature for 2 h. After reaching full conversion (TLC analysis) the mixture was filtered through a plug of silica (1.5 cm) and

washed with *tert*-butyl methyl ether (3 x 5 mL). The filtrate was concentrated under reduced pressure and purification of the crude product *via* flash chromatography using cyclohexane/*tert*-butyl methyl ether = 2:1 as eluent followed by recrystallization from n-pentane/CH<sub>2</sub>Cl<sub>2</sub> gave **9c** (360 mg, 1.86 mmol, 49%) as a slightly yellow solid.

 $\mathbf{R}_{f} = 0.26$  (cyclohexane/tert-butyl methyl ether = 1:1).

<sup>1</sup>**H NMR** (500 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 3.91 (br s, 2H, N $H_2$ ), 6.65 (m<sub>c</sub>, 2H), 7.29–7.36 (m, 5H), 7.48–7.50 (m, 2H) ppm.

<sup>13</sup>C NMR (126 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 87.5, 90.5, 112.5, 115.0, 124.3, 128.1, 128.7, 131.6, 133.3, 147.6 ppm.

**HRMS** (ESI) calcd for  $C_{14}H_{12}N^+$  [(M+H)+]: 194.0964, found 194.0970.

The analytic data is in accordance with the literature.[18]

# 7.4 4-(Phenylethynyl)benzonitrile (9g)

Prepared from ethynylbenzene (490 mg, 4.80 mmol, 1.20 equiv) and 4-bromobenzonitrile (728 mg, 4.00 mmol, 1.00 equiv) using [(PPh<sub>3</sub>)<sub>2</sub>PdCl<sub>2</sub>] (28 mg, 40  $\mu$ mol, 1.0 mol%) and CuI (7.6 mg, 40  $\mu$ mol, 1.0 mol%) in Et<sub>3</sub>N (15 mL) following **GP1**. The reaction mixture was stirred for 50 h at room temperature. Purification of the crude product *via* flash chromatography cyclohexane/*tert*-butyl methyl ether = 50:1 as eluent followed by

recrystallization from *n*-pentane/CH<sub>2</sub>Cl<sub>2</sub> gave **9g** (542 mg, 2.67 mmol, 67%) as a white solid.

 $R_f = 0.49$  (cyclohexane/tert-butyl methyl ether = 10:1).

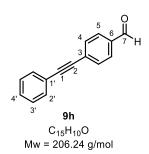
<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 7.36–7.41 (m, 3H), 7.53–7.56 (m, 2H), 7.60–7.61 (m, 2H), 7.63–7.65 (m, 2H) ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>):  $\delta$  = 87.9, 93.9, 116.6, 118.7, 122.4, 128.4, 128.7, 129.3, 131.9, 132.2, 132.2 ppm.

**HRMS** (APCI) calcd for  $C_{15}H_{10}N^+$  [(M+H)+]: 204.0808, found: 204.0812.

The analytic data is in accordance with the literature.[19]

# 7.5 4-(Phenylethynyl)benzaldehyde (**9h**)



Prepared from ethynylbenzene (1.23 g, 12.0 mmol, 1.00 equiv) and 4-bromobenzaldehyde (2.22 g, 12.0 mmol, 1.00 equiv) using  $[(PPh_3)_2PdCl_2]$  (84 mg, 0.12 mmol, 1.0 mol%) and CuI (23 mg, 0.12 mmol, 1.0 mol%) in  $Et_3N$  (45 mL) according to **GP1**. After 3 d the reaction was quenched, purification of the crude product *via* flash chromatography using cyclohexane/*tert*-butyl methyl ether = 10:1 as eluent followed by

recrystallization from n-pentane/CH $_2$ Cl $_2$  gave **9h** (931 mg, 4.51 mmol, 38%) as a shiny brown solid.

 $\mathbf{R}_{\rm f} = 0.45$  (cyclohexane/tert-butyl methyl ether = 4:1).

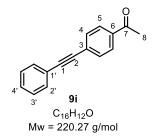
<sup>1</sup>**H NMR** (500 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 7.39–7.41 (m, 3H), 7.57–7.59 (m, 2H), 7.70 (m, 2H), 7.87 (m, 2H), 10.0 (s, 1H) ppm.

<sup>13</sup>C NMR (126 MHz, CD<sub>2</sub>Cl<sub>2</sub>): δ = 88.9, 93.5, 122.9, 128.9, 129.4, 129.8, 129.9, 132.2, 132.5, 136.0, 191.7 ppm.

**HRMS** (APCI) calcd for  $C_{15}H_{11}O^+$  [(M+H)<sup>+</sup>]: 207.0804, found 207.0808.

The analytic data is in accordance with the literature. [20]

#### 7.6 1-(4-(Phenylethynyl)phenyl)ethan-1-one (9i)



Prepared from ethynylbenzene (613 mg, 6.0 mmol, 1.00 equiv) and 1-(4-bromophenyl)ethan-1-one (1.19 g, 6.0 mmol, 1.00 equiv) using [(PPh<sub>3</sub>)<sub>2</sub>PdCl<sub>2</sub>] (42 mg, 60  $\mu$ mol, 1.0 mol%) and CuI (11 mg, 60  $\mu$ mol, 1.0 mol%) in Et<sub>3</sub>N (20 mL) according to **GP1**. After 40 h the reaction was quenched, purification of the crude product *via* flash chromatography cyclohexane/*tert*-butyl methyl ether = 10:1 as eluent followed by

recrystallization from *n*-pentane/CH<sub>2</sub>Cl<sub>2</sub> gave **9i** (726 mg, 3.30 mmol, 55%) as an off-white powder.

 $\mathbf{R}_f = 0.30$  (cyclohexane/tert-butyl methyl ether = 4:1).

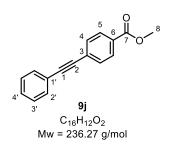
<sup>1</sup>**H NMR** (500 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 2.59 (s, 3H), 7.39 (m, 3H), 7.55–7.59 (m, 2H), 7.63 (m, 2H), 7.94 (m, 2H) ppm.

<sup>13</sup>**C NMR** (126 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 26.8, 88.9, 92.8, 123.1, 128.4, 128.6, 128.9, 129.3, 132.0, 132.1, 136.8, 197.4 ppm.

**HRMS** (APCI) calcd for  $C_{16}H_{13}O^+$  [(M+H)+]: 221.0961, found 221.0964.

The analytic data is in accordance with the literature. [21]

# 7.7 Methyl 4-(phenylethynyl)benzoate (9j)



Prepared from ethynylbenzene (306 mg, 3.0 mmol, 1.00 equiv) and methyl 4-iodobenzoate (943 mg, 3.60 mmol, 1.20 equiv) using [(PPh<sub>3</sub>)<sub>2</sub>PdCl<sub>2</sub>] (21 mg, 30  $\mu$ mol, 1.0 mol%) and CuI (5.7 mg, 30  $\mu$ mol, 1.0 mol%) in Et<sub>3</sub>N (11 mL) following **GP1**. The reaction mixture was stirred for 24 h at room temperature. Purification of the crude product *via* flash chromatography cyclohexane/*tert*-butyl methyl ether = 50:1 as

eluent gave 9j (329 mg, 1.39 mmol, 46%) as a slightly yellow solid.

 $R_f = 0.43$  (cyclohexane/tert-butyl methyl ether = 10:1).

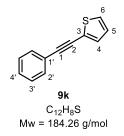
<sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 3.93 (s, 3H), 7.35–7.39 (m, 3H), 7.53–7.57 (m, 2H), 7.59 (m<sub>c</sub>, 2H), 8.02 (m<sub>c</sub>, 2H) ppm.

<sup>13</sup>**C NMR** (126 MHz, CDCl<sub>3</sub>):  $\delta$  = 52.3, 88.8, 92.5, 122.9, 128.1, 128.6, 128.9, 129.6, 129.6, 131.6, 131.9, 166.7 ppm.

**HRMS** (ESI) calcd for  $C_{16}H_{13}O_2^+$  [(M+H)+]: 237.0910, found: 237.0914.

The analytic data is in accordance with the literature.<sup>[22]</sup>

# 7.8 2-(Phenylethynyl)thiophene (**9k**)



Prepared from ethynylbenzene (613 mg, 6.00 mmol, 1.00 equiv) and 2-iodothiophene (1.26 g, 6.00 mmol, 1.00 equiv) using [(PPh<sub>3</sub>)<sub>2</sub>PdCl<sub>2</sub>] (42 mg, 60  $\mu$ mol, 1.0 mol%) and CuI (11 mg, 60  $\mu$ mol, 1.0 mol%) in Et<sub>3</sub>N (20 mL) according to **GP1**. After 24 h the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane as eluent gave **9k** (945 mg, 5.13 mmol, 85%) as a colorless oil which solidified upon standing.

 $\mathbf{R}_{f} = 0.37$  (*n*-pentane).

<sup>1</sup>**H NMR** (500 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 7.03–7.05 (m, 1H), 7.30–7.32 (m, 1H), 7.33–7.35 (m, 1H), 7.35–7.40 (m, 3H), 7.51–7.54 (m, 2H) ppm.

<sup>13</sup>**C NMR** (126 MHz,  $CD_2Cl_2$ ):  $\delta$  = 82.9, 93.3, 123.2, 123.6, 127.6, 127.8, 128.9, 128.9, 131.7, 132.4 ppm.

**HRMS** (EI) calcd for  $C_{12}H_8S^{*+}$  [(M)\*\*]: 184.0341, found 184.0343.

The analytic data is in accordance with the literature. [23]

#### 7.9 3-(Phenylethynyl)pyridine (91)

Prepared from ethynylbenzene (490 mg, 4.80 mmol, 1.20 equiv) and 3-bromopyridine (632 mg, 4.00 mmol, 1.00 equiv) using  $[(PPh_3)_2PdCl_2]$  (56 mg, 80  $\mu$ mol, 2 mol%) and Cul (15 mg, 80  $\mu$ mol, 2 mol%) in Et<sub>3</sub>N (15 mL) at 50 °C according to **GP1**. After 48 h the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane/*tert*-butyl methyl ether = 4:1as eluent followed by recrystallization from *n*-

pentane/CH<sub>2</sub>Cl<sub>2</sub> gave **9I** (611 mg, 3.41 mmol, 85%) as a light brown solid.

 $\mathbf{R}_f = 0.39$  (cyclohexane/tert-butyl methyl ether = 2:1).

<sup>1</sup>**H NMR** (400 MHz, CDCl<sub>3</sub>):  $\delta$  = 7.28 (m<sub>c</sub>, 1H), 7.35–7.38 (m, 3H), 7.52–7.57 (m, 2H), 7.80 (m<sub>c</sub>, 1H), 8.65 (m<sub>c</sub>, 1H), 8.77 (m<sub>c</sub>, 1H) ppm.

<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>):  $\delta$  = 86.0, 92.7, 120.6, 122.6, 123.1, 128.5, 128.9, 131.8, 138.5, 148.7, 152.4 ppm.

**HRMS** (ESI) calcd for  $C_{13}H_{10}N^+$  [(M+H)<sup>+</sup>]: 180.0808, found 180.0807.

The analytic data is in accordance with the literature.<sup>[24]</sup>

# 7.10 4-(3-Methoxyphenyl)but-3-yn-1-yl pivalate (**11a**)

7' 
$$0.5'$$
  $0.5'$ 

Prepared from but-3-yn-1-yl pivalate (**S15**, 617 mg, 4.00 mmol, 1.00 equiv) and 1-iodo-3-methoxybenzene (1.03 g, 4.4 mmol, 1.10 equiv) using [(PPh<sub>3</sub>)<sub>2</sub>PdCl<sub>2</sub>] (28 mg, 40  $\mu$ mol, 1.0 mol%) and Cul (7.6 mg, 40  $\mu$ mol, 1.0 mol%) in Et<sub>3</sub>N (15 mL) at room temperature according to **GP1**. After 24 h the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane/*tert*-

butyl methyl ether = 50:1 gave 11a (914 mg, 3.51 mmol, 88%) as a slightly yellow oil.

 $\mathbf{R}_f = 0.50$  (cyclohexane/tert-butyl methyl ether = 5:1).

<sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.23 (s, 9H), 2.74 (t, <sup>3</sup>J = 6.8 Hz, 2H), 3.79 (s, 3H), 4.25 (t, <sup>3</sup>J = 6.8 Hz, 2H), 6.85 (m<sub>c</sub>, 1H), 6.92 (m<sub>c</sub>, 1H), 6.98 (d, <sup>3</sup>J = 7.6 Hz, 1H), 7.19 (dd, <sup>3</sup>J = 8.0 Hz, 1H) ppm.

<sup>13</sup>**C NMR** (126 MHz, CDCl<sub>3</sub>):  $\delta$  = 20.1, 27.3, 38.9, 55.4, 62.2, 81.9, 85.6, 114.6, 116.6, 124.2, 124.6, 129.4, 159.4, 178.5 ppm.

**HRMS** (ESI) calcd for  $C_{16}H_{21}O_3^+$  [(M+H)+]: 261.1485, found 261.1483.

IR (ATR) v = 2961 (m), 1726 (s), 1598 (m), 1574 (m), 1479 (m), 1461 (m), 1283 (s), 1203 (m), 1143 (s), 1037 (s), 779 (s), 686 (s) cm<sup>-1</sup>.

#### 7.11 4-(3-(Trifluoromethyl)phenyl)but-3-yn-1-yl pivalate (**11b**)

$$F_3C$$
 $f_3C$ 
 $f_3C$ 

Mw = 298.31 g/mol

Prepared from but-3-yn-1-yl pivalate (**S15**, 617 mg, 4.00 mmol, 1.00 equiv) and 1-iodo-3-(trifluoromethyl)benzene (1.20 g, 4.4 mmol, 1.10 equiv) using [(PPh<sub>3</sub>)<sub>2</sub>PdCl<sub>2</sub>] (28 mg, 40  $\mu$ mol, 1.0 mol%) and Cul (7.6 mg, 40  $\mu$ mol, 1.0 mol%) in Et<sub>3</sub>N (15 mL) at room temperature according to **GP1**. After 40 h the reaction was quenched, purification of the crude product *via* flash chromatography using

cyclohexane/tert-butyl methyl ether = 50:1 as eluent gave **11b** (1.07 g, 3.60 mmol, 90%) as a slightly yellow oil.

 $\mathbf{R}_f = 0.36$  (cyclohexane/tert-butyl methyl ether = 20:1).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.23 (s, 9H), 2.75 (t, <sup>3</sup>*J* = 6.7 Hz, 2H), 4.25 (t, <sup>3</sup>*J* = 5.7 Hz, 2H), 7.40 (m<sub>c</sub>, 1H), 7.53 (m<sub>c</sub>, 2H), 7.64 (s, 1H) ppm.

<sup>13</sup>**C NMR** (126 MHz, CDCl<sub>3</sub>):  $\delta$  = 20.0, 27.3, 38.9, 62.0, 80.7, 87.7, 123.9 (q,  ${}^{1}J$  = 272 Hz), 124.5, 124.6 (q,  ${}^{3}J$  = 4.2 Hz), 128.5 (q,  ${}^{3}J$  = 3.8 Hz), 128.9, 131.0 (q,  ${}^{2}J$  = 32.5 Hz), 134.8, 178.4 ppm. ppm.

<sup>19</sup>**F NMR** (471 MHz, CDCl<sub>3</sub>):  $\delta$  = -63.0 ppm.

**HRMS** (APCI) calcd for  $C_{16}H_{17}F_3O_2^+$  [(M+H)+]: 299.1253, found 299.1251.

IR (ATR) v = 2971 (m), 1728 (s), 1481 (m), 1432 (m), 1329 (s), 1282 (m), 1236 (m), 1329 (S), 1124 (s), 1093 (s), 1002 (m), 900 (m), 800 (s), 695 (s) cm<sup>-1</sup>.

## 7.12 Methyl 4-(4-(pivaloyloxy)but-1-yn-1-yl)benzoate (**11c**)

Prepared from but-3-yn-1-yl pivalate (**S15**, 617 mg, 4.00 mmol, 1.00 equiv) and methyl 4-iodobenzoate (1.15 g, 4.4 mmol, 1.10 equiv) using [(PPh<sub>3</sub>)<sub>2</sub>PdCl<sub>2</sub>] (28 mg, 40  $\mu$ mol, 1.0 mol%) and Cul (7.6 mg, 40  $\mu$ mol, 1.0 mol%) in Et<sub>3</sub>N (15 mL) at room temperature according to **GP1**. After 24 h the reaction was quenched, purification of the crude product *via* flash

chromatography using cyclohexane/*tert*-butyl methyl ether = 10:1 gave **11c** (734 mg, 2.55 mmol, 64%) as a light brown solid.

**M.p.** =  $43 \, ^{\circ}$ C.

 $\mathbf{R}_f = 0.44$  (cyclohexane/tert-butyl methyl ether = 5:1).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.22 (s, 9H), 2.76 (t, <sup>3</sup>*J* = 6.7 Hz, 2H), 3.90 (s, 3H), 4.25 (t, <sup>3</sup>*J* = 6.7 Hz, 2H), 7.43 (m<sub>c</sub>, 2H), 7.95 (m<sub>c</sub>, 2H) ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>):  $\delta$  = 20.2, 27.3, 38.9, 52.3, 62.0, 81.5, 89.1, 128.3, 129.4, 129.6, 131.7, 166.7, 178.4 ppm.

**HRMS** (APCI) calcd for  $C_{17}H_{21}O_4^+$  [(M+H)+]: 289.1434, found 289.1433.

IR (ATR) v = 2950 (m), 1717 (s), 1603 (m), 1461 (m), 1437 (m), 1400 (m), 1274 (s), 1149 (s), 1108 (s), 1031 (m), 993 (m), 857 (s), 767 (s), 694 (s) cm<sup>-1</sup>.

# 7.13 4-(4-Cyanophenyl)but-3-yn-1-yl pivalate (**11d**)

N 8 3'

2'

11d

$$C_{16}H_{17}NO_{2}$$
 $Mw = 255.32$ 

Prepared from but-3-yn-1-yl pivalate (**S15**, 617 mg, 4.00 mmol, 1.00 equiv) and 4-iodobenzonitrile (964 mg, 4.4 mmol, 1.10 equiv) using [(PPh<sub>3</sub>)<sub>2</sub>PdCl<sub>2</sub>] (28 mg, 15  $\mu$ mol, 1.0 mol%) and Cul (7.6 mg, 40  $\mu$ mol, 1.0 mol%) in Et<sub>3</sub>N (15 mL) at room temperature according to **GP1**. After 20 h the reaction was quenched, purification of the

crude product *via* flash chromatography using cyclohexane/*tert*-butyl methyl ether =  $30:1\rightarrow10:1$  as eluent gave **11d** (811 mg, 3.18 mmol, 80%) as a yellow oil.

 $\mathbf{R}_f = 0.42$  (cyclohexane/tert-butyl methyl ether 4:1).

**1H NMR** (500 MHz, CDCl<sub>3</sub>): 1.22 (s, 9H), 2.77 (t,  ${}^{3}J$  = 6.7 Hz, 2H), 4.25 (t,  ${}^{3}J$  = 6.7 Hz, 2H), 7.44–7.45 (m, 2H), 7.56–7.58 (m, 2H) ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>): 20.2, 27.3, 38.9, 61.8, 80.7, 90.9, 111.5, 118.6, 128.5, 132.1, 132.3, 178.4 ppm.

**HRMS** (ESI) calcd for  $C_{16}H_{18}NO_2^+$  [(M+H)+]: 256.1332, found 256.1333.

**IR** (ATR) v = 2969 (m), 2226 (m), 1724 (s), 1603 (m), 1365 (w), 1478 (m), 1281 (m), 1143 (s), 1036 (m), 838 (s), 768 (m) cm<sup>-1</sup>.

## 7.14 4-(4-Chlorophenyl)but-3-yn-1-yl pivalate (**11e**)

 $CI \xrightarrow{3'} 0 \xrightarrow{5} 6 \xrightarrow{7}$   $CI \xrightarrow{4'} 3'$   $CI \xrightarrow{1}^{2'} 2'$   $CI_{5}H_{17}CIO_{2}$  Mw = 264.75 g/mol

Prepared from but-3-yn-1-yl pivalate (**S15**, 617 mg, 4.00 mmol, 1.00 equiv) and 1-chloro-4-iodobenzene (1.05 g, 4.4 mmol, 1.10 equiv) using [(PPh<sub>3</sub>)<sub>2</sub>PdCl<sub>2</sub>] (28 mg, 40  $\mu$ mol, 1.0 mol%) and Cul (7.6 mg, 40  $\mu$ mol, 1.0 mol%) in Et<sub>3</sub>N (15 mL) at room temperature according to **GP1**. After 28 h the reaction was quenched, purification of the crude product *via* flash chromatography using

cyclohexane/*tert*-butyl methyl ether = 100:1 as eluent gave **11e** (897 mg, 3.39 mmol, 85%) as a slightly yellow solid.

 $\mathbf{R}_f = 0.41$  (cyclohexane/tert-butyl methyl ether = 20:1).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.22 (s, 9H), 2.73 (t, <sup>3</sup>*J* = 6.7 Hz, 2H), 4.24 (t, <sup>3</sup>*J* = 6.7 Hz, 2H), 7.25 (m<sub>c</sub>, 2H), 7.31 (m<sub>c</sub>, 2H) ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>):  $\delta$  = 20.1, 27.3, 38.9, 62.1, 81.0, 86.9, 122.1, 128.7, 133.0, 134.0, 178.4 ppm.

**HRMS** (APCI) calcd for  $C_{15}H_{18}CIO_2^+$  [(M+H)+]: 265.0990, found 265.0994.

**IR** (ATR) v = 2969 (m), 1726 (s), 1487 (s), 1396 (m), 1280 (s), 1143 (s), 1089 (s), 1036 (m), 1013 (m), 826 (s), 768 (m) cm<sup>-1</sup>.

## 7.15 (5-Methylhex-1-yn-1-yl)benzene (**11f**)

3' 
$$\frac{2'}{4'}$$
  $\frac{1}{6'}$   $\frac{1}{6'}$   $\frac{11f}{C_{13}H_{16}}$  Mw = 172.27

Prepared from 5-methyl-1-hexyne (263  $\mu$ L, 2.00 mmol, 1.00 equiv) and iodobenzene (245  $\mu$ L, 4.4 mmol, 1.10 equiv) using [(PPh<sub>3</sub>)<sub>2</sub>PdCl<sub>2</sub>] (14 mg, 20  $\mu$ mol, 1.0 mol%) and CuI (3.8 mg, 420  $\mu$ mol, 1.0 mol%) in Et<sub>3</sub>N (5 mL) at room temperature according to **GP1**. After 20 h the reaction was quenched, purification of the crude product *via* flash chromatography using

cyclohexane/tert-butyl methyl ether =  $10:1\rightarrow 4:1$  as eluent gave **11f** (927 mg, 3.57 mmol, 90%) as a pale yellow oil.

**R** $_f = 0.57$  (pentane).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>): 0.93 (s, 3H), 0.95 (s, 3H), 1.51 (q,  ${}^{3}J$  = 7.3 Hz, 2H), 1.77 (sept,  ${}^{3}J$  = 6.7 Hz, 1H), 2.41 (t,  ${}^{3}J$  = 7.5 Hz, 2H), 7.25–7.29 (m, 3H), 7.38–7.40 (m, 2H) ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>): 17.6, 22.4, 27.4, 37.8, 80.6, 90.6, 124.3, 127.6, 128.3, 131.7 ppm. HRMS (ESI) calcd for C<sub>13</sub>H<sub>15</sub><sup>-</sup> [(M-H)<sup>-</sup>]: 171.1179, found 171.1169.

IR (ATR) v = 3057 (w), 2954 (m), 2928 (m), 2868 (m), 2234 (w), 1597 (m), 1465 (m), 1383 (w), 1320 (w), 1063 (w), 1023 (w), 911 (w), 753(s), 689 (s) cm<sup>-1</sup>.

# 7.16 Methyl-5-phenylpent-4-ynoate (11g)

Following a modified procedure<sup>[25]</sup> 5-phenylpent-4-ynoic acid (0.26 g, 1.5 mmol, 1.0 equiv) and  $K_2CO_3$  (0.42 g, 3.0 mmol, 2.0 equiv) were suspended in DMF (6 mL) and MeI (0.19 mL, 3.0 mmol, 2.0 equiv) was added dropwise at rt. The mixture was stirred for 3 h. The mixture was concentrated and  $H_2O$  (40 mL) was added. The aqueous layer was

extracted with *tert*-butyl methyl ether (3 x 20 mL) and the combined organic layers were dried over MgSO<sub>4</sub>. Removal of all volatiles under reduced pressure afforded the crude product which was purified *via* flash chromatography using cyclohexane/*tert*-butyl methyl ether = 20:1 as eluent. The target compound **11g** (0.26 g, 1.4 mmol, 93%) was obtained as a colorless oil.

 $\mathbf{R}_f = 0.42$  (cyclohexane/tert-butyl methyl ether = 10:1)

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 2.64 (m<sub>c</sub>, 2H), 2.74 (m<sub>c</sub>, 2H), 3.72 (s, 3H), 7.26–7.39 (m, 3H), 7.37–7.40 (m, 2H) ppm.

<sup>13</sup>**C NMR** (125 MHz, CDCl<sub>3</sub>):  $\delta$  = 15.5, 33.6, 51.9, 81.3, 88.1, 123.7, 127.9, 128.3, 131.7, 172.5 ppm.

**HRMS** (APCI) calculated for  $C_{12}H_{13}O_2^+$  [(M+H)+]: 189.0910, found 189.0908.

The analytic data is in accordance with the literature.[26]

#### 7.17 3-Phenylprop-2-yn-1-yl pivalate (S13)

Prepared from 3-phenylprop-2-yn-1-ol (**S19**, 400 mg, 3.03 mmol, 1.00 equiv) and pivaloyl chloride (439 mg, 3.64 mmol, 1.20 equiv) using DMAP (740 mg, 6.06 mmol, 2.00 equiv) in  $CH_2Cl_2$  (12 mL) at room temperature according to **GP2**. After 27 h the reaction was quenched, purification of the crude product *via* flash chromatography using cyclohexane/*tert*-butyl methyl ether = 20:1 as eluent gave **S13** (643 mg,

2.97 mmol, 98%) as a colorless oil.

 $\mathbf{R}_f = 0.43$  (cyclohexane/tert-butyl methyl ether = 20:1).

<sup>1</sup>**H NMR** (500 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 1.24 (s, 9H), 4.88 (s, 2H), 7.31–7.37 (m, 3H), 7.43–7.47 (m, 2H) ppm.

<sup>13</sup>C NMR (126 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 27.3, 39.1, 53.1, 84.0, 86.2, 122.7, 128.8, 129.2, 132.2, 178.0 ppm.

**HRMS** (EI) calcd for  $C_{14}H_{16}O_2^{••}$  [(M) ••]: 216.1145, found 216.1143.

**IR** (ATR) v = 2971 (m), 2872 (w), 1730 (s), 1490 (m), 1364 (m), 1277 (s), 1131 (s), 1031 (s), 988 (m), 952 (m), 754 (s), 689 (s) cm<sup>-1</sup>.

# 7.18 Triisopropyl((4-phenylbut-3-yn-1-yl)oxy)silane (11i)

3
0
5

11i
$$C_{19}H_{30}OSi$$
Mw = 302.53 a/mol

In a Schlenk tube 4-Phenylbut-3-yn-1-ol (**\$2**, 585 mg, 4.00 mmol, 1.00 equiv), DMAP (2.4 mg, 0.02 mmol, 5.0 mol%) and imidazole (327 mg, 4.80 mmol, 1.20 equiv) were dissolved in DMF (8 mL). To this solution chlorotriisopropylsilane (771 mg, 4.00 mmol, 1.00 equiv) was added dropwise at room temperature. After 19 h the reaction was

quenched by adding H<sub>2</sub>O (60 mL). The aqueous layer was extracted with tert-butyl methyl ether

(3 x 10 mL) and the combined organic layers were washed with  $H_2O$  (20 mL) and brine (20 mL). After drying over MgSO<sub>4</sub>, filtration and concentration under reduced pressure the crude product was obtained. Purification *via* flash chromatography using cyclohexane/*tert*-butyl methyl ether = 100:1 as eluent gave **11i** (1.0 g, 3.3 mmol, 83%) as a slightly yellow oil.

 $\mathbf{R}_f = 0.59$  (cyclohexane/tert-butyl methyl ether = 30:1).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.08–1.10 (m, 18H), 1.11–1.17 (m, 3H), 2.66 (t, <sup>3</sup>*J* = 7.2 Hz, 2H), 3.90 (t, <sup>3</sup>*J* = 7.2 Hz, 2H), 7.27–7.30 (m, 3H), 7.38–7.41 (m, 2H) ppm.

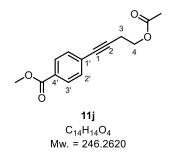
<sup>13</sup>C NMR (126 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 12.2, 18.1, 24.1, 62.4, 81.7, 87.4, 124.0, 127.8, 128.3, 131.7 ppm.

<sup>29</sup>**Si DEPT NMR** (99 MHz, CDCl<sub>3</sub>, J = 20.0 Hz, tip angle 45.0 °): δ = 13.4 ppm.

**HRMS** (EI) calcd for  $C_{16}H_{23}OSi^+$  [(M- $C_3H_7$ )+]: 259.1513, found 259.1505.

IR (ATR) v = 2940 (s), 2864 (s), 1461 (m), 1383 (m), 1104 (s), 1069 (s), 994 (m), 880 (s), 797 (m), 753 (s), 685 (s) cm<sup>-1</sup>.

## 7.19 Methyl 4-(4-acetoxybut-1-yn-1-yl)benzoate (**11j**)



Prepared from methyl 4-(4-hydroxybut-1-yn-1-yl)benzoate (612 mg, 3.0 mmol, 1.0 equiv), DMAP (733 mg, 6.0 mmol, 2 equiv) and acethylbromide (0.27 mL, 3.6 mmol, 1.2 equiv) in  $CH_2Cl_2$  (12 mL) at room temperature according to GP2. After 15 h the reaction was quenched, the mixture was filtrated, then was eluded with  $CH_2Cl_2$  and purification of the crude product *via* flash chromatography using

cyclohexane/*tert*-butyl methyl ether = 5:1 as eluent gave **11j** (708 mg, 2.88 mmol, 96%) as a pale yellow solid.

 $\mathbf{R}_f = 0.46$  (cyclohexane/tert-butyl methyl ether = 2:1)

<sup>1</sup>**H NMR** (500 MHz, CD<sub>2</sub>Cl<sub>2</sub>): 2.07 (s, 3H), 2.77 (t,  ${}^{3}J = 6.8$  Hz, 2H), 3.88 (s, 3H), 4.24 (t,  ${}^{3}J = 6.8$  Hz, 2H), 7.76 (d,  ${}^{3}J = 8.3$  Hz, 2H), 7.95 (d,  ${}^{3}J = 8.6$  Hz, 2H) ppm.

<sup>13</sup>**C NMR** (125 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 20.3, 21.0, 52.4, 62.5, 81.5, 89.5, 128.5, 129.7, 129.9, 131.9, 166.7, 171.0 ppm.

**HRMS** (APCI) calculated for  $C_{14}H_{15}O_4^+$  [(M+H)+]: 247.0965 found 247.0963.

**IR** (ATR) v = 2958 (w), 1741 (s), 1603 (m), 1432 (s), 1364 (s), 1278 (s), 1233 (s), 1191 (s), 1106 (s), 1042 (s), 950 (m), 853 (s), 767 (s), 696 (s) cm<sup>-1</sup>.

**HRMS** (APCI) calculated for  $C_{14}H_{15}O_4^+$  [(M+H)+]: 247.0965, found247.0977.

**IR** (ATR) v = 2952 (w), 2920 (w), 1717 (s), 1605 (m), 1559 (w), 1434 (m), 1271 (s), 1230 (s), 1174 (m), 1106 (s), 1040 (s), 857 (m), 767 (s) cm<sup>-1</sup>.

## 7.20 5-(Quinolin-3-yl)pent-4-yn-1-ol (**\$19**)

5' 
$$\frac{4'}{6'}$$
  $\frac{2'}{7'}$   $\frac{3'}{9'}$   $\frac{1}{9'}$   $\frac{1}{4}$  OH

S19

 $C_{14}H_{13}NO$ 
 $Mw = 211.2640$ 

Prepared from 3-bromoquinoline (400  $\mu$ L, 3.00 mmol, 1.00 equiv) and pentyn-1-ol (306  $\mu$ L, 1.10 mmol, 1.10 equiv) using [(PPh<sub>3</sub>)<sub>2</sub>PdCl<sub>2</sub>] (21 mg, 30  $\mu$ mol, 1 mol%) and CuI (17 mg, 90  $\mu$ mol, 3 mol%) in Et<sub>3</sub>N (5 mL) at 60 °C according to **GP1**. After 23 h the reaction was quenched. The crude product was further use without purification.

 $\mathbf{R}_f = 0.49$  (*tert*-butyl methyl ether).

<sup>1</sup>**H NMR** (400 MHz, CDCl<sub>3</sub>): 1.90 (q,  ${}^{3}J$  = 6.9 Hz, 2H), 2.61 (t,  ${}^{3}J$  = 6.9 Hz, 2H), 2.57 (br s, 1H), 3.85 (t,  ${}^{3}J$  = 6.0 Hz, 2H), 7.52 (ddd,  ${}^{3}J$  = 8.2 Hz,  ${}^{4}J$  = 5.7 Hz,  ${}^{5}J$  = 1.1 Hz, 1H), 7.67 (ddd,  ${}^{3}J$  = 8.6 Hz,  ${}^{4}J$  = 6.9 Hz,  ${}^{5}J$  = 1.6 Hz, 1H), 7.71 (dd,  ${}^{3}J$  = 8.3 Hz,  ${}^{4}J$  = 1.2 Hz, 1H), 8.05 (dd,  ${}^{3}J$  = 8.4 Hz,  ${}^{4}J$  = 0.5 Hz, 1H), 8.12 (d,  ${}^{4}J$  = 2.0 Hz, 1H), 8.84 (d,  ${}^{4}J$  = 2.1 Hz, 1H) ppm.

<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>): 16.2, 31.4, 61.3, 78.4, 93.3, 118.1, 127.3, 127.4, 127.5, 129.2, 129.9, 138.3, 146.5, 152.4 ppm.

**HRMS** (ESI) calcd for  $C_{14}H_{13}NO^+$  [(M+H)+]: 212.1070, found 212.1069.

The analytic data is in accordance with the literature.<sup>[27]</sup>

# 7.21 5-(Quinolin-3-yl)pent-4-yn-1-yl pivalate (**11k**)

Prepared from 5-(quinolin-3-yl)pent-4-yn-1-ol (**S19**, 317 mg, 1.50 mmol, 1.00 equiv), 4-(dimethylamino)pyridine (DMAP, 9 mg, 75  $\mu$ mol, 5 mol%) and Et<sub>3</sub>N (250  $\mu$ L, 1.80 mmol, 1.20 equiv) were dissolved in CH<sub>2</sub>Cl<sub>2</sub> (5 mL). To this mixture pivaloyl chloride (220  $\mu$ L, 1.80 mmol, 1.20 equiv) was added dropwise at room

temperature according to GP4. After 21 h the reaction was quenched, the purification of crude

product *via* flash chromatography using cyclohexane/*tert*-butyl methyl ether = 30:1 as eluent giving **11k** (327 mg, 1.11 mmol, 74%) as a yellow oil.

 $\mathbf{R}_f = 0.28$  (cyclohexane/tert-butyl methyl ether).

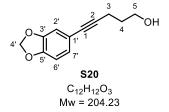
<sup>1</sup>**H NMR** (400 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.22 (s, 9H), 2.00 (p,  ${}^{3}J$  = 7.1 Hz, 2H), 2.56 (t,  ${}^{3}J$  = 7.1 Hz, 2H), 4.24 (t,  ${}^{3}J$  = 6.2 Hz, 2H), 7.54 (ddd,  ${}^{3}J$  = 8.0 Hz,  ${}^{4}J$  = 7.1 Hz,  ${}^{5}J$  = 1.2 Hz 1H), 7.69 (ddd,  ${}^{3}J$  = 8.5 Hz,  ${}^{4}J$  = 7.0 Hz,  ${}^{5}J$  = 1.5 Hz 1H), 7.75 (d,  ${}^{3}J$  = 8.2 Hz, 1H), 8.06 (d,  ${}^{3}J$  = 8.2 Hz, 1H), 8.16 (d,  ${}^{4}J$  = 1.6 Hz, 1H), 8.87 (d,  ${}^{4}J$  = 2.0 Hz, 1H) ppm.

<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>):  $\delta$  = 16.5, 27.4, 27.9, 39.0, 63.1, 78.7, 92.4, 118.8, 127.3, 127.4, 127.6, 129.5, 129.9, 138.3, 146.8, 152.5, 178.6 ppm.

**HRMS** (ESI) calcd for  $C_{19}H_{22}NO_2^+$  [(M+H)+]: 296.1645, found 296.1638.

IR (ATR) v = 2960 (m), 2231 (w), 1722 (s), 1618 (w), 1564 (m), 1480 (m), 1397 (w), 1346 (w), 1280 (m), 1148 (s), 1035 (m), 907 (m), 784 (s), 750 (s) cm<sup>-1</sup>.

#### 7.22 5-(Benzo[d][1,3]dioxol-5-yl)pent-4-yn-1-ol (**\$20**)



Prepared from 1-bromo-(3,4-methylene-dioxy)benzene (360  $\mu$ L, 3.00 mmol, 1.00 equiv) and pent-4-yn-1-ol (305  $\mu$ L, 3.30 mmol, 1.10 equiv) using [(PPh<sub>3</sub>)<sub>2</sub>PdCl<sub>2</sub>] (105 mg, 0.3 mmol, 5.0 mol%) and Cul (57 mg, 0.15 mmol, 3.0 mol%) in Et<sub>3</sub>N (5 mL) at room temperature according to **GP1**. After 30 h the reaction was quenched, purification of

the crude product *via* flash chromatography using cyclohexane/*tert*-butyl methyl ether = 5:1 as eluent gave **S20** (565 mg, 1.82 mmol, 93%) as a white solid.

 $\mathbf{R}_f = 0.37$  (pentane/tert-butyl methyl ether 4:1).

<sup>1</sup>**H NMR** (400 MHz, CDCl<sub>3</sub>): 1.58 (br s, 1H), 1.84 (p,  ${}^{3}J = 6.4$  Hz, 2H), 2.51 (t,  ${}^{3}J = 7.0$  Hz, 2H), 3.81 (t,  ${}^{3}J = 6.1$  Hz, 2H), 5.95 (s, 2H), 6.71 (d,  ${}^{3}J = 8.1$  Hz, 1H), 6.84 (d,  ${}^{4}J = 1.5$  Hz, 1H), 6.90 (dd,  ${}^{3}J = 8.0$  Hz,  ${}^{4}J = 1.6$  Hz, 1H) ppm.

<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>): 16.1, 31.5, 62.0, 81.0, 87.6, 101.3, 108.5, 111.8, 117.1, 126.0, 147.4, 147.5 ppm.

**HRMS** (ESI) calcd for  $C_{12}H_{13}O_{3}^{+}$  [(M+H)+]: 205.0859, found 205.0860.

The analytic data is in accordance with the literature. [28]

### 7.23 5-(Benzo[*d*][1,3]dioxol-5-yl)pent-4-yn-1-yl acetate (**11l**)

Prepared from 5-(benzo[d][1,3]dioxol-5-yl)pent-4-yn-1-ol (**S20**, 204 mg, 1.0mmol 1.00 equiv), DMAP (244 mg, 2.0 mmol, 2.0 equiv) and acetyl chloride (89  $\mu$ L, 1.2 mmol, 1.20 equiv) in CH<sub>2</sub>Cl<sub>2</sub> (5 mL) at room temperature according to **GP2**. After 16 h the reaction was quenched, the mixture was filtered, then was eluted with CH<sub>2</sub>Cl<sub>2</sub> and

purification of the crude product *via* flash chromatography using cyclohexane/*tert*-butyl methyl ether = 30:1 as eluent gave **11I** (222 mg, 0.90 mmol, 90%) as a pale yellow solid.

**M.p.** =  $47 \, ^{\circ}$ C.

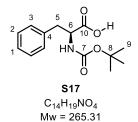
<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>): 1.91 (p,  ${}^{3}J$  = 7.0 Hz, 2H), 2.06 (s, 3H), 2.48 (t,  ${}^{3}J$  = 6.8 Hz, 2H), 4.21 (t,  ${}^{3}J$  = 6.3 Hz, 2H), 5.95 (s, 2H), 6.71 (d,  ${}^{3}J$  = 8.1 Hz, 1H), 6.84 (d,  ${}^{4}J$  = 1.6 Hz, 1H), 6.90 (dd,  ${}^{3}J$  = 8.1 Hz,  ${}^{4}J$  = 1.6 Hz, 1H) ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>): 16.3, 21.1, 28.0, 63.4, 81.2, 87.0, 101.3, 108.5, 111.8, 117.1, 126.1, 147.5, 147.6, 171.2 ppm.

**HRMS** (ESI) calcd for  $C_{14}H_{15}O_4^+$  [(M+H)+]: 247.0965, found 247.0964.

**IR** (ATR) v = 3328 (m), 2881 (m), 1602 (w), 1483 (s), 1438(s), 1326 (m), 1243 (s), 1207 (s), 1033 (s), 930 (s), 857 (m), 806 (s), 721 (w) cm<sup>-1</sup>.

# 7.24 (*tert*-Butoxycarbonyl)-L-phenylalanine (**S17**)



Following a modified procedure<sup>[29]</sup> phenylalanine was dissolved in dioxane/water (2:1, 30 mL), which was added NaOH (1M, 10 mL) and cooled in an ice-bath. Then, (Boc)<sub>2</sub>O (3272 g, 15 mmol, 1.5 equiv) and NaHCO<sub>3</sub> (840 mg, 10 mmol, 1.0 equiv) were added and stirred for 23 h at room temperature. The mixture was reduced to half of original volume under

reduced pressure. The residue was diluted with EtOAc (40 mL), cooled in ice-bath and acidified to pH = 2.5-3 with KHSO<sub>4</sub> (1M). The layer was separated by extraction with EtOAc ( $2\times20$  mL). Then, the combined organic layers were washed with water ( $3\times20$  mL), dried over MgSO<sub>4</sub> and evaporated to give **\$17** (2660 mg, 10.0 mmol, quantitive yield) as a colorless oil.

 $\mathbf{R}_{f} = 0.37$  (pentane/tert-butyl methyl ether 4:1).

 $[\alpha]_D^{20}$ = +33.6 (c 1.0, CHCl<sub>3</sub>).

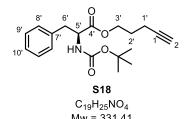
<sup>1</sup>**H NMR** (400 MHz, CDCl<sub>3</sub>):) 1.32–1.43 (m, 9H), 3.18–3.22 (m, 2H), 6.61 (br, 1H), 4.92 (br, 1H), 7.19 (m<sub>c</sub>, 2H), 7.26–7.31 (m, 3H) ppm.

<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>): 27.5, 28.4, 40.0, 54.4, 80.3, 85.3, 127.1, 128.7, 129.5, 136.0, 146.9, 155.5, 176.2 ppm.

**HRMS** (ESI) calcd for  $C_{14}H_{20}NO_4^+$  [(M+H)+]: 266.1387, found 266.1381.

The analytic data is in accordance with the literature.[30]

#### 7.25 Pent-4-yn-1-yl (*tert*-butoxycarbonyl)-L-phenylalaninate (**S18**)



In a flame-dried Schlenk flask, (S17,tert-butoxycarbonyl)-L-phenylalanine (795 mg, 3.0 mmol, 1.00 equiv), 4-pentyn-1-ol (416  $\mu$ L, 4.5 mmol, 1.50 equiv) and DMAP (440 mg, 3.60 mmol, 1.20 equiv) was dissolved in CH<sub>3</sub>CN (3 mL). The mixture was cooled in ice-bath. Then, DCC (805 mg, 3.90 mmol, 1.30 equiv) was added

to reaction mixture, stirred at room temperature for 16 h. The mixture was filtered and washed with TBME (2x10 mL). The filtrated was evaporated and purified of the crude product *via* flash chromatography using cyclohexane/*tert*-butyl methyl ether = 30:1 as eluent gave **S18** (398 mg, 1.20 mmol, 41%) as a yellow oil.

 $\mathbf{R}_f = 0.77$  (cyclohexane/*tert*-butyl methyl ether 10:1).

 $[\alpha]_D^{20}$ = +56.1 (c 1.0, CHCl<sub>3</sub>).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>): 1.42 (s, 9H), 1.76–1.83 (m, 2H), 1.97 (t,  ${}^{3}J$  = 2.6 Hz, 1H), 2.17 (td,  ${}^{3}J$  = 7.5 Hz,  ${}^{4}J$  = 2.6 Hz, 2H), 3.08 (d,  ${}^{3}J$  = 5.4 Hz, 2H), 4.19 (td,  ${}^{3}J$  = 6.7 Hz,  ${}^{4}J$  = 1.6 Hz, 2H), 7.14 (d,  ${}^{3}J$  = 7.2 Hz, 2H), 4.57 (m<sub>c</sub>, 1H), 4.99 (m<sub>c</sub>, 1H), 7.22–7.26 (m, 1H), 7.27–7.31 (m, 2H) ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>): 15.2, 27.1, 27.5, 28.4, 38.6, 54.6, 63.9, 69.3, 80.0, 83.0, 127.2, 128.7, 129.4, 136.1, 155.2, 172.0 ppm.

**HRMS** (ESI) calcd for  $C_{19}H_{26}NO_4^+$  [(M+H)+]:332.1856, found 332.1859.

IR (ATR) v = 3383 (w), 3293 (w), 2973 (w), 1705 (s), 1494 (m), 1453 (w), 1346 (m), 1158 (s), 1023 (m), 859 (w), 745 (w), 699 (m) cm<sup>-1</sup>.

#### 7.26 5-Phenylpent-4-yn-1-yl (*tert*-butoxycarbonyl)-L-phenylalaninate (**11m**)

Prepared from *tert*-butoxycarbonyl)-L-phenylalaninate (**S18**, 331 mg, 1.00 mmol, 1.00 equiv) and iodobenzene (123  $\mu$ L, 1.10 mmol, 1.10 equiv) using [(PPh<sub>3</sub>)<sub>2</sub>PdCl<sub>2</sub>] (7 mg, 10  $\mu$ mol, 1.0 mol%) and CuI (7 mg, 30  $\mu$ mol, 3 mol%) in Et<sub>3</sub>N (5 mL) at room temperature according to **GP1**. After 23 h the reaction

was quenched, purification of the crude product *via* flash chromatography using pentane/*tert*-butyl methyl ether = 10:1 as eluent gave **11m** (387 mg, 0.95 mmol, 95%) as an orange oil.

 $\mathbf{R}_f = 0.48$  (pentane/*tert*-butyl methyl ether 10:1).

 $[\alpha]_D^{20}$ = +12.5 (c 1.0, CHCl<sub>3</sub>).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>): 1.43 (s, 9H), 1.87–1.90 (m, 2H), 2.42 (t,  ${}^{3}J$  = 7.2 Hz, 2H), 3.09 (d,  ${}^{3}J$  = 4.7 Hz, 2H), 4.26 (t,  ${}^{3}J$  = 6.2 Hz, 2H), 4.58–4.60 (m, 1H), 4.99 (m<sub>c</sub>, 1H), 7.14–7.15 (m, 2H), 7.23–7.29 (m, 6H), 7.38–7.40 (m, 2H) ppm .

<sup>13</sup>**C NMR** (126 MHz, CDCl<sub>3</sub>): 16.2, 27.1, 27.8, 28.4, 38.7, 49.6, 54.7, 64.1, 80.1, 81.6, 88.5, 123.8, 127.2, 127.9, 128.7, 129.5, 131.7, 136.1, 155.2, 172.1 ppm.

**HRMS** (ESI) calcd for  $C_{25}H_{29}NO_4^+$  [(M+H)+]: 408.2169, found 408.2168.

**IR** (ATR) v = 3375 (w), 2973 (w), 2120 (w), 1709 (s), 1599 (w), 1490 (s), 1453 (w), 1364 (m), 1247 (m), 1157 (s), 1052 (m), 1023 (m), 858 (w), 754 (s), 692 (s) cm<sup>-1</sup>.

# 7.27 5-(Quinolin-3-yl)pent-4-yn-1-yl (*tert*-butoxycarbonyl)-L-phenylalaninate (**11n**)

In a flame-dried Schlenk flask, (*tert*-butoxycarbonyl)-L-phenylalanine (**\$18**, 398 mg, 1.50 mmol, 1.00 equiv), 5-(quinolin-3-yl)pent-4-yn-1-ol (349 mg, 1.65 mmol, 1.10 equiv) and DMAP (220 mg, 1.8 mmol, 1.2 equiv) was dissolved in CH<sub>3</sub>CN (5 mL). The mixture was cooled in an

ice-bath. Then, DCC (402 mg, 1.95 mmol, 1.30 equiv) was added to reaction mixture, and the mixture was stirred at room temperature for 25 h. The mixture was filtered and washed with

TBME. The filtrate was evaporated and purified of the crude product *via* flash chromatography using pentane/*tert*-butyl methyl ether = 4:1 as eluent gave **11n** (451 mg, 0.98 mmol, 66%) as a colorless oil.

 $\mathbf{R}_f = 0.77$  (pentane/tert-butyl methyl ether 1:1).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>): 1.42 (s, 9H), 2.48 (t,  ${}^{3}J = 7.0$  Hz, 2H), 1.93 (m<sub>c</sub>, 2H), 3.10 (d,  ${}^{3}J = 6.1$  Hz, 2H), 4.28 (td,  ${}^{3}J = 7.2$  Hz, J = 1.8 Hz, 2H), 4.61 (m<sub>c</sub>, 1H), 5.00 (m<sub>c</sub>, 1H), 7.15–7.16 (m, 2H), 7.23–7.30 (m, 3H), 7.54 (ddd,  ${}^{3}J = 8.3$  Hz,  ${}^{3}J = 7.0$  Hz,  ${}^{4}J = 1.4$  Hz, 1H), 7.70 (ddd,  ${}^{3}J = 9.0$  Hz,  ${}^{3}J = 6.9$  Hz,  ${}^{4}J = 1.4$  Hz, 1H), 7.75 (m<sub>c</sub>, 1H), 8.07 (dd,  ${}^{3}J = 8.3$  Hz,  ${}^{4}J = 0.3$  Hz, 1H), 8.17 (d,  ${}^{4}J = 1.9$  Hz, 1H). 8.87 (d,  ${}^{4}J = 2.0$  Hz, 1H) ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>): 16.4, 27.7, 28.4, 38.7, 54.7, 64.0, 78.9, 80.1, 92.1, 117.9, 127.2, 127.3, 127.4, 127.6, 128.7, 128.4, 129.4, 129.5, 136.1, 138.3, 146.8, 152.5, 172.1 ppm.

**HRMS** (ESI) calcd for  $C_{28}H_{31}N_2O_4^+$  [(M+H)+]: 459.2278, found 459.2270.

**IR** (ATR) v = 3270 (w), 2971 (m), 2231 (w), 1704 (s), 1489 (s), 1453 (m), 1363 (s), 1247 (m), 1158 (s), 1018 (m), 907 (w), 783 (m), 750 (s) 698 (m) cm<sup>-1</sup>.

# 7.28 $17\alpha$ -(4-Methoxycarbonylyphenyl)-19-norpregna-1,3,5(10),20-tetraene-3,17,-diol (**11o**)

110  

$$C_{28}H_{30}O_{4}$$
  
 $Mw = 430.5440$ 

solid.

Prepared from 4'-iodoacetophenone (492 mg, 2.00 mmol, 1.00 equiv) and ethynylestradiol (310 mg, 2.20 mmol, 1.00 equiv)using [(PPh<sub>3</sub>)<sub>2</sub>PdCl<sub>2</sub>] (14 mg, 20  $\mu$ mol, 1.0 mol%) and CuI (3.8 mg, 20  $\mu$ mol, 1.0 mol%) in Et<sub>3</sub>N (5 mL) at room temperature according to **GP1**. After 30 h the reaction was quenched, purification of the crude product *via* flash chromatography using cyclohexane/*tert*-butyl methyl ether = 5:1 as eluent gave **11o** (754 mg, 1.82 mmol, 91%) as a white

**M.p.** =  $110 \, ^{\circ}$ C.

 $\mathbf{R}_f = 0.30$  (*tert*-butyl methyl ether).

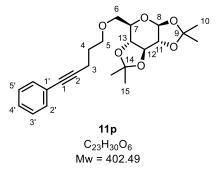
 $[\alpha]_D^{20}$ = +2.3 (c 1.0, CHCl<sub>3</sub>).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>): 0.94 (s, 3H), 1.73–1.98 (m, 9H), 2.09–2.15 (m, 1H), 2.20–2.25 (m, 2H), 2.35–2-47 (m, 2H), 2.60 (s, 3H), 2.81–2.85 (m, 2H), 5.35 (br s, 1H), 6.58 (d,  ${}^{4}J$  = 2.6 Hz, 1H), 6.64 ( ${}^{3}J$  = 8.4 Hz, 2.7 Hz, 1H), 7.15 (d,  ${}^{3}J$  = 8.4 Hz, 1H), 7.51 (d,  ${}^{3}J$  = 8.7 Hz, 2H), 7.89 ( ${}^{3}J$  = 8.7 Hz, 2H) ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>): 13.0, 23.1, 26.6, 26.7, 27.4, 29.8, 33.3, 39.3, 43.8, 47.9, 50.1, 73.2, 80.6, 85.4, 95.5, 112.9, 115.4, 126.6, 128.1, 128.4, 131.9, 132.4, 136.3, 138.3, 153.7, 197.7 ppm. HRMS (ESI) calcd for  $C_{28}H_{29}O_4^{-1}$  [(M-H)-]: 429.2071, found 429.2062.

**IR** (ATR) v = 3353 (w), 2923 (w), 2866 (w), 1699 (s), 1599 (s), 1498 (m), 1402 (m), 1357 (s), 1263 (s), 1178 (m), 1059 (m), 961 (w), 839 (s), 722 (w) cm<sup>-1</sup>.

# 7.29 (3aS,5aR,8aS,8bR)-2,2,7,7-Tetramethyl-5-(((5-phenylpent-4-yn-1-yl)oxy)-methyl)-tetrahydro-5*H*-bis([1,3]dioxolo)[4,5-b:4',5'-d]pyran (11p)



In a flame-dried Schlenk flask, ((3aS,5aR,8aS,8bR) 2,2,7,7-tetramethyltetrahydro-5*H*-bis([1,3]dioxolo)[4,5-b:4',5'-d]pyran-5-yl)methanol<sup>[8]</sup> (1.05 g, 2.4 mmol, 1.20 equiv was dissolved in DMF (10 mL), followed by addition of KOH (168 mg, 3.0 mmol, 1.50 equiv). The suspension was stirred for 10 min before adding 5-phenylpent-4-yn-1-yl-4-methylbenzenesulfonate<sup>[9]</sup> (628 mg, 2.0 mmol, 1.00 equiv) at room temperature. After 30 h

the reaction was quenched, purification of the crude product *via* flash chromatography using cyclohexane/*tert*-butyl methyl ether = 8:1 as eluent gave **11p** (731 mg, 1.81 mmol, 91%) as a pale yellow oil.

 $\mathbf{R}_f = 0.57$  (cyclohexane/tert-butyl methyl ether 4:1). [ $\alpha$ ]<sub>D</sub><sup>20</sup>= -18.5 (c 1.0, CHCl<sub>3</sub>).

<sup>1</sup>**H NMR** (400 MHz, CDCl<sub>3</sub>): 1.29 (s, 3H), 1.34 (s, 3H), 1.42 (s, 3H), 1.50 (s, 3H), 1.80–1.92 (m, 2H), 2.52 (t,  ${}^{3}J$  = 7.0 Hz, 2H), 3.65–3.71 (m, 1H), 3.78–3.81 (m, 1H), 3.90 (d,  ${}^{3}J$  = 3.0 Hz, 1H), 3.99 (dd,  ${}^{3}J$  = 8.6 Hz,  ${}^{3}J$  = 6.0 Hz, 1H), 4.07–4.14 (m, 2H), 4.30–4.35 (m, 1H), 4.58 (d,  ${}^{3}J$  = 3.6 Hz, 1H), 5.88 (d,  ${}^{3}J$  = 3.6 Hz, 1H), 7.26–7.29 (m, 3H), 7.37–7.40 (m, 2H) ppm.

<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>): 16.2, 25.5, 26.4, 26.9, 27.0, 28.9, 67.5, 69.0, 72.7, 81.2, 81.4, 82.3, 82.6, 89.4, 105.5, 109.1, 111.9, 124.0, 127.8, 128.4, 131.7 ppm.

**HRMS** (ESI) calcd for  $C_{23}H_{31}O_6^+$  [(M+H)+]: 403.2115, found 403.2114.

IR (ATR) v = 2984 (w), 2933 (w), 1734 (w), 1490 (w), 1372(s), 1213 (s), 1125 (w), 1069 (s), 1014 (s), 909 (s), 845 (s), 728 (s) cm<sup>-1</sup>.

#### 7.30 4-(2-Hydroxyphenyl)but-3-yn-1-yl pivalate (**13a**)

Prepared from but-3-yn-1-yl pivalate (**S15**, 617 mg, 4.00 mmol, 1.00 equiv) and 2-iodophenol (968 mg, 4.4 mmol, 1.10 equiv) using [(PPh<sub>3</sub>)<sub>2</sub>PdCl<sub>2</sub>] (28 mg, 15  $\mu$ mol, 1.0 mol%) and CuI (7.6 mg, 40  $\mu$ mol, 1.0 mol%) in Et<sub>3</sub>N (15 mL) at room temperature according to **GP1**. After 20 h the reaction was quenched, purification of the crude product *via* 

flash chromatography using cyclohexane/*tert*-butyl methyl ether = 4:1 as eluent gave **13a** (927 mg, 3.76 mmol, 95%) as a yellow oil.

 $\mathbf{R}_f = 0.57$  (cyclohexane/tert-butyl methyl ether 4:1).

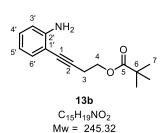
<sup>1</sup>**H NMR** (400 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.23 (s, 9H), 2.73 (t, <sup>3</sup>*J* = 6.8 Hz, 2H), 4.25 (t, <sup>3</sup>*J* = 6.7 Hz, 2H), 5.61 (br s, 1H), 6.78 (dd, <sup>3</sup>*J* = 5.9 Hz, <sup>4</sup>*J* = 0.5 Hz, 1H), 6.86-6.87 (m, 1H), 6.95 (dt, <sup>3</sup>*J* = 7.7 Hz, <sup>4</sup>*J* = 1.1 Hz, 1H), 7.14 (t, <sup>3</sup>*J* = 8.1 Hz, 1H) ppm.

<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>):  $\delta$  = 20.0, 27.3, 39.0, 62.4, 81.7, 85.7, 115.6, 118.5, 124.3, 124.7, 129.6, 155.6, 179.0 ppm.

**HRMS** (ESI) calcd for  $C_{15}H_{19}O_{3}^{+}$  [(M+H)<sup>+</sup>]: 247.1329, found 247.1328.

**IR** (ATR) v = 3385 (m), 2969 (m), 1700 (s), 1577 (s), 1478 (m), 1442 (m), 1365 (w), 1286 (s), 1222 (w), 1152 (s), 1036 (w), 966 (w), 867 (m), 781 (s) cm<sup>-1</sup>.

# 7.31 4-(2-Aminophenyl)but-3-yn-1-yl pivalate (13b)



Prepared from but-3-yn-1-yl pivalate (**S15**, 617 mg, 4.00 mmol, 1.00 equiv) and 2-iodoaniline (964 mg, 4.4 mmol, 1.10 equiv) using  $[(PPh_3)_2PdCl_2]$  (28 mg, 15 µmol, 1.0 mol%) and Cul (7.6 mg, 40 µmol, 1.0 mol%) in Et<sub>3</sub>N (15 mL) at room temperature according to **GP1**. After 20 h the reaction was quenched, purification of the crude product *via* flash

chromatography using cyclohexane/tert-butyl methyl ether =  $10:1\rightarrow 4:1$  as eluent gave **13b** (614 mg, 2.50 mmol, 63%) as a dark yellow oil.

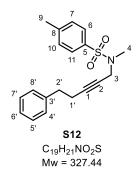
 $\mathbf{R}_f = 0.16$  (cyclohexane/tert-butyl methyl ether 4:1).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>): 1.23 (s, 9H), 2.81 (t,  ${}^{3}J$  = 6.5 Hz, 2H), 4.18 (br s, 2H), 4.28 (t,  ${}^{3}J$  = 6.6 Hz, 2H), 6.64–6.68 (m, 2H), 7.07–7.10 (m, 1H), 7.22 (dd,  ${}^{3}J$  = 6.2 Hz,  ${}^{4}J$  = 1.6 Hz, 1H) ppm. <sup>13</sup>**C NMR** (126 MHz, CDCl<sub>3</sub>): 20.4, 27.3, 38.9, 62.4, 78.6, 91.0, 108.3, 114.3, 117.9, 129.4, 132.3, 148.0, 178.6 ppm.

**HRMS** (ESI) calcd for  $C_{15}H_{20}NO_2^+$  [(M+H)+]: 246.1489, found 246.1486.

**IR** (ATR) v = 3470 (w), 3373 (w), 2967 (m), 1719 (s), 1613 (s), 1491 (m), 1454 (m), 1365 (w), 1281 (m), 1145 (s), 1034 (m), 922 (w), 830 (w), 745 (s) cm<sup>-1</sup>.

### 7.32 *N*,4-Dimethyl-*N*-(5-phenylpent-2-yn-1-yl)benzenesulfonamide (**S12**)



In a flame-dried Schlenk flask, 5-phenylpent-2-yn-1-ol (321 mg, 2.0 mmol, 1.0 equiv), *N*-methyl-*p*-toluenesulfonamide<sup>[10]</sup> (408 mg, 2.2 mmol, 1.1 equiv) and PPh<sub>3</sub> (630 mg, 2.4 mmol, 1.2 equiv) were dissolved in THF (20 mL) and stirred under nitrogen atmosphere. The mixture was cooled in an ice-bath and to this mixture was slowly added diisopropyl azodicarboxylate (DIAD) (0.433 mL, 2.2 mmol, 1.1 equiv). The reaction mixture was stirred for 16 h at room temperature. The THF was removed under reduced pressure. The

residue was suspended in hexane (10 mL) and stirred for 30 min). The PPh<sub>3</sub>O was removed by filtration through a plug of celite. All volatiles were removed under reduce pressure, purification by flash column chromatography on silica gel (cyclohexane/tert-butyl methyl ether = 25:1 as eluent gave **S12** (412 mg, 1.26 mmol, 63%) as a colorless oil.

 $\mathbf{R}_f = 0.43$  (cyclohexane/tert-butyl methyl ether = 5:1).

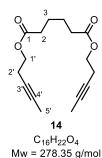
<sup>1</sup>**H NMR** (400 MHz, CDCl<sub>3</sub>): 2.26 (tt,  ${}^{3}J$  = 5.4 Hz,  ${}^{5}J$  = 2.3 Hz, 2H), 2.41 (s, 3H), 2.60 (t,  ${}^{3}J$  = 6.7 Hz, 2H), 2.72 (s, 3H), 3.97 (t,  ${}^{5}J$  = 2.3 Hz, 2H), 7.08–7.11 (m, 2H), 7.18–7.22 (m, 1H), 7.25–7.29 (m, 4H), 7.68–7.70 (m, 2H) ppm.

<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>): 20.7, 21.7, 34.4, 34.8, 40.4, 73.3, 85.7, 126.5, 128.2, 128.4, 128.5, 129.5, 134.6, 140.5, 143.5 ppm.

**HRMS** (ESI) calcd for  $C_{19}H_{22}NO_2S^+$  [(M+H)+]: 328.1366, found 328.1366.

The analytic data is in accordance with the literature.[10]

#### 7.33 Di(pent-3-yn-1-yl) adipate (**16**)



Prepared from adipic acid (877 mg, 6.00 mmol, 1.00 equiv) and pent-3-yn-1-ol (1.01 g, 1.11 mL, 12.0 mmol, 2.00 equiv) using DMAP (73 mg, 0.60 mmol, 0.10 equiv) and DCC (2.60 g, 12.6 mmol, 2.10 equiv) in  $CH_2Cl_2$  (60 mL) at room temperature according to **GP3**. After 45 h the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane/*tert*-butyl methyl ether = 10:1 as eluent gave **16** (1.19 g, 4.28 mmol, 71%) as a white solid.

**M.p.** =  $57 \, ^{\circ}$ C.

 $\mathbf{R}_f = 0.47$  (cyclohexane/tert-butyl methyl ether = 2:1).

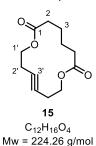
<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.67 (m<sub>c</sub>, 4H), 1.76 (t, <sup>4</sup>*J* = 2.5 Hz, 6H), 2.34 (m<sub>c</sub>, 4H), 2.44 (m<sub>c</sub>, 4H), 4.11 (t, <sup>3</sup>*J* = 7.0 Hz, 4H) ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>):  $\delta$  = 3.6, 19.4, 24.5, 33.9, 62.9, 74.9, 77.4, 173.2 ppm.

**HRMS** (ESI) calcd for  $C_{16}H_{23}O_4^+$  [(M+H)+]: 279.1591, found 279.1588.

**IR** (ATR) v = 2957 (w), 2917 (w), 1732 (s), 1468 (m), 1393 (s), 1369 (s), 1249 (s), 1159 (s), 1136 (s), 1068 (s), 1049 (s), 980 (s), 913 (s), 749 (s), 734 (s), 707 (m) cm<sup>-1</sup>.

# 7.34 1,8-Dioxacyclotetradec-11-yne-2,7-dione (17)



In a glovebox under nitrogen atmosphere di(pent-3-yn-1-yl) adipate (**16**, 446 mg, 1.60 mmol, 1.00 equiv) was dissolved in toluene (80 mL) and 4 Å MS (200 mg) were added. This mixture was stirred for 1 h before tri-*tert*-butoxy(2,2-dimethylpropylidyne)tungsten (22.4 mg, 80  $\mu$ mol, 3.0 mol%) was added. After 20 h the reaction was filtered through SiO<sub>2</sub> (1 cm) and the filtrate was concentrated under reduced pressure to afford the crude product which was

purified *via* flash chromatography using *n*-pentane/*tert*-butyl methyl ether = 3:1 as eluent giving **17** (0.22 g, 0.98 mmol, 61%) as a white solid.

 $\mathbf{R}_f = 0.47$  (cyclohexane/tert-butyl methyl ether = 1:1).

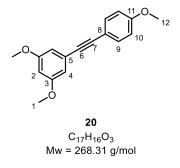
<sup>1</sup>**H NMR** (500 MHz,  $CD_2CI_2$ ):  $\delta = 1.72$  (m<sub>c</sub>, 4H), 2.35 (m<sub>c</sub>, 4H), 2.50 (m<sub>c</sub>, 4H), 4.10 (m<sub>c</sub>, 4H) ppm.

<sup>13</sup>C NMR (126 MHz,  $CD_2Cl_2$ ):  $\delta$  = 19.5, 25.4, 35.3, 62.9, 78.3, 173.3 ppm.

**HRMS** (ESI) calcd for  $C_{12}H_{17}O_4^+$  [(M+H)+]: 225.1121, found 225.1121.

The analytic data is in accordance with the literature.[31]

#### 7.35 1,3-Dimethoxy-5-((4-methoxyphenyl)ethynyl)benzene (24)



Prepared from methyl 1-ethynyl-3,5-dimethoxybenzene (**S3**, 649 mg, 4.0 mmol, 1.00 equiv) and 1-iodo-4-methoxybenzene (1.03 g, 4.40 mmol, 1.10 equiv) using [(PPh<sub>3</sub>)<sub>2</sub>PdCl<sub>2</sub>] (28 mg, 40  $\mu$ mol, 1.0 mol%) and Cul (7.6 mg, 40  $\mu$ mol, 1.0 mol%) in Et<sub>3</sub>N (15 mL) at room temperature according to **GP1**. After 18 h the reaction was quenched, purification of the crude product *via* flash chromatography using cyclohexane/*tert*-butyl methyl ether = 4:1 as eluent gave **20** (854

mg, 3.18 mmol, 80%) as a slightly yellow oil.

 $\mathbf{R}_f = 0.48$  (cyclohexane/tert-butyl methyl ether = 2:1).

<sup>1</sup>**H NMR** (500 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 3.80 (s, 6H), 3.83 (s, 3H), 6.45 (t, <sup>4</sup>*J* = 2.3 Hz, 1H), 6.68 (d, <sup>4</sup>*J* = 2.4 Hz, 2H), 6.88 (m<sub>c</sub>, 2H), 7.47 (m<sub>c</sub>, 2H) ppm.

<sup>13</sup>**C NMR** (126 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 55.4, 55.6, 88.2, 89.1, 101.7, 109.4, 114.2, 115.4, 125.0, 133.3, 159.9, 160.7 ppm.

**HRMS** (ESI) calcd for  $C_{17}H_{17}O_{3}^{+}$  [(M+H)+]: 269.1172, found 269.1182.

The analytic data is in accordance with the literature. [32]

# 8 Preparation of *E*-Alkenes

#### 8.1 (*E*)-4-Phenylbut-3-en-1-yl pivalate (**7**)

Prepared from 4-phenylbut-3-yn-1-yl pivalate (**6**, 59 mg, 0.26 mmol, 1.0 equiv) using Nil $_2$  (4.0 mg, 13 µmol, 5.0 mol%) and dppf (8.6 mg, 16 µmol, 6.0 mol%) in 1,4-dioxane (3 mL) at 100 °C and 15 bar H $_2$  according to **GP5**. After 15 h the reaction was quenched, purification of the crude product *via* flash chromatography using

*n*-pentane/*tert*-butyl methyl ether = 50:1 as eluent gave **7** (E/Z = 99:1, 33 mg, 0.14 mmol, 55%) as a slightly yellow oil, which contains 5% of the corresponding alkane.

 $\mathbf{R}_f = 0.40$  (cyclohexane/tert-butyl methyl ether = 20:1).

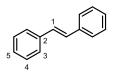
<sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.20 (s, 9H, H-7), 2.55 (dtd,  ${}^{3}J_{3,2}$  = 7.0 Hz,  ${}^{3}J_{3,4}$  = 6.6 Hz,  ${}^{4}J_{3,1}$  = 1.4 Hz, 2H, H-3), 4.20 (t,  ${}^{3}J_{4,3}$  = 6.6 Hz, 2H, H-4), 6.17 (dt,  ${}^{3}J_{2,1}$  = 15.8 Hz,  ${}^{3}J_{2,3}$  = 7.0 Hz, 1H, H-2), 6.47 (d,  ${}^{3}J_{1,2}$  = 15.8 Hz, 1H, H-1), 7.22 (m<sub>c</sub>, 1H, H-4'), 7.28–7.32 (m, 2H, H-3'), 7.33–7.35 (m, 2H, H-2') ppm.

<sup>13</sup>**C NMR** (126 MHz, CDCl<sub>3</sub>): δ = 27.3 (C-7), 32.6 (C-3), 38.9 (C-6), 63.5 (C-4), 125.9 (C-2), 126.2 (C-2'), 127.3 (C-4'), 128.7 (C-3'), 132.5 (C-1), 137.5 (C-1'), 178.6 (C-5) ppm.

**HRMS** (APCI) calcd for  $C_{15}H_{19}O_2^+$  [(M-H)<sup>+</sup>]: 231.1380, found 231.1376.

IR (ATR) v = 2960 (m), 1723 (s), 1478 (s), 1397 (m), 1364 (m), 1282 (s), 1147 (s), 1033 (m), 963 (s), 741 (s), 691 (s) cm<sup>-1</sup>.

# 8.2 (*E*)-1,2-Diphenylethene (**10a**)



**10a**  $C_{14}H_{12}$ Mw = 180.25 g/mol

Condition **A**: Prepared from 1,2-diphenylethyne (**9a**, 46 mg, 0.26 mmol, 1.0 equiv) using Nil<sub>2</sub> (4.0 mg, 13  $\mu$ mol, 5.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 6.0 mol%) %) in 1,4-dioxane (1 mL) at 100 °C and 20 bar H<sub>2</sub> for 18 h.

Condition **B**: Using **9a** (23 mg, 0.13 mmol, 1.0 equiv), Ni(OTf) $_2$  (4.6 mg, 13 µmol, 10.0 mol%) and dppf (8.6 mg, 16 µmol, 12.0 mol%) in 1,4-dioxane

(1 mL) at 100 °C and 20 bar  $H_2$  for 18 h according to **GP5**. The reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane as eluent gave **10a** as a white solid (condition **A**: 33 mg, 0.18 mmol, 71%, condition **B**: 20 mg, 0.11 mmol, 87%).

 $\mathbf{R}_{f} = 0.42$  (*n*-pentane).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 7.16 (s, 2H, H-1), 7.29 (m, 2H, H-5), 7.39 (m, 4H, H-4), 7.56 (m, 4H, H-3) ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>):  $\delta$  = 126.9 (C-3), 128.1 (C-5), 129.0 (C-1), 129.1 (C-4), 137.8 (C-2) ppm.

**HRMS** (EI) calcd for  $C_{14}H_{12}^{++}$  [(M)\*+]: 180.0934, found 180.0929.

The analytic data is in accordance with the literature.[33]

#### 8.3 (*E*)-4-Styrylphenol (**10b**)

10b

 $C_{14}H_{12}O$ Mw = 196.25 g/mol

Condition **A**: Prepared from 4-(phenylethynyl)phenol (**9b**, 50 mg, 0.26 mmol, 1.0 equiv) using NiI<sub>2</sub> (4.0 mg, 13  $\mu$ mol, 5.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 6.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 20 bar H<sub>2</sub> for 19 h.

Condition **B**: Using **9b** (25 mg, 0.13 mmol, 1.0 equiv),  $Ni(OTf)_2$  (4.6 mg, 13  $\mu$ mol, 10.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 12.0 mol%) in 1,4-

dioxane (1 mL) at 100 °C and 20 bar  $H_2$  for 18 h according to **GP5**. Then, the reaction was quenched, purification of the crude product *via* flash chromatography using cyclohexane/*tert*-butyl methyl ether = 3:1 as eluent gave **10b** as a white solid (condition **A**: 43 mg, 0.22 mmol, 86%, condition **B**: 21 mg, 0.11 mmol, 84%).

 $\mathbf{R}_f = 0.42$  (cyclohexane/tert-butyl methyl ether = 2:1).

<sup>1</sup>H NMR (500 MHz, DMSO-d<sub>6</sub>):  $\delta$  = 6.77 (m<sub>c</sub>, 2H, H-5), 7.01 (d, <sup>3</sup>J<sub>1,2</sub> = 16.4 Hz, 1H, H-1), 7.14 (d, <sup>3</sup>J<sub>2,1</sub> = 16.4 Hz, 1H, H-2), 7.22 (m<sub>c</sub>, 1H, H-4'), 7.34 (m<sub>c</sub>, 2H, H-3'), 7.42 (m<sub>c</sub>, 2H, H-4), 7.53 (m<sub>c</sub>, 2H, H-2'), 9.57 (s, 1H, O*H*) ppm.

<sup>13</sup>**C NMR** (126 MHz, DMSO- $d_6$ ): δ = 115.5 (C-5), 125.1 (C-1), 126.0 (C-2'), 127.0 (C-4'), 127.9 (C-4), 128.1 (C-3), 128.4 (C-2), 128.6 (C-3'), 137.5 (C-1'), 157.3 (C-6) ppm.

**HRMS** (EI) calcd for  $C_{14}H_{12}O^{++}$  [(M)+]: 196.0883, found 196.0877.

**IR** (ATR) v = 3371 (br m), 1588 (m), 1506 (m), 1440 (m), 1365 (m), 1242 (m), 1104 (m), 1073 (m), 958 (s), 816 (s), 745 (s), 686 (s) cm<sup>-1</sup>.

### 8.4 (*E*)-4-Styrylaniline (**10c**)

Condition **A**: Prepared from 4-(phenylethynyl)aniline (**9c**, 50 mg, 0.26 mmol, 1.00 equiv) using [Ni(dppf) $I_2$ ] (12.0 mg, 13 µmol, 5.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 20 bar  $H_2$  for 18 h.

**10c**  $C_{14}H_{13}N$  Mw = 195.27 g/mol

Condition **B**: Using **9c** (25 mg, 0.13 mmol, 1.0 equiv), Ni(OTf)<sub>2</sub> (4.6 mg, 13  $\mu$ mol, 10.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 12.0 mol%) in 1,4-

dioxane (1 mL) at 100 °C and 20 bar  $H_2$  for 18 h according to **GP5**. The reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane/*tert*-butyl methyl ether = 3:1 as eluent gave **10c** as a yellow solid (condition **A**: 41 mg, 0.21 mmol, 82% containing 2%, condition **B**: 19 mg, 0.10 mmol, 75%).

 $\mathbf{R}_f = 0.34$  (cyclohexane/tert-butyl methyl ether = 1:1).

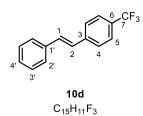
<sup>1</sup>**H NMR** (500 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 3.81 (br s, 2H, N*H*), 6.68 (m<sub>c</sub>, 2H, H-5), 6.93 (d, <sup>3</sup>*J*<sub>1,2</sub> = 16.3 Hz, 1H, H-1), 7.05 (d, <sup>3</sup>*J*<sub>2,1</sub> = 16.3 Hz, 1H, H-2), 7.22 (m<sub>c</sub>, 1H, H-4'), 7.33–7.36 (m, 4H, H-4, H-3'), 7.48-7.50 (m, 2H, H-2') ppm.

<sup>13</sup>**C NMR** (126 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 115.3 (C-5), 125.1 (C-1), 126.4 (C-2'), 127.3 (C-4'), 128.0 (C-3), 128.1 (C-4), 129.0 (C-3'), 129.1 (C-2), 138.4 (C-1'), 147.1 (C-6) ppm.

**HRMS** (ESI) calcd for  $C_{14}H_{14}N^+$  [(M+H)+]: 196.1121, found 196.1121.

**IR** (ATR) v = 3443 (w), 3357 (w), 3025 (w), 1601 (m), 1587 (s), 1511 (s), 1445 (m), 1281 (s), 1176 (s), 1068 (m), 966 (s), 817 (s), 752 (s), 715 (m), 689 (s) cm<sup>-1</sup>.

# 8.5 (E)-1-Styryl-4-(trifluoromethyl)benzene (10d)



Mw = 248.25 g/mol

Condition **A**: Prepared from 1-(phenylethynyl)-4-(trifluoromethyl)benzene (**9d**, 63 mg, 0.26 mmol, 1.00 equiv) using Nil<sub>2</sub> (4.0 mg, 13  $\mu$ mol, 5.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 6.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 20 bar H<sub>2</sub> for 19 h.

Condition **B**: Using **9d** (32 mg, 0.13 mmol, 1.0 equiv), Ni(OTf)<sub>2</sub> (4.6 mg, 13  $\mu$ mol, 10.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 12.0 mol%) in 1,4-

dioxane (1 mL) at 100 °C and 20 bar  $H_2$  for 16 h according to **GP5**. Then, the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane as eluent

gave **10d** as a white solid. (condition **A**: 54 mg, 0.22 mmol, 86%, condition **B**: 31 mg, 0.13mmol, 99%).

 $\mathbf{R}_f = 0.48 \ (n\text{-pentane}).$ 

<sup>1</sup>H NMR (500 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 7.17 (d, <sup>3</sup>J<sub>2,1</sub> = 16.4 Hz, 1H, H-2), 7.24 (d, <sup>3</sup>J<sub>1,2</sub> = 16.4 Hz, 1H, H-1), 7.32 (m<sub>c</sub>, 1H, H-4'), 7.40 (m<sub>c</sub>, 2H, H-3'), 7.55–7.58 (m, 2H, H-2'), 7.64 (m<sub>c</sub>, 4H, H-4, H-5) ppm. <sup>13</sup>C NMR (126 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 124.8 (q, <sup>1</sup>J<sub>7,F</sub> = 271.3 Hz, C-7), 126.0 (q, <sup>3</sup>J<sub>5,F</sub> = 3.6 Hz, C-5), 127.0 (C-4), 127.2 (C-2'), 127.4 (C-2), 128.7 (C-4'), 129.2 (C-3'), 129.4 (q, <sup>2</sup>J<sub>6,F</sub> = 32.8 Hz, C-6), 131.6 (C-1), 137.1 (C-1'), 141.4 (C-3) ppm.

<sup>19</sup>**F NMR** (471 MHz,  $CD_2Cl_2$ ):  $\delta = -62.7$  ppm.

**HRMS** (EI) calcd for  $C_{15}H_{11}F_{3}^{+}$  [(M)<sup>+</sup>]: 248.0807, found 248.0804.

The analytic data is in accordance with the literature.<sup>[34]</sup>

#### 8.6 (*E*)-1-Methoxy-4-styrylbenzene (**10e**)

10e CueHusO

 $C_{15}H_{14}O$ Mw = 210.28 g/mol Condition **A**: Prepared from 1-methoxy-4-(phenylethynyl)benzene (**9e**, 53 mg, 0.26 mmol, 1.00 equiv) using Nil<sub>2</sub> (4.0 mg, 13  $\mu$ mol, 5.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 6.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 20 bar H<sub>2</sub> for 19 h.

Condition **B**: Using **9e** (27 mg, 0.13 mmol, 1.0 equiv), Ni(OTf)<sub>2</sub> (4.6 mg, 13 µmol, 10.0 mol%) and dppf (8.6 mg, 16 µmol, 12.0 mol%) in 1,4-

dioxane (1 mL) at 100 °C and 20 bar H<sub>2</sub> according to **GP5**. Then, the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane/*tert*-butyl methyl ether = 30:1 as eluent gave as a white solid **10e** (condition **A**: 47 mg, 0.22 mmol, 87%, condition **B**, 25 mg, 0.12 mmol, 93%).

 $\mathbf{R}_f = 0.48$  (cyclohexane/tert-butyl methyl ether = 10:1).

<sup>1</sup>**H NMR** (500 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 3.82 (s, 3H, H-7), 6.91 (m<sub>c</sub>, 2H, H-5), 7.00 (d,  ${}^{3}J_{1,2}$  = 16.4 Hz, 1H, H-1), 7.10 (d,  ${}^{3}J_{2,1}$  = 16.4 Hz, 1H, H-2), 7.24 (m<sub>c</sub>, 1H, H-4'), 7.36 (m<sub>c</sub>, 2H, H-3'), 7.48 (m<sub>c</sub>, 2H, H-4), 7.50–7.52 (m, 2H, H-2') ppm.

<sup>13</sup>**C NMR** (126 MHz,  $CD_2CI_2$ ):  $\delta$  = 55.7 (C-7), 114.5 (C-5), 126.6 (C-2'), 126.8 (C-1), 127.6 (C-4'), 128.1 (C-4), 128.5 (C-2), 129.1 (C-3'), 130.5 (C-3), 138.1 (C-1'), 159.9 (C-6) ppm.

**HRMS** (EI) calcd for  $C_{15}H_{14}O^{++}$  [(M)\*\*]: 210.1039, found 210.1031.

**IR** (ATR) v = 2999 (w), 2833 (w), 1598 (m), 1508 (s), 1439 (m), 1294 (m), 1244 (s), 1176 (s), 1028 (s), 965 (s), 859 (m), 827 (s), 811 (s), 749 (s), 687 (s) cm<sup>-1</sup>.

#### 8.7 (*E*)-1-Chloro-4-styrylbenzene (**10f**)

1 10f

 $C_{14}H_{11}CI$ Mw = 214.69 g/mol Condition **A**: Prepared from 1-chloro-4-(phenylethynyl)benzene (**9f**, 54 mg, 0.26 mmol, 1.0 equiv) using NiI<sub>2</sub> (4.0 mg, 13  $\mu$ mol, 5.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 6.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 20 bar H<sub>2</sub> for 18 h.

Condition **B**: Using **9f** (27 mg, 0.13 mmol, 1.0 equiv), Ni(OTf)<sub>2</sub> (4.6 mg, 13  $\mu$ mol, 10.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 12.0 mol%) in 1,4-dioxane

(1 mL) at 100 °C and 20 bar H<sub>2</sub> for 16 h according to **GP5**. Then, the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane as eluent gave **10f** as a white solid (condition **A**:49 mg, 0.23 mmol, 89%, condition **B**: 23 mg, 0.11 mmol, 85%).

 $\mathbf{R}_f = 0.48 \ (n\text{-pentane}).$ 

<sup>1</sup>**H NMR** (500 MHz,  $CD_2CI_2$ ):  $\delta$  = 7.11 (m<sub>c</sub>, 2H, H-1, H-2), 7.29 (m<sub>c</sub>, 1H, H-4'), 7.35 (m<sub>c</sub>, 2H, H-5), 7.38 (m<sub>c</sub>, 2H, H-3'), 7.48 (m<sub>c</sub>, 2H, H-4), 7.52–7.54 (m, 2H, H-2') ppm.

<sup>13</sup>**C NMR** (126 MHz,  $CD_2CI_2$ ):  $\delta$  = 126.9 (C-2'), 127.6 (C-2), 128.1 (C-4), 128.3 (C-4'), 129.1 (C-3'), 129.2 (C-5)\*, 129.7 (C-1), 133.4 (C-6), 136.4 (C-3), 137.4 (C-1') ppm.

**HRMS** (EI) calcd for  $C_{14}H_{11}CI^{*+}$  [(M)\*\*]: 214.0544, found 214.0552.

The analytic data is in accordance with the literature. [35]

# 8.8 (E)-4-Styrylbenzonitrile (10g)

 $C_{15}H_{11}N$ Mw = 205.26 g/mol

Prepared from 4-(phenylethynyl)benzonitrile (**9g**, 52 mg, 0.26 mmol, 1.00 equiv) using Nil<sub>2</sub> (4.0 mg, 13  $\mu$ mol, 5.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 6.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 20 bar H<sub>2</sub> according to **GP5**. After 18 h the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane/*tert*-butyl methyl ether = 20:1 as eluent gave **10g** (43 mg, 0.21 mmol, 82%) as a white solid.

 $\mathbf{R}_f = 0.56$  (cyclohexane/tert-butyl methyl ether = 2:1).

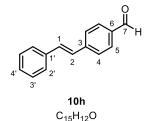
<sup>1</sup>**H NMR** (500 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 7.13 (d, <sup>3</sup>J<sub>2,1</sub> = 16.4 Hz, 1H, H-2), 7.25 (d, <sup>3</sup>J<sub>1,2</sub> = 16.4 Hz, 1H, H-1), 7.33 (m<sub>c</sub>, 1H, H-4'), 7.40 (m<sub>c</sub>, 2H, H-3'), 7.55–7.57 (m, 2H, H-2'), 7.61 (m<sub>c</sub>, 2H, H-4), 7.65 (m<sub>c</sub>, 2H, H-5) ppm.

<sup>13</sup>**C NMR** (126 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 111.0 (C-6), 119.3 (C-7), 127.1 (C-2), 127.2 (C-4)\*, 127.3 (C-2')\*, 129.0 (C-4'), 129.2 (C-3'), 132.6 (C-1), 132.9 (C-5), 136.8 (C-1'), 142.2 (C-3) ppm.

**HRMS** (APCI) calcd for  $C_{15}H_{12}N^+$  [(M+H)+]: 206.0964, found 206.0961.

The analytic data is in accordance with the literature. [36]

#### 8.9 (*E*)-4-Styrylbenzaldehyde (**10h**)



1.00 equiv) using Nil $_2$  (4.0 mg, 13 µmol, 5.0 mol%) and dppf (8.6 mg, 16 µmol, 6.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 20 bar H $_2$  according to **GP5**. After 19 h the reaction was quenched, purification of the crude product via flash chromatography using cyclohexane/tert-butyl methyl ether = 30:1 as eluent gave **10h** (45 mg, 0.22 mmol, 84%) as a

Prepared from 4-(phenylethynyl)benzaldehyde (9h, 53 mg, 0.26 mmol,

slightly yellow solid.

Mw = 208.26 g/mol

 $\mathbf{R}_f = 0.47$  (cyclohexane/tert-butyl methyl ether = 4:1).

<sup>1</sup>H NMR (500 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 7.19 (d, <sup>3</sup>J<sub>2,1</sub> = 16.4 Hz, 1H, H-2), 7.30 (d, <sup>3</sup>J<sub>1,2</sub> = 16.4 Hz, 1H, H-1), 7.32 (m<sub>c</sub>, 1H, H-4'), 7.40 (m<sub>c</sub>, 2H, H-3'), 7.57–7.59 (m, 2H, H-2'), 7.69 (m<sub>c</sub>, 2H, H-4), 7.87 (m<sub>c</sub>, 2H, H-5), 9.99 (s, 1H, H-7) ppm.

<sup>13</sup>**C NMR** (126 MHz,  $CD_2CI_2$ ):  $\delta$  = 127.3 (C-4)\*, 127.3 (C-2')\*, 127.7 (C-2), 128.9 (C-4'), 129.2 (C-3'), 130.5 (C-5), 132.4 (C-1), 135.9 (C-6), 137.1 (C-1'), 143.7 (C-3), 191.8 (C-7) ppm.

**HRMS** (EI) calcd for  $C_{15}H_{12}O^{*+}$  [(M)\*\*]: 208.0883, found 208.0877.

The analytic data is in accordance with the literature. [37]

# 8.10 (*E*)-1-(4-Styrylphenyl)ethan-1-one (**10i**)

Mw = 222.29 g/mol

Prepared from 1-(4-(phenylethynyl)phenyl)ethan-1-one (9i, 56 mg, 0.26 mmol, 1.00 equiv) using Nil<sub>2</sub> (4.0 mg, 13 µmol, 5.0 mol%) and dppf (8.6 mg, 16 µmol, 6.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 20 bar H<sub>2</sub> according to **GP5**. After 19 h the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane/*tert*-butyl methyl ether = 30:1 as eluent gave 10i (50 mg, 0.23 mmol, 88%) as a

white solid.

 $\mathbf{R}_f = 0.34$  (cyclohexane/tert-butyl methyl ether = 4:1).

<sup>1</sup>**H NMR** (500 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 2.58 (s, 3H, H-8), 7.17 (d,  ${}^{3}J_{2,1}$  = 16.4 Hz, 1H, H-2), 7.27 (d,  ${}^{3}J_{1,2}$  = 16.4 Hz, 1H, H-1), 7.31 (m<sub>c</sub>, 1H, H-4'), 7.40 (m<sub>c</sub>, 2H, H-3'), 7.56–7.58 (m, 2H, H-2'), 7.62 (m<sub>c</sub>, 2H, H-4), 7.95 (m<sub>c</sub>, 2H, H-5) ppm.

<sup>13</sup>C NMR (126 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 26.8 (C-8), 126.9 (C-4), 127.2 (C-2'), 127.8 (C-2), 128.7 (C-4'), 129.2 (C-5)\*, 129.2 (C-3')\*, 131.7 (C-1), 136.5 (C-6), 137.2 (C-1'), 142.3 (C-3), 197.5 (C-7) ppm. HRMS (APCI) calcd for C<sub>16</sub>H<sub>15</sub>O<sup>+</sup> [(M+H)<sup>+</sup>]: 223.1112, found 223.1117.

The analytic data is in accordance with the literature. [38]

#### 8.11 Methyl (E)-4-styrylbenzoate (10j)

 $C_{16}H_{14}O_2$ Mw = 238.29 g/mol

Prepared from methyl 4-(phenylethynyl)benzoate (9j, 61 mg, 0.26 mmol, 1.00 equiv) using Nil<sub>2</sub> (4.0 mg, 13 µmol, 5.0 mol%) and dppf (8.6 mg, 16 µmol, 6.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 30 bar H<sub>2</sub> according to **GP5**. After 24 h the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane/*tert*-butyl methyl ether = 50:1 as eluent gave **10j** (52 mg,

0.22 mmol, 85%) as a slightly vellow solid.

 $\mathbf{R}_f = 0.33$  (cyclohexane/tert-butyl methyl ether = 10:1).

<sup>1</sup>**H NMR** (500 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 3.90 (s, 3H, H-8), 7.17 (d,  ${}^{3}J_{2,1}$  = 16.4 Hz, 1H, H-2), 7.26 (d,  ${}^{3}J_{1,2}$  = 16.4 Hz, 1H, H-1), 7.31 (m<sub>c</sub>, 1H, H-4'), 7.39 (m<sub>c</sub>, 2H, H-3'), 7.55–7.57 (m, 2H, H-2'), 7.60 (m<sub>c</sub>, 2H, H-4), 8.02 (m<sub>c</sub>, 2H, H-5) ppm.

<sup>13</sup>**C NMR** (126 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 52.3 (C-8), 126.7 (C-4), 127.2 (C-2'), 127.9 (C-2), 128.6 (C-4'), 129.2 (C-3'), 129.5 (C-6), 130.3 (C-5), 131.6 (C-1), 137.2 (C-1'), 142.2 (C-3), 167.0 (C-7) ppm.

**HRMS** (EI) calcd for  $C_{16}H_{14}O^{++}$  [(M)<sup>++</sup>]: 238.0988, found 238.0991.

The analytic data is in accordance with the literature. [39]

#### 8.12 (*E*)-2-Styrylthiophene (**10k**)

1 3 5 6 4' 2' 2 4

 $C_{12}H_{10}S$ Mw = 186.27 g/mol Condition **A**: Prepared from 2-(phenylethynyl)thiophene (**9k**, 47 mg, 0.26 mmol, 1.00 equiv) using Nil<sub>2</sub> (4.0 mg, 13  $\mu$ mol, 5.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 6.0 mol%) at 100 °C in 1,4-dioxane (1 mL) for 18 h.

Condition **B**: Using 9k (24 mg, 0.13 mmol, 1.0 equiv), Ni(OTf)<sub>2</sub> (4.6 mg, 13 µmol, 10.0 mol%) and dppf (8.6 mg, 16 µmol, 12.0 mol%) in 1,4-dioxane

(1 mL) at 100 °C and 20 bar  $H_2$  according to **GP5**. Then, the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane as eluent gave **10k** as a white solid (condition **A**: 38 mg, 0.21 mmol, 80% containing 3% of the alkane, condition **B**: 16 mg, 0.09 mmol, 70%).

 $\mathbf{R}_f = 0.52$  (*n*-pentane).

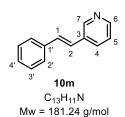
<sup>1</sup>**H NMR** (500 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 6.96 (d, <sup>3</sup>*J*<sub>1,2</sub> = 16.1 Hz, 1H, H-1), 7.03 (dd, <sup>3</sup>*J*<sub>5,6</sub> = 5.1 Hz, <sup>3</sup>*J*<sub>5,4</sub> = 3.6 Hz, 1H, H-5), 7.11 (m<sub>c</sub>, 1H, H-4), 7.23 (m<sub>c</sub>, 1H, H-6), 7.26 (m<sub>c</sub>, 1H, H-4'), 7.28 (d, <sup>3</sup>*J*<sub>2,1</sub> = 16.1 Hz, 1H, H-2), 7.36 (m<sub>c</sub>, 2H, H-3'), 7.48–7.50 (m, 2H, H-2') ppm.

<sup>13</sup>**C NMR** (126 MHz,  $CD_2CI_2$ ):  $\delta$  = 122.1 (C-2), 124.8 (C-6), 126.6 (C-4), 126.7 (C-2'), 128.0 (C-5)\*, 128.1 (C-4')\*, 128.6 (C-1), 129.1 (C-3'), 137.4 (C-1'), 143.3 (C-3) ppm.

**HRMS** (EI) calcd for  $C_{12}H_{10}S^{*+}$  [(M)\*\*]: 186.0498, found 186.0489.

The analytic data is in accordance with the literature. [40]

# 8.13 (*E*)-3-Styrylpyridine (**10m**)



Prepared from 3-(phenylethynyl)pyridine (**9m**, 46 mg, 0.26 mmol, 1.00 equiv) using Nil<sub>2</sub> (8.0 mg, 26  $\mu$ mol, 10 mol%) and dppf (17 mg, 32  $\mu$ mol, 12 mol%) in 1,4-dioxane (2 mL) at 100 °C and 40 bar H<sub>2</sub> according to **GP5**. After 24 h the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane/*tert*-butyl methyl ether = 5:1 as eluent gave

10m (40 mg, 0.22 mmol, 86%) as a brown solid, which contained starting material (~5%) and

dppf. For characterization purposes, a preparative TLC was conducted (cyclohexane/*tert*-butyl methyl ether = 1:1).

 $\mathbf{R}_f = 0.37$  (cyclohexane/tert-butyl methyl ether = 1:2).

<sup>1</sup>**H NMR** (500 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 7.11 (d,  ${}^{3}J_{2,1}$  = 16.5 Hz, 1H, H-2), 7.20 (d,  ${}^{3}J_{1,2}$  = 16.5 Hz, 1H, H-1), 7.28–7.30 (m, 1H, H-5), 7.28–7.32 (m, 1H, H-4'), 7.39 (m<sub>c</sub>, 2H, H-3'), 7.54–7.56 (m, 2H, H-2'), 7.86 (m<sub>c</sub>, 1H, H-4), 8.46 (dd,  ${}^{3}J_{6,5}$  = 4.8 Hz,  ${}^{4}J_{6,4}$  = 1.6 Hz, 1H, H-6), 8.72 (d,  ${}^{4}J_{7,4}$  = 2.2 Hz, 1H, H-7) ppm.

<sup>13</sup>**C NMR** (126 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 123.9 (C-5), 125.4 (C-2), 127.0 (C-2'), 128.6 (C-4'), 129.2 (C-3'), 131.0 (C-1), 132.9 (C-4), 133.3 (C-3), 137.2 (C-1'), 149.0 (C-6)\*, 149.0 (C-7)\* ppm.

**HRMS** (ESI) calcd for  $C_{13}H_{12}N^+$  [(M+H)+]: 182.0964, found 182.0965.

**IR** (ATR) v = 3023 (w), 2921 (w), 2851 (w), 1562 (m), 1491 (m), 1476 (m), 1434 (m), 1410 (m), 1162 (m), 1119 (m), 1022 (s), 960 (s), 797 8s), 744 (s), 690 (s) cm<sup>-1</sup>.

#### 8.14 (*E*)-4-(3-Methoxyphenyl)but-3-en-1-yl pivalate (**12a**)

12a  $C_{16}H_{22}O_3$  Mw = 262.35 g/mol

Condition **A**: Prepared from 4-(3-methoxyphenyl)but-3-yn-1-yl pivalate (**11a**, 67 mg, 0.26 mmol, 1.0 equiv) using Nil<sub>2</sub> (4.0 mg, 13  $\mu$ mol, 5.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 6.0 mol%), 15 bar H<sub>2</sub> in 1,4-dioxane (1 mL) at 100 °C for 16 h.

Mw = 262.35 g/mol Condition **B**: using **11a** (34 mg, 0.13 mmol, 1.0 equiv), Ni(OTf)<sub>2</sub> (4.6 mg, 13 μmol, 10.0 mol%) and dppf (8.6 mg, 16 μmol, 12.0 mol%), 30 bar H<sub>2</sub> in 1,4-dioxane (1 mL) at 100 °C for 16 h and according to **GP5**. Then, the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane/*tert*-butyl methyl ether = 25:1 as eluent gave **12a** as a yellow oil (condition **A**: E/Z = 96:4, 35 mg, 0.13 mmol, 53% containing 12% the corresponding alkane, condition **B**: E/Z = 97:3, 26 mg, 0.10 mmol, 76% containing 4% alkane).

 $\mathbf{R}_f = 0.44$  (cyclohexane/tert-butyl methyl ether = 5:1).

<sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.19 (s, 9H, H-7), 2.54 (dtd,  ${}^{3}J_{3,2}$  = 6.8 Hz,  ${}^{3}J_{3,4}$  = 6.7 Hz,  ${}^{4}J_{3,1}$  = 1.3 Hz, 2H, H-3), 3.81 (s, 3H, H-7'), 4.19 (t,  ${}^{3}J_{4,3}$  = 6.6 Hz, 2H, H-4), 6.16 (dt,  ${}^{3}J_{2,1}$  = 15.8 Hz,  ${}^{3}J_{2,3}$  = 7.1 Hz, 1H, H-2), 6.43 (d,  ${}^{3}J_{1,2}$  = 15.8 Hz, 1H, H-1), 6.78 (m<sub>c</sub>, 1H, H-4'), 6.87 (s, 1H, H-6'), 6.93 (d,  ${}^{3}J_{2',3'}$  = 7.7 Hz, 1H, H-2'), 7.22 (dd,  ${}^{3}J_{3',2'}$  = 3 $J_{3',4'}$  = 7.9 Hz, 1H, H-3') ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>): δ = 27.3 (C-7), 32.6 (C-3), 38.9 (C-6), 55.3 (C-7'), 63.5 (C-4), 111.6 (C-6'), 112.9 (C-4'), 118.9 (C-2'), 126.3 (C-2), 129.6 (C-3'), 132.4 (C-1), 139.0 (C-1'), 159.9 (C-5'), 178.6 (C-5) ppm.

**HRMS** (EI) calcd for  $C_{16}H_{22}O_3^{*+}$  [(M)\*\*]: 262.1564, found 262.1554.

IR (ATR) v = 2957 (m), 1722 (s), 1598 (m), 1579 (m), 1479 (m), 1457 (m), 1432 (m), 1283 (s), 1263 (s), 1148 (s), 1039 (s), 965 (s), 869 (m), 769 (s), 688 (s) cm<sup>-1</sup>.

#### 8.15 (*E*)-4-(3-(Trifluoromethyl)phenyl)but-3-en-1-yl pivalate (**12b**)

$$F_3C$$
 $5'$ 
 $1$ 
 $2$ 
 $4$ 
 $0$ 
 $5$ 
 $6$ 
 $7$ 
 $1$ 
 $2$ 
 $4$ 
 $0$ 
 $5$ 
 $6$ 
 $7$ 

 $C_{16}H_{19}F_3O_2$ Mw = 300.32 g/mol

Condition **A**: Prepared from 4-(3-(trifluoromethyl)phenyl)but-3-yn-1-yl pivalate (**11b**, 76 mg, 0.26 mmol, 1.0 equiv) using Nil<sub>2</sub> (4.0 mg, 13  $\mu$ mol, 5.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 6.0 mol%),15 bar H<sub>2</sub> in 1,4-dioxane (1 mL) at 100 °C for 16 h.

Mw = 300.32 g/mol Condition **B**: Using **11b** (38 mg, 0.13 mmol, 1.0 equiv Ni(OTf)<sub>2</sub> (4.6 mg, 13 μmol, 10.0 mol%) and dppf (8.6 mg, 16 μmol, 12.0 mol%), 30 bar H<sub>2</sub> in 1,4-dioxane (1 mL) at 100 °C for 16 h according to **GP5**. Then, the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane/*tert*-butyl methyl ether = 50:1 as eluent gave **12b** as a slightly yellow oil (condition **A**: E/Z = 98:2, 39 mg, 0.13 mmol, 51% containing 13% the corresponding alkane, condition **B**: E/Z = 97:3, 32 mg, 0.11 mmol, 80% containing 5% the corresponding alkane.

 $\mathbf{R}_f = 0.55$  (*n*-pentane/*tert*-butyl methyl ether = 10:1).

<sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.19 (s, 9H, H-7), 2.57 (dtd,  ${}^{3}J_{3,2}$  = 6.8 Hz,  ${}^{3}J_{3,4}$  = 6.5 Hz,  ${}^{4}J_{3,1}$  = 1.3 Hz, 2H, H-3), 4.21 (t,  ${}^{3}J_{4,3}$  = 6.5 Hz, 2H, H-4), 6.25 (dt,  ${}^{3}J_{2,1}$  = 15.8 Hz,  ${}^{3}J_{2,3}$  = 7.0 Hz, 1H, H-2), 6.49 (d,  ${}^{3}J_{1,2}$  = 15.8 Hz, 1H, H-1), 7.41 (m<sub>c</sub>, 1H, H-3'), 7.46 (d,  ${}^{3}J_{4',3'}$  = 7.6 Hz, 1H, H-4'), 7.50 (d,  ${}^{3}J_{2',3'}$  = 7.6 Hz, 1H, H-2'), 7.56 (s, 1H, H-6') ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>):  $\delta$  = 27.3 (C-7), 32.6 (C-3), 38.9 (C-6), 63.2 (C-4), 122.9 (q,  ${}^{3}J_{6',F}$  = 4.1 Hz, C-6'), 123.9 (q,  ${}^{3}J_{4',F}$  = 3.8 Hz, C-4'), 124.3 (q,  ${}^{1}J_{7',F}$  = 271 Hz, C-7'), 128.2 (C-2), 129.1 (C-2')\*, 129.3 (C-3')\*, 131.1 (q,  ${}^{2}J_{5',F}$  = 32.6 Hz, C-5'), 131.2 (C-1), 138.2 (C-1'), 178.6 (C-5) ppm.

<sup>19</sup>**F NMR** (471 MHz, CDCl<sub>3</sub>):  $\delta = -62.8$  ppm.

**HRMS** (EI) calcd for  $C_{16}H_{19}F_3O_2^+$  [(M)<sup>+</sup>]: 300.1332, found 300.1329.

**IR** (ATR) v = 2969 (m), 1724 (s), 1480 (m), 1327 (s), 1282 (s), 1152 (s), 1121 (s), 1070 (s), 964 (m), 900 (m), 798 (m), 697 (s) 662 (m) cm<sup>-1</sup>.

#### 8.16 Methyl (*E*)-4-(4-(pivaloyloxy)but-1-en-1-yl)benzoate (**12c**)

12c  $C_{17}H_{22}O_4$ Mw = 290.36 g/mol

Condition **A**: Prepared from methyl 4-(4-(pivaloyloxy)but-1-yn-1-yl)benzoate (**11c**, 74 mg, 0.26 mmol, 1.0 equiv) using Nil<sub>2</sub> (4.0 mg, 13  $\mu$ mol, 5.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 6.0 mol%), 15 bar H<sub>2</sub> in 1,4-dioxane (1 mL) at 100 °C for 16 h.

Mw = 290.36 g/mol Condition **B**: Using **11c** (38 mg, 0.13 mmol, 1.0 equiv), Ni(OTf)<sub>2</sub> (4.6 mg, 13 µmol, 10.0 mol%) and dppf (8.6 mg, 16 µmol, 12.0 mol%) 30 bar H<sub>2</sub> in 1,4-dioxane (1 mL) at 100 °C for 16 h according to **GP5**. Then, the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane/*tert*-butyl methyl ether = 20:1 as eluent gave **12c** as a light brown solid (condition **A**: E/Z = 98:2, 38 mg, 0.13 mmol, 52% containing 10% corresponding alkane, condition **B**: E/Z = 97:3, 28 mg, 0.10 mmol, 75% containing 5% corresponding alkane).

**M.p.** =  $42 \, ^{\circ}$ C.

 $\mathbf{R}_f = 0.57$  (cyclohexane/tert-butyl methyl ether = 4:1).

<sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.18 (s, 9H, H-7), 2.56 (m<sub>c</sub>, 2H, H-3), 3.90 (s, 3H, H-6'), 4.20 (t,  ${}^{3}J_{4,3}$  = 6.5 Hz, 2H, H-4), 6.29 (dt,  ${}^{3}J_{2,1}$  = 15.9 Hz,  ${}^{3}J_{2,3}$  = 6.9 Hz, 1H, H-2), 6.49 (d,  ${}^{3}J_{1,2}$  = 15.9 Hz, 1H, H-1), 7.38 (m<sub>c</sub>, 2H, H-2'), 7.96 (m<sub>c</sub>, 2H, H-3') ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>):  $\delta$  = 27.3 (C-7), 32.7 (C-3), 38.9 (C-5), 52.1 (C-6'), 63.2 (C-4), 126.0 (C-2'), 128.8 (C-4'), 128.9 (C-2), 130.0 (C-3'), 131.7 (C-1), 141.9 (C-1'), 167.0 (C-5'), 178.6 (C-5) ppm.

**HRMS** (ESI) calcd for  $C_{17}H_{22}O_4^+$  [(M+H)+]: 291.1591, found 291.1591.

**IR** (ATR) v = 2957 (m), 1714 (s), 1605 (m), 1433 (m), 1275 (s), 1150 (s), 1106 (s), 1034 (m), 1012 (m), 968 (s), 866 (m), 757 (s), 697 (s) cm<sup>-1</sup>.

# 8.17 (*E*)-4-(4-Cyanophenyl)but-3-en-1-yl pivalate (**12d**)

N 5'
A'
$$2'$$
 $1$ 
 $2'$ 
 $1$ 
 $3'$ 
 $2'$ 
 $1$ 
 $3$ 
 $2'$ 
 $1$ 
 $3$ 
 $2'$ 
 $1$ 
 $3$ 
 $3$ 
 $4$ 
 $5$ 
 $6$ 
 $7$ 

E-12d

 $C_{16}H_{19}NO_{2}$ 
 $Mw = 257.33$ 

Prepared from 4-(4-cyanophenyl)but-3-yn-1-yl pivalate (**11d**, 33 mg, 0.13 mmol, 1.0 equiv) using Ni(OTf)<sub>2</sub> (4.6 mg, 13  $\mu$ mol, 10.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 12.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 30 bar H<sub>2</sub> according to **GP5**. After 16 h the reaction was quenched, purification of the crude product *via* flash

chromatography using pentane/*tert*-butyl methyl ether = 20:1 as eluent gave **12d** (E/Z = 94:6, 26 mg, 0.22 mmol, 78%) as a yellow oil which contains 3% of the corresponding alkane.

 $\mathbf{R}_f = 0.31$  (pentane/tert-butyl methyl ether = 10:1).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>): 1.18 (s, 9H, H-7), 2.58 (dtd,  ${}^{3}J_{3,2} = 7.0$  Hz,  ${}^{3}J_{3,4} = 6.3$  Hz,  ${}^{4}J_{3,1} = 1.3$ , 2H, H-3), 4.21 (t,  ${}^{3}J_{4,3} = 6.3$  Hz, 2H H-4), 6.31 (dt,  ${}^{3}J_{2,1} = 16.0$  Hz,  ${}^{3}J_{2,3} = 7.0$  Hz, 1H, H-2), 6.46 (d,  ${}^{3}J_{1,2} = 16.0$  Hz, 1H, H-1), 7.39 (d,  ${}^{3}J_{2',3'} = 8.3$  Hz, 2H, H-2'), 7.57 (d,  ${}^{3}J_{3',2'} = 8.3$  Hz, 2H, H-3') ppm. <sup>13</sup>**C NMR** (126 MHz, CDCl<sub>3</sub>): 27.3 (C-7), 32.7 (C-3), 38.9 (C-6), 63.0 (C-4), 110.6 (C-4'), 119.1 (C-5'), 126.6 (C-3'), 126.7 (C-3'), 130.4 (C-2), 131.0 (C-1), 132.5 (C-3'), 141.9 (C1'), 178.5 (C-5') ppm.

**HRMS** (ESI) calcd for  $C_{16}H_{20}NO_3^+$  [(M+OH)+]: 256.1338, found 256.1333.

**IR** (ATR) v = 3452 (w), 2971 (m), 2228 (m), 1721 (s), 1609 (w), 1479 (m), 1398 (w), 1282 (s), 1151 (s), 1036 (m), 831 (m), 735 (s) cm<sup>-1</sup>.

#### 8.18 (*E*)-4-(4-Chlorophenyl)but-3-en-1-yl pivalate (**12e**)

1 3 0 5 6 7

CI 4 3'

12e

$$E/Z = 97:3$$
 $C_{15}H_{19}CIO_2$ 
 $Mw = 266.77 \text{ g/mol}$ 

Prepared from 4-(4-chlorophenyl)but-3-yn-1-yl pivalate **11e** (39 mg, 0.13 mmol, 1.0 equiv), Ni(OTf)<sub>2</sub> (4.6 mg, 13 µmol, 10.0 mol%) and dppf (8.6 mg, 16 µmol, 12.0 mol%), 30 bar H<sub>2</sub> in 1,4-dioxane (1 mL) at 100 °C for 16h according to **GP5**. Then, the reaction was quenched, purification of the crude product *via* flash chromatography

using *n*-pentane/*tert*-butyl methyl ether = 100:1 as eluent gave **12e** as a slightly yellow oil (E/Z = 92:8, 34 mg, 0.13 mmol, 99% containing 3% of the alkane).

 $\mathbf{R}_f = 0.55$  (cyclohexane/tert-butyl methyl ether = 10:1).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.19 (s, 9H, H-7), 2.53 (dtd,  ${}^{3}J_{3,2}$  = 6.8 Hz,  ${}^{3}J_{3,4}$  = 6.7 Hz,  ${}^{4}J_{3,1}$  = 1.4 Hz, 2H, H-3), 4.19 (t,  ${}^{3}J_{4,3}$  = 6.6 Hz, 2H, H-4), 6.14 (dt,  ${}^{3}J_{2,1}$  = 15.8 Hz,  ${}^{3}J_{2,3}$  = 7.0 Hz, 1H, H-2), 6.41 (dt,  ${}^{3}J_{1,2}$  = 15.8 Hz,  ${}^{4}J_{1,3}$  = 1.3 Hz, 1H, H-1), 7.24–7.28 (m, 4H, H-2', H-3') ppm.

<sup>13</sup>**C NMR** (126 MHz, CDCl<sub>3</sub>):  $\delta$  = 27.3 (C-7), 32.6 (C-3), 38.9 (C-6), 63.3 (C-4), 126.7 (C-2), 127.4 (C-2'), 128.8 (C-3'), 131.3 (C-1), 132.9 (C-4'), 136.0 (C-1'), 178.6 (C-5) ppm.

**HRMS** (EI) calcd for  $C_{15}H_{19}CIO_{2}^{*+}$  [(M)\*\*]: 266.1068, found 266.1064.

**IR** (ATR) v = 3968 (m), 1723 (s), 1489 (m), 1480 (m), 1282 (s), 1148 (s), 1089 (s), 1034 (m), 1011 (m), 966 (m), 821 (m), 769 (m) cm<sup>-1</sup>.

#### 8.19 (*E*)-(5-Methylhex-1-en-1-yl)benzene (**12f**)

Prepared from 5-methylhex-1-yn-1-yl)benzene( $\mathbf{11f}$ , 44 mg, 0.26 mmol, 1.0 equiv) using Ni(OTf)<sub>2</sub> (9.2 mg, 26 µmol, 10.0 mol%) and dppf (17.2 mg, 32 µmol, 12.0 mol%) in 1,4-dioxane (2 mL) at 100 °C and 30 bar H<sub>2</sub> according to **GP5**. After 16 h the reaction was quenched, purification of the crude product *via* flash chromatography using pentane/*tert*-butyl methyl ether = 30:1 as

eluent gave **12f** (E/Z = 97:3, 28 mg, 0.16 mmol, 62%) as a pale yellow oil.

**R** $_f = 0.87$  (pentane).

<sup>1</sup>**H NMR** (400 MHz, CDCl<sub>3</sub>): 0.93 (s, 3H, H-6), 0.94 (s, 3H, H-6), 1.35–1.40 (m, 2H, H-4), 1.60–1.67 (m, 1H, H-5), 2.20–2.26 (m, 2H, H-3), 6.23 (dt,  ${}^{3}J_{2,1}$ = 16.0 Hz,  ${}^{3}J_{2,3}$  = 6.9 Hz; 1H, H-2), 6.40 (d,  ${}^{3}J_{1,2}$  = 6.9 Hz, 1H, H-1), 7.19 (tt,  ${}^{3}J_{4',3'}$  = 7.2 Hz,  ${}^{4}J_{4',2'}$  = 1.4 Hz, 1H, H-4'), 7.28–7.32 (m, 2H, H-3'), 7.34–7.37 (m, 2H, H2') ppm.

<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>): 22.7 (C-5), 27.7 (C-6), 31.1 (C-3), 38.7 (C-4), 126.0 (C-2'), 126.9.(C-4'), 128.6 (C-3'), 129.7 (C-1), 131.5 (C-2), 138.1 (C-1') ppm.

**HRMS** (ESI) calcd for  $C_{13}H_{17}^{-}$  [(M-H)<sup>-</sup>]: 173.1325, found 173.1324.

# 8.20 Methyl (*E*)-5-phenylpent-4-enoate (**12g**)

Prepared from methyl 5-phenylpent-4-ynoate (**11g**, 24 mg, 0.13 mmol, 1.0 equiv) using Ni(OTf)<sub>2</sub> (4.0 mg, 13  $\mu$ mol, 10.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 12.0 mol%) in 1,4-dioxane (3 mL) at 100 °C and 20 bar H<sub>2</sub> according to **GP5**. After 18 h the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane/*tert*-butyl

methyl ether = 50:1 as eluent gave **12g** (E/Z = 95:5, 24 mg, 0.13 µmol, 67%) as a yellow oil, which contains 6% of the corresponding alkane.

 $\mathbf{R}_f = 0.56$  (cyclohexane/tert-butyl methyl ether = 20:1).

<sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 2.48–2.57 (m, 4H, H-3, H-4), 3.70 (s, 3H, H-6), 6.21 (dt,  ${}^{3}J_{2,1}$  = 15.8 Hz,  ${}^{3}J_{2,3}$  = 6.6 Hz, 1H, H-2), 6.44 (d,  ${}^{3}J_{1,2}$  = 15.8 Hz, 1H, H-1), 7.21 (m<sub>c</sub>, 1H, H-4'), 7.28–7.31 (m, 2H, H-3'), 7.33–7.35 (m, 2H, H-2') ppm.

<sup>13</sup>**C NMR** (125 MHz, CDCl<sub>3</sub>):  $\delta$  = 28.4 (C-3), 34.0 (C-4), 51.7 (C-6), 126.2 (C-2'), 127.3 (C-4'), 128.5 (C-2), 128.6 (C-3'), 131.1 (C-1), 137.5 (C-1'), 173.5 (C-5) ppm.

**HRMS** (EI) calculated for  $C_{12}H_{14}O_2^+$  [(M)+]: 190.0988, found 190.0979.

The analytic data is in accordance with the literature.[41]

#### 8.21 (*E*)-(5-(Benzyloxy)pent-1-en-1-yl)benzene (**12h**)

Prepared from (5-(benzyloxy)pent-1-yn-1-yl)benzene (**11h**, 32 mg, 0.13 mmol, 1.0 equiv) using Ni(OTf)<sub>2</sub> (4.6 mg, 13  $\mu$ mol, 10.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 12.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 20 bar H<sub>2</sub> according to **GP5**. After 18 h the reaction was quenched, purification of the crude product *via* flash chromatography

using *n*-pentane/*tert*-butyl methyl ether = 100:1 as eluent gave **12h** (E/Z = 95:5, 24 mg, 0.10 mmol, 72%) as a yellow oil, which contains 6% of the corresponding alkane.

 $\mathbf{R}_f = 0.60$  (pentane/tert-butyl methyl ether = 10:1).

<sup>1</sup>**H NMR** (400 MHz, CDCl<sub>3</sub>): 1.82 (m<sub>c</sub>, 2H, H-3), 2.33 (m<sub>c</sub>, 2H, H-4), 3.55 (t,  ${}^{3}J_{5,4} = 6.5$  Hz, 2H, H-5), 4.51 (S, 2H, H-6), 6.23 (dt,  ${}^{3}J_{2,1} = 15.8$  Hz,  ${}^{4}J_{2,3} = 6.8$  Hz, 1H, H-2), 6.42 (m<sub>c</sub>, 1H, H-1), 7.28–7.37 (m, 10H) ppm.

 $^{13}\textbf{C NMR} \ (101 \ \text{MHz}, \ \text{CDCl}_3); \ 29.5 \ (\text{C}-3), \ 29.8 \ (\text{C}-4), \ 69.8 \ (\text{C}-5), \ 73.0 \ (\text{C}-6), \ 126.1 \ (\text{C}-2'), \ 127.0 \ (\text{C}-4'), \ 127.8 \ (\text{C}-8\&10), \ 128.5 \ (\text{C}3\&5), \ 128.6 \ (\text{C}-3'), \ 130.4 \ (\text{C}-1\&2), \ 137.9 \ (\text{C}-1'), \ 138.7 \ (\text{C}-7) \ ppm.$ 

**HRMS** (EI) calculated for  $C_{18}H_{20}O^+$  [(M+H)+]: 253.1587, found 253.1585.

The analytic data is in accordance with the literature. [42]

#### 8.22 (E)-Triisopropyl((4-phenylbut-3-en-1-yl)oxy)silane (12i)

1 3 0 Si 5 6 E-12i 
$$C_{19}H_{32}OSi$$
  $Mw = 304.55$ 

Prepared from triisopropyl((4-phenylbut-3-yn-1-yl)oxy)silane (**11i**, 39 mg, 0.13 mmol, 1.0 equiv) using Ni(OTf)<sub>2</sub> (4.6 mg, 13  $\mu$ mol, 10.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 12.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 20 bar H<sub>2</sub> according to **GP5**. After 18 h the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-

pentane/tert-butyl methyl ether = 100:1 as eluent gave 12i (E/Z = 88:12, 23 mg, 0.08 mmol, 60%) as a yellow oil, which contains 1% of the corresponding alkane.

 $\mathbf{R}_f = 0.78$  (pentane/*tert*-butyl methyl ether = 10:1).

<sup>1</sup>**H NMR** (400 MHz, CDCl<sub>3</sub>): 1.06–1.15 (m, 21H, H-5&6), 2.48 (qd, 6.9 Hz, 1.3 Hz, 2H, H-3), 3.82 (t,  ${}^{3}J_{4,3}$  = 6.8 Hz, 2H, H-4), 6.27 (dt,  ${}^{3}J_{2,1}$  = 15.9 Hz,  ${}^{3}J_{2,3}$  = 6.1 Hz, 1H, H-2), 6.46 (d,  ${}^{3}J_{1,2}$  = 15.8 Hz, 1H, H-1), 7.20 (m<sub>c</sub> 1H, H-4'), 7.28–7.36 (m, 4H) ppm.

<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>): 12.2 (C-5), 18.2 (C-6), 37.0 (C-3), 63.4 (C-4), 126.1 (C-2'), 127.1 (C-4'), 127.5 (C-2), 128.6 (C-3'), 131.6 (C-1), 137.9 (C-1') ppm.

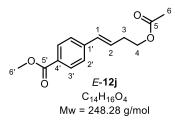
<sup>29</sup>**Si DEPT NMR** (99 MHz, CDCl<sub>3</sub>, J = 20.0 Hz, tip angle 45.0 °): δ = 12.7 ppm.

IR (ATR) v = 3026 (w), 2941 (s), 3864 (s), 1643 (m), 1383 (w), 1463 (m), 1383 (w), 1248 (w), 1105 (s), 1013 (w), 964 (m), 882 (m), 744 (m), 689 (m) cm<sup>-1</sup>.

**HRMS** (EI) calculated for  $C_{19}H_{32}OSi^+$  [(M+H)+]: 305.2295, found 305.2295.

IR (ATR) v = 3026 (w), 2941 (s), 2854 (s), 1463 (m), 1105 (s), 964 (m), 882 (m), 744 (m), 689 (m) cm<sup>-1</sup>.

# 8.23 Methyl (*E*)-4-(4-acetoxybut-1-en-1-yl)benzoate (**12j**)



Prepared from methyl 4-(4-acetoxybut-1-yn-1-yl)benzoate (**11j**, 28mg, 0.13 mmol, 1.0 equiv) using Ni(OTf)<sub>2</sub> (4.0 mg, 13  $\mu$ mol, 10.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 12.0 mol%) in 1,4-dioxane (3 mL) at 100 °C and 20 bar H<sub>2</sub> according to **GP5**. After 18 h the reaction was quenched, purification of the crude product *via* flash

chromatography using *n*-pentane/*tert*-butyl methyl ether = 50:1 as eluent gave **12j** (E/Z = 95:5, 24 mg, 0.10 mmol, 68%) as a yellow oil, which contains 6% of the corresponding alkane.

 $\mathbf{R}_f = 0.53$  (cyclohexane/tert-butyl methyl ether = 2:1).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>): δ = 2.05 (s, 3H, H-6), 2.57 (dtd,  ${}^{3}J_{3,2} = 6.9$  Hz,  ${}^{3}J_{3,4} = 6.7$  Hz,  ${}^{4}J_{3,1} = 1.3$  Hz, 2H, H-3), 3.89 (s, 3H), 4.20 (t,  ${}^{3}J_{4,3} = 6.6$  Hz, 2H, H-4), 6.30 (dt,  ${}^{3}J_{2,1} = 15.9$  Hz, 1H, H-2), 6.50 (d,  ${}^{3}J_{1,2} = 15.9$  Hz, 1H, H-1), 7.38 (d,  ${}^{3}J_{1,2} = 8.2$  Hz, 2H, H-2'), 7.96 (d,  ${}^{3}J_{1,2} = 8.2$  Hz, 2H, H3') ppm.

<sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>): 21.1 (C-6), 32.6 (C-3), 52.1 (C-6), 63.5 (C-4), 126.1 (C-2'), 128.7 (C-2), 128.9 (C-4'), 130.0 (C-3'), 131.7 (C-1), 141.8 (C-1'), 167.0 (C-5), 171.1 (C-5) ppm.

**HRMS** (EI) calculated for  $C_{14}H_{15}O_4$  [(M-H)]: 249.1121, found 249.1131.

IR (ATR) v = 2952 (w), 1714 (s), 1605 (m), 1434 (m), 1364 (w), 1274 (s), 1230 (s), 1177 (s), 1107 (s), 1033 (m), 960 (m), 913 (w), 866 (w), 757 (m), 731 (m), 696 (m) cm<sup>-1</sup>.

#### 8.24 (*E*)-5-(Quinolin-3-yl)pent-4-en-1-yl pivalate (**12k**)

Prepared from 5-(quinolin-3-yl)pent-4-yn-1-yl pivalate (38 mg, 0.13 mmol, 1.0 equiv) using Ni(OTf)<sub>2</sub> (4.6 mg, 13  $\mu$ mol, 10.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 12.0 mol%) in 1,4-dioxane (1 mL) at 100°C and 30 bar H<sub>2</sub> according to **GP5**. After 16 h the reaction was quenched, purification of the crude product *via* flash

chromatography using pentane/tert-butyl methyl ether = 10:1 as eluent gave **12k** (E/Z = 97:3, 22 mg, 0.08 mmol, 70%) as a light yellow oil which contains 2% of the corresponding alkane.

 $\mathbf{R}_f = 0.40$  (pentane/tert-butyl methyl ether = 3:1).

<sup>1</sup>**H NMR** (400 MHz, CDCl<sub>3</sub>): 1.22 (s, 9H, H-8), 1.87 (m<sub>c</sub>, 2H, H-4), 2.37 (m<sub>c</sub>, 2H, H-3), 4.15 (t,  ${}^{3}J_{5,4}$  = 6.4 Hz, 2H, H-5), 6.45 (dt,  ${}^{3}J_{2,1}$  = 16.0 Hz,  ${}^{3}J_{2,3}$  = 7.0 Hz, 1H, H-2), 6.55 (d,  ${}^{3}J_{1,2}$  = 16.0 Hz, 1H, H-1), 7.51 (t,  ${}^{3}J_{5',4'86'}$  = 7.7 Hz, 1H, H-5'), 7.64 (ddd,  ${}^{3}J_{6',7'}$  = 8.1 Hz,  ${}^{3}J_{6',5'}$  = 7.7 Hz,  ${}^{4}J_{6',4'}$  = 1.3 Hz, 1H, H-6'), 7.77 (d,  ${}^{3}J_{4',5'}$  = 8.0 Hz, 1H, H-4'), 7.99 (s, 1H, H-2'), 8.05 (d,  ${}^{3}J_{7',6'}$  = 8.1 Hz, 1H, H-7'), 8.97 (br s, 1H, H-9') ppm.

<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>): 27.4 (C-8), 28.3 (C-4), 29.9 (C-3), 38.9 (C-7), 63.8 (C-5), 127.0 (C-5'), 127.7 (C-1), 127.8 (C-4'), 128.7 (C-3'), 129.0 (C-6'), 129.3 (C-7'), 130.5 (C-1'), 131.8 (C-2'), 132.3 (C-2), 147.4 (C-8'), 149.3 (C-9'), 178.7 (C-6) ppm.

**HRMS** (ESI) calcd for  $C_{19}H_{23}NO_2^+$  [(M+H)+]: 298.1802, found 298.1800.

IR (ATR) v = 3445 (w), 2957 (m), 1721 (s), 1569 (w), 1478 (m), 1282 (s), 1149 (s), 1034 (m), 964 (m), 908 (w), 860 (w), 749 (s) cm<sup>-1</sup>.

#### 8.25 (*E*)-5-(Benzo[*d*][1,3]dioxol-5-yl)pent-4-en-1-yl acetate (**12l**)

7' 
$$O_{4'}$$
  $O_{2'}$   $O_{2'}$   $O_{4'}$   $O_{2'}$   $O_{4'}$   $O_{2'}$   $O_{4'}$   $O_{2'}$   $O_{4'}$   $O_{2'}$   $O_{4'}$   $O_{4'}$ 

Prepared from 5-(benzo[d][1,3]dioxol-5-yl)pent-4-yn-1-ol (11I, 32 mg, 0.13 mmol, 1.0 equiv) using Ni(OTf)<sub>2</sub> (4.6 mg, 13 µmol, 10.0 mol%) and dppf (8.6 mg, 16 µmol, 12.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 30 bar H<sub>2</sub> according to **GP5**. After 16 h the reaction was guenched, purification of the crude product *via* flash

chromatography using pentane/tert-butyl methyl ether = 30:1 as eluent gave **12I** (E/Z = 91:9, 28 mg, 0.11 mmol, 87%) as a colorless oil.

 $\mathbf{R}_f = 0.43$  (pentane/tert-butyl methyl ether = 10:1).

**¹H NMR** (500 MHz, CDCl<sub>3</sub>): 1.79 (m<sub>c</sub>, 2H, H-4), 2.05 (s, 3H, H-7), 2.25 (dtd,  ${}^{3}J_{3,2} = 7.3$  Hz,  ${}^{3}J_{3,4} = 6.7$  Hz,  ${}^{4}J_{3,1} = 1.3$  Hz, 2H, H-3), 4.11 (t,  ${}^{3}J_{5,4} = 6.7$  Hz, 2H, H-5), 5.93 (s, 2H, H-7'), 6.03 (dt,  ${}^{3}J_{2,1} = 15.8$  Hz,  ${}^{3}J_{2,3} = 7.3$  Hz, 1H, H-2), 6.32 (d,  ${}^{3}J_{1,2} = 15.8$  Hz, 1H, H-1), 6.72–6.79 (m, 2H, H2'&H3'), 6.88 (d,  ${}^{4}J_{6,2'} = 1.4$  Hz, 1H, H6') ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>): 21.1 (C-7), 28.5 (C-4), 29.4 (C-3), 64.0 (C-5), 101.1 (C-7'), 105.5 (C-6'), 108.3 (C-2'), 120.5 (C-3'), 127.7 (C-2), 130.4 (C-1), 132.2 (C-1'), 146.9 (C-5'), 148.1 (C-4'), 171.3 (C-6) ppm.

**HRMS** (ESI) calcd for  $C_{28}H_{31}O_4$  [(M-H)]:249.1121, found 249.1121.

IR (ATR) v = 2894 (m), 1732 (s), 1605 (w), 1487 (s), 1442 (s), 1364 (m), 1232 (s), 1096 (w), 1035 (s), 964 (m), 929 (m), 860 (s), 794 (m) cm<sup>-1</sup>.

8.26 (*E*)-5-Phenylpent-4-en-1-yl (*tert*-butoxycarbonyl)-L-phenylalaninate (**12m**)

Prepared from 5-(quinolin-3-yl)pent-4-yn-1-yl (*tert*-butoxycar-bonyl)-L-phenylalaninate (**11m**, 32 mg, 0.13 mmol, 1.0 equiv) using Ni(OTf)<sub>2</sub> (4.6 mg, 13  $\mu$ mol, 10.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 12.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 30 bar H<sub>2</sub> according to **GP5**. After 16 h the reaction was quenched, purification of the crude product *via* flash

chromatography using pentane/tert-butyl methyl ether = 10:1 as eluent gave 12m (E/Z = 93:7, 30 mg, 0.06 mmol, 58%) as a yellow oil.

 $\mathbf{R}_f = 0.42$  (pentane/tert-butylthyl ether = 10:1).  $[\alpha]_D^{20} = +32.1$  (c 1.0, CHCl<sub>3</sub>).

**¹H NMR** (500 MHz, CDCl<sub>3</sub>): 1.43 (s, 9H, H-13), 1.78 (m<sub>c</sub>, 2H, H-1'), 2.22 (q,  ${}^{3}J_{6',5'}$  = 7.0 Hz, 2H, H-2'), 3.05–3.14 (m, 2H, H-6'), 4.12–4.18 (m, 2H, H-3'), 4.60 (m<sub>c</sub>, 1H, H-5'), 5.00 (m<sub>c</sub>, 1H, *NH*), 6.17 (dt,  ${}^{3}J_{1,2}$  = 15.9 Hz,  ${}^{3}J_{1,1'}$  = 6.9 Hz, 1H, H-1), 6.40 (d,  ${}^{3}J_{2,1}$  = 15.9 Hz, 1H, H-2), 7.15 (d,  ${}^{3}J_{8',9'}$  = 7.0 Hz, 2H, H-8'), 7.20–7.26 (m, 2H, H-10'&H-6), 7.28-7.32 (m, 4H, H-9'&H5), 7.33–7.35 (m, 2H, H-4) ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>): 28.3 (C-1'), 28.4 (C-13'), 29.3 (C-2'), 38.6 (C-6'), 54.6 (C-5'), 64.9 (C-3'), 80.0 (C-12'), 126.1 (C-4), 127.1 (C-10')\*, 127.2 (C-6)\*, 128.6 (C-9', C-5), 129.4 (C-8'), 131.0 (C-2), 136.2 (C-3), 137.6 (C-7'), 155.2 (C-11'), 172.1 (C-4') ppm.

**HRMS** (ESI) calcd for  $C_{25}H_{32}ON_4^+$  [(M+H)+]:410.2326, found 410.2325.

**IR** (ATR) v = 3378 (w), 2973 (w), 2930 (w), 1704 (s), 1600 (w), 1493 (s), 1452 (m), 1364 (s), 1274 (m), 1158 (s), 1052 (m), 1021 (m), 955 (m), 859 (w), 741 (s), 696 (s) cm<sup>-1</sup>.

# 8.27 (*E*)-5-(Quinolin-3-yl)pent-4-en-1-yl (*tert*-butoxycarbonyl)-L-phenylalaninate (**12n**)

Prepared from 5-(quinolin-3-yl)pent-4-yn-1-yl (*tert*-butoxycarbonyl)-L-phenylalaninate (11n, 27 mg, 0.13 mmol, 1.0 equiv) using Ni(OTf)<sub>2</sub> (4.6 mg, 13 µmol, 10.0 mol%) and dppf (8.6 mg, 16 µmol, 12.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 30 bar H<sub>2</sub> according to **GP5**. After 64 h the reaction was quenched, purification of the

crude product via flash chromatography using pentane/tert-butyl methyl ether = 10:1 as eluent

gave **12n** (E/Z = 97:3, 24 mg, 0.05 mmol, 43%) as a yellow oil which contains 17% of the corresponding alkane.

 $\mathbf{R}_f = 0.43$  (pentane/*tert*-butylthyl ether = 3:1).  $[\alpha]_D^{20} = +13.6$  (c 1.0, CHCl<sub>3</sub>).

<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): 1.42 (s, 9H, H-13'), 1.83 (m<sub>c</sub>, 2H, H-2'), 2.29 (m<sub>c</sub>, 2H, H-1'), 3.10 (m<sub>c</sub>, 2H, H-6'), 4.18 (m<sub>c</sub>, 2H, H-3'), 4.59 (m<sub>c</sub>, 1H, H-5'), 5.00 (d,  ${}^{3}J_{NH,5'} = 7.2$  Hz, 1H, *NH*), 6.40 (dt,  ${}^{3}J_{1,2'} = 16.7$  Hz,  ${}^{3}J_{1,1'} = 6.7$  Hz, 1H, H-1), 6.54 (d,  ${}^{3}J_{2,1} = 16.7$  Hz, 1H, H-2), 7.11–7.16 (m, 1H, H-10'), 7.22–7.30 (m, 4H, H-8' & H-9'), 7.51 (ddd,  ${}^{3}J_{8,7} = 8.2$  Hz,  ${}^{3}J_{8,9} = 6.7$  Hz,  ${}^{4}J_{8,6} = 1.0$  Hz, 1H, H-8), 7.65 (ddd,  ${}^{3}J_{7,8} = 8.2$  Hz,  ${}^{3}J_{7,6} = 6.7$  Hz,  ${}^{4}J_{7,9} = 1.0$  Hz, 1H, H-7), 7.77 (d,  ${}^{3}J_{6,7} = 7.2$  Hz, 1H, H-6), 7.98 (d,  ${}^{3}J_{11,2} = 1.9$  Hz, 1H, H-11), 8.07 (m<sub>c</sub>, 1H, H-9), 8.96 (d,  ${}^{3}J_{4,11} = 2.0$  Hz, 1H, H-4) ppm. 13**C NMR** (101 MHz, CDCl<sub>3</sub>): 28.1 (C-2'), 28.4 (C-13'), 29.6 (C-1'), 38.6 (C-6'), 54.7 (C-5'), 65.3 (C-3'), 80.1 (C-12'), 127.0 (C-8), 127.9 (C-2, C-6, C-5), 128.7 (C-7, C-8' & C-9'), 129.2 (C-9), 129.4 (C-10'), 130.5 (C-3) 132.0 (C-1 & C-11), 136.2 (C-7'), 147.3 (C-10), 149.3 (C-4), 155.2 (C-11'), 172.2 (C-4') ppm.

**HRMS** (ESI) calcd for  $C_{28}H_{32}N_2O_4^+$  [(M+H)+]: 461.2435, found 461.2441.

**IR** (ATR) v = 3359 (w), 2927 (m), 1706 (s), 1618 (w), 1493 (m), 1453 (w), 1364 (m), 1249 (m), 1163 (s), 1052 (w), 1018 (w), 966 (w), 751 (m), 700 (m) cm<sup>-1</sup>.

# 8.28 $17\alpha$ -20*E*-21-(4-Methoxycarbonylyphenyl)-19-norpregna-1,3,5(10),20-tetraene-3,17,-diol (**12o**)

Prepared from  $17\alpha$ -20*E*-21-(4-Methoxycarbonylyphenyl)-19-norpregna-1,3,5(10),20-tetraene-3,17,-diol (**11o**, 53 mg, 0.13 mmol, 1.0 equiv) using Ni(OTf)<sub>2</sub> (4.6 mg, 13 µmol, 10.0 mol%) and dppf (8.6 mg, 16 µmol, 12.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 20 bar H<sub>2</sub> according to **GP5**. After 16 h the reaction was quenched, purification of the crude product *via* flash chromatography using pentane/*tert*-butyl methyl ether = 5:1 as eluent gave **12o** (E/Z = 73:27, 29 mg,

0.07 mmol, 55%) as a pale yellow oil.

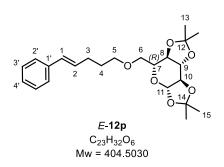
 $\mathbf{R}_f = 0.78$  (pentane/tert-butyl methyl ether = 1:1).  $[\alpha]_D^{20} = -45.5$  (c 1.0, CHCl<sub>3</sub>).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>): 1.00 (s, 3H, H-18'), 1.25–2.41 (m, 13H, steroid envelope<sup>[43]</sup>), 2.60 (s, 3H, H-8), 2.82–2.90 (m, 2H, H-7'), 5,21 (br s, 1H, *OH*), 5.98 (br s, 1H, *OH*), 6.59–6.66 (m, 2H, H-9', H-11'), 6.78 (d,  ${}^{3}J_{2,1}$  = 16.7 Hz, 1H, H-2), 6.91 (d,  ${}^{3}J_{1,2}$  = 16.7 Hz, 1H, H-1), 7.15 (d,  ${}^{3}J_{12'-11'}$  = 8.4 Hz, 1H, H-12'), 7.49 (d,  ${}^{3}J_{4,5}$  = 8.0 Hz, 2H, H-4), 7.91–7.93 (m, 2H, H-5) ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>): 16.5 (C-18'), 26.8 (C-8), 27.1 (C-15'), 27.8 (C-3', C-6'), 29.7 (C-7'), 27.8 (C-3'), 32.6 (C-2'), 35.8 (C-16'), 37.4 (C-5'), 44.4 (C-14'), 46.8 (C-17'), 56.7 (C-4'), 85.3 (C-1'), 112.9 (C-9'), 115.5 (C-11'), 126.30 (C-2), 126.3 (C-4), 126.6 (C-12'), 129.0 (C-5), 132.6 (C-1), 132.8 (C-13'), 135.6 (C-6), 138.3 (C-8'), 142.9 (C-3), 153.1 (C-10'), 197.9 (C-7) ppm. HRMS (ESI) calcd for  $C_{28}H_{31}O_4^{-1}$  [(M-H)-]:431.2208, found 431.2228.

The analytic data is in accordance with the literature. [43]

8.29 (3aS,5aR,8aS,8bR)-2,2,7,7-Tetramethyl-5-(((E)-5-phenylpent-4-en-1-yl)0xy)-methyl)tetrahydro-5*H*-bis([1,3]dioxolo)[4,5-b:4',5'-d]pyran (12p)



Prepared from (3aS,5aR,8aS,8bR)-2,2,7,7-tetramethyl-5-(((5-phenylpent-4-yn-1-yl)oxy)methyl)tetrahydro-5H-bis([1,3]dioxolo)[4,5-b:4',5'-d]pyran (**11p**, 25 mg, 0.13 mmol, 1.0 equiv) using Ni(OTf)<sub>2</sub> (4.6 mg, 13 µmol, 10.0 mol%) and dppf (8.6 mg, 16 µmol, 12.0 mol%) in 1,4-dioxane (1 mL) at 100°C and 30 bar H<sub>2</sub> according to **GP5**. After 16 h the reaction was quenched, purification of the crude product *via* flash chromatography using

pentane/tert-butyl methyl ether = 15:1 as eluent gave 12p (E/Z = 76:24 (25 mg, 0.06 mmol, 49%) as a light yellow oil.

 $\mathbf{R}_f = 0.43$  (pentane/*tert*-butyl methyl ether = 10:1).  $[\alpha]_D^{20} = +13.6$  (c 1.0, CHCl<sub>3</sub>).

**¹H NMR** (500 MHz, CDCl<sub>3</sub>): 1.30 (s, 3H, H-15), 1.35 (s, 3H, H-13), 1.43 (s, 3H, H-13), 1.49 (s, 3H, H-15), 1.75 (m<sub>c</sub>, 2H, H-4), 2.30 (q,  ${}^{3}J_{3,482}$  = 7.10 Hz, 2H, H-3), 3.52–3.59 (m, 1H, H-6), 3.61–3.68 (m, 2H, H-6), 3.87 (m<sub>c</sub>, 1H, H-8), 3.95–4.05 (m, 1H, H-5), 4.08–4.12 (m, 1H, H-5), 4.12–4,14 (m, 1H, H-10), 4.32–4.36 (m, 1H, H-7), 4.53 (d, J = 3.7 Hz, 1H, H-9), 5.88 (d,  ${}^{3}J_{11,10}$  = 3.7 Hz, 1H, H-11), 6.21 (dt,  ${}^{3}J_{2,1}$  = 15.8 Hz,  ${}^{3}J_{2,3}$  = 7.0 Hz, 1H, H-2), 6.41 (d,  ${}^{3}J_{1,2}$  = 15.8 Hz, 1H, H-1), 7.17–7.24 (m, 1H, H-4'), 7.26–7.31 (m, 2H, H2', H3'), 7.33–7.34 (m, 1H, H-2') ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>): 25.5 (C-13), 26.3 (C-15), 26.9 C-13), 27.0 (C-15), 29.4 (C-4) 29.6 (C-3), 67.4 (C-5), 69.9 (C-6), 72.6 (C-7), 81.3 (C-10), 82.3 (C-8), 82.61 (C-9), 105.42 (C-11), 109.1 (C-12), 111.9 (C-14), 126.1 (C-2'), 127.1 (H-4'), 128.6 (H-3'), 130.1 (C-2), 130.6 (C-1), 137.8 (C-1') ppm.

**HRMS** (ESI) calcd for  $C_{19}H_{21}NO_2S^-$  [(M-H)<sup>-</sup>]: 405.2272 found 405.2269.

IR (ATR) v = 2984 (m), 2932 (m), 1452 (w), 1371(s), 1212 (s), 1163 (m), 1068 (s), 1016 (s), 964 (w), 874 (s), 742 (m), 695 (m) cm<sup>-1</sup>.

#### 8.30 (*E*)-4-(2-Hydroxyphenyl)but-3-en-1-yl pivalate (**14**)

3' 2' 1 3 0 5 6 4 OH

E-14  $C_{15}H_{20}O_3$   $M_W = 248.32$ 

Prepared from 4-(2-hydroxyphenyl)but-3-yn-1-yl pivalate (**13a**, 32 mg, 0.13 mmol, 1.0 equiv) using Ni(OTf)<sub>2</sub> (4.6 mg, 13  $\mu$ mol, 10.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 12.0 mol%) in 1,4-dioxane (1 mL) at 100°C and 30 bar H<sub>2</sub> according to **GP5**. After 16 h the reaction was quenched, purification of the crude product *via* flash chromatography using

pentane/tert-butyl methyl ether = 10:1 as eluent gave **14** (E/Z = 97:3, 30 mg, 0.12 mmol, 96%) as a colorless oil which contains 5% of the corresponding alkane.

 $\mathbf{R}_f = 0.41$  (pentane/tert-butyl methyl ether = 10:1).

<sup>1</sup>**H NMR** (400 MHz, CDCl<sub>3</sub>): 1.20 (s, 9H, H-7), 2.52 (dtd,  ${}^{3}J_{3,2} = 6.7$  Hz,  ${}^{3}J_{3,4} = 6.6$  Hz,  ${}^{3}J_{3,1} = 1.4$  Hz, 2H, H-3), 4.19 (t,  ${}^{3}J_{4,3} = 6.6$  Hz, 2H, H-4), 5.65 (s, 1H, *OH*), 6.12 (dt,  ${}^{3}J_{2,1} = 15.5$  Hz,  ${}^{3}J_{2,3} = 7.0$  Hz, 1H, H-1), 6.39 (d,  ${}^{3}J_{1,2} = 16.0$  Hz, 1H, H-1), 6.72 (ddd,  ${}^{3}J_{3',4'} = 8.2$  Hz,  ${}^{3}J_{3',2'} = 7.7$  Hz,  ${}^{3}J_{3',5'} = 0.8$  Hz, 1H, H-3'), 6.83 (m<sub>c</sub>, 1H, H-5'), 6.89 (d,  ${}^{3}J_{2',3'} = 7.7$  Hz, 1H, H-2'), 7.16 (t,  ${}^{3}J_{4',3'85'} = 7.9$  Hz, 1H, H-4') ppm.

<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>): 27.3 (C-7), 32.5 (C-3), 39.0 (C-6), 63.7 (C-4), 112.8 (C-5'), 114.5 (C-3'), 118.9 (C-2'), 126.2 (C-2), 129.8 (C-4'), 132.3 (C-1), 139.1 (C-1'), 156.1 (C-6'), 179.2 (C-5) ppm.

**HRMS** (ESI) calcd for  $C_{15}H_{20}O_3$  [(M-H)]: 247.1340 found 247.1328.

IR (ATR) v = 3386 (m), 2967 (m), 1699 (s), 1590 (m), 1450 (m), 1285 (m), 1152 (s), 1033 (w), 964 (m), 869 (w), 773 (m), 687 (m) cm<sup>-1</sup>.

#### 8.31 2-(1*H*-Indol-2-yl)ethyl pivalate (**15**)

3' 
$$\stackrel{4'}{2'}$$
  $\stackrel{5'}{1}$   $\stackrel{6'}{1}$   $\stackrel{NH}{3}$   $\stackrel{4}{0}$   $\stackrel{7}{5}$   $\stackrel{6}{6}$   $\stackrel{7}{1}$   $\stackrel{15}{6}$   $\stackrel{C_{15}H_{19}NO_2}{1}$   $\stackrel{MW}{=}$  245.32

Prepared from 4-(2-aminophenyl)but-3-yn-1-yl pivalate (**13b**) (32 mg, 0.13 mmol, 1.0 equiv) using Ni(OTf)<sub>2</sub> (4.6 mg, 13  $\mu$ mol, 10.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 12.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 30 bar H<sub>2</sub> according to **GP5**. After 16 h the reaction was quenched, purification of the crude product *via* flash chromatography using

pentane/tert-butyl methyl ether = 4:1 as eluent gave **15** (11 mg, 0.05 mmol, 36%) as a brown gum.

 $\mathbf{R}_f = 0.47$  (pentane/tert-butyl methyl ether = 10:1).

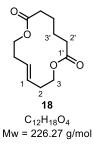
<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>): 1.22 (s, 9H, H-7), 3.11 (dd,  ${}^{3}J_{3,4} = 6.4$  Hz,  ${}^{4}J_{3,1} = 0.6$  Hz, 2H, H-3), 4.38 (t,  ${}^{3}J_{4,3} = 6.4$  Hz, 2H, H-4), 6.31–6.30 (m, 1H, H-1), 7.09 (ddd,  ${}^{3}J_{3',2'} = 8.0$  Hz,  ${}^{3}J_{3',4'} = 7.2$  Hz,  ${}^{4}J_{3',5'} = 1.1$  Hz, 1H, H-3'), 7.14 (ddd,  ${}^{3}J_{4',5'} = 8.0$  Hz,  ${}^{3}J_{4',3'} = 7.2$  Hz,  ${}^{4}J_{4',2'} = 1.1$  Hz, 1H, H4'), 7.31 (m<sub>c</sub>, 1H, H-5'), 7.54 (d,  ${}^{3}J_{2',3'} = 8.1$  Hz, 1H, H-2'), 8.09 (br s, 1H, *NH*) ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>): 27.4 (C-7), 28. (C-3)1, 38.9 (C-6), 63.6 (C-4), 101.0 (C-1), 110.6 (C-5'), 119.9 (C-3'), 120.2 (C-2'), 121.6 (C-4'), 128.7 (C-1'), 135.6 (C-2), 136.2 (C-6'), 178.6 (C-5) ppm.

**HRMS** (ESI) calcd for  $C_{16}H_{20}NO_3^+$  [(M+OH)+]: 246.1489, found 274.1497.

IR (ATR) v = 3387 (w), 2953 (s), 2916 (s), 1728 (m), 1616 (w), 1458 (m), 1377 (m), 1285 (w), 1157 (m), 1034 (w), 973 (w), 749 (w) cm<sup>-1</sup>.

# 8.32 (*E*)-1,8-Dioxacyclotetradec-11-ene-2,7-dione (**18**)



Prepared from 1,8-dioxacyclotetradec-11-yne-2,7-dione (**17**, 57 mg, 0.26 mmol, 1.0 equiv) using Nil<sub>2</sub> (4.0 mg, 13  $\mu$ mol, 5.0 mol%) and dppf (8.6 mg, 16  $\mu$ mol, 6.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 20 bar H<sub>2</sub> according to **GP5**. After 24 h the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane/*tert*-butyl methyl ether = 40:1 as eluent gave **18** (26 mg, 0.11 mmol, 45%) as a white solid.

 $\mathbf{R}_f = 0.52$  (cyclohexane/tert-butyl methyl ether = 1:1)

<sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.64 (m<sub>c</sub>, 4H, H-3'), 2.34 (m<sub>c</sub>, 4H, H-2'), 2.36–2.39 (m, 4H, H-2), 4.12–4.15 (m, 4H, H-3), 5.45 (m<sub>c</sub>, 2H, H-1) ppm.

<sup>13</sup>**C NMR** (126 MHz, CDCl<sub>3</sub>):  $\delta$  = 24.9 (C-3'), 32.0 (C-2), 35.2 (C-2'), 63.3 (C-3), 129.4 (C-1), 173.3 (C-1') ppm.

**HRMS** (ESI) calcd for  $C_{16}H_{19}F_3O_2^+$  [(M)+]: 227.1278, found 227.1280.

The analytic data is in accordance with the literature.<sup>[44]</sup>

#### 8.33 (E)-1,3-Dimethoxy-5-(4-methoxystyryl)benzene (E-25)

MeO 
$$\frac{1}{2}$$
  $\frac{1}{2}$   $\frac{3}{4}$   $\frac{6}{5}$  OMe  $\frac{1}{7}$  OMe  $\frac{1}{2}$   $\frac{2}{4}$   $\frac{1}{5}$   $\frac{1}{5}$   $\frac{2}{5}$   $\frac{1}{5}$   $\frac{$ 

Prepared from 1,3-dimethoxy-5-((4-methoxyphenyl)ethynyl)benzene (24, 0.14 g, 0.52 mmol, 1.0 equiv) using Nil<sub>2</sub> (8.0 mg, 26  $\mu$ mol, 5.0 mol%) and dppf (17 mg, 32  $\mu$ mol, 6.0 mol%) in 1,4-dioxane (2 mL) at 100 °C and 20 bar H<sub>2</sub> according to **GP5**. After 18 h the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane/*tert*-butyl methyl ether = 30:1 as eluent gave *E*-25

(0.11 g, 0.41 mmol, 79%) as a slightly yellow solid.

 $\mathbf{R}_f = 0.59$  (cyclohexane/tert-butyl methyl ether = 2:1).

<sup>1</sup>**H NMR** (400 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 3.82 (m, 9H, H-7, H-5'), 6.37 (t,  ${}^4J_{4',2'}$  = 2.2 Hz, 1H, H-4'), 6.66 (d,  ${}^4J_{2',4'}$  = 2.3 Hz, 2H, H-2'), 6.91 (m<sub>c</sub>, 2H, H-5), 6.92 (d,  ${}^3J_{1,2}$  = 16.3 Hz, 1H, H-1), 7.07 (d,  ${}^3J_{2,1}$  = 16.3 Hz, 1H, H-2), 7.47 (m<sub>c</sub>, 2H, H-4) ppm.

<sup>13</sup>C NMR (101 MHz, CD<sub>2</sub>Cl<sub>2</sub>):  $\delta$  = 55.7 (C-7), 55.7 (C-5'), 99.9 (C-4'), 104.6 (C-2'), 114.5 (C-5), 126.7 (C-1), 128.1 (C-4), 129.0 (C-2), 130.2 (C-3), 140.1 (C-1'), 159.9 (C-6), 161.5 (C-3') ppm. **HRMS** (APCI) calcd for C<sub>17</sub>H<sub>19</sub>O<sub>3</sub><sup>+</sup> [(M+H)<sup>+</sup>]: 271.1329, found 271.1324.

The analytic data is in accordance with the literature. [45]

# 8.34 (*E*)-*N*,4-Dimethyl-*N*-(5-phenylpent-4-en-1-yl)benzenesulfonamide (**28**)

Prepared from 
$$N$$
,4-dimethyl- $N$ -(5-phenylpent-2-yn-1-yl)benzenesulfonamide (**S12**, 42 mg, 0.13 mmol, 1.0 equiv) using Ni(OTf)<sub>2</sub> (4.6 mg, 13 µmol, 10.0 mol%) and dppf (8.6 mg,  $E$ -28  $E$ -28  $E$ -28  $E$ -29  $E$ -29

pentane/tert-butyl methyl ether = 4:1 as eluent gave **28** (E/Z = 97:3, 26 mg, 0.08 mmol, 61%) as a colorless oil which contains 23% of the other isomers

 $\mathbf{R}_f = 0.47$  (pentane/tert-butyl methyl ether = 4:1).

<sup>1</sup>**H NMR** (400 MHz, CDCl<sub>3</sub>): 1.72 (p,  ${}^{3}J_{4,385} = 7.4$  Hz, 2H, H-4), 2.27 (dtd,  ${}^{3}J_{3,4} = 7.4$ ,  ${}^{3}J_{3,2} = 7.1$  Hz,  ${}^{3}J_{3,1}$  1.3 Hz, 2H, H-3), 2.42 (s, 3H, H-11), 2.73 (s, 3H, H-6), 3.04 (t,  ${}^{3}J_{5,4} = 7.4$  Hz, 2H, H-5), 6.20 (dt,  ${}^{3}J_{2,1} = 15.8$  Hz,  ${}^{3}J_{2,3} = 6.9$  Hz, 1H, H-2), 6.42 (d,  ${}^{3}J_{2,1} = 15.8$  Hz, 1H, H-1), 7.28–7.36 (m, 7H, H-2', H-3', H-4', H-9), 7.66–7.68 (m, 2H, H-8) ppm.

<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>): 21.6 (C-11), 27.5 (C-4), 30.0 (C-3), 34.9 (C-6), 49.8 (C-5), 126.1 (C-2'), 127.1 (C-4'), 127.5 (C-8), 128.6 (C-4'), 129.5 (C-2), 129.8 (C-9), 130.9 (C-1), 134.7 (C-10), 143.4 (C-7) ppm.

**HRMS** (ESI) calcd for  $C_{19}H_{24}NO_2S^+$  [(M+H)+]: 330.1522 found 330.1524.

IR (ATR) v = 2969 (w), 2928 (m), 1724 (m), 1597 (w), 1455 (w), 1340 (m), 1285 (w), 1159 (s), 1090 (w), 966 (m), 815 (w), 744 (w), 716 (w) cm<sup>-1</sup>

# 9 Formation of ( $\mathbb{Z}$ )-1,3-Dimethoxy-5-(4-methoxystyryl)benzene ( $\mathbb{Z}$ -25)

#### 9.1 (Z)-1,3-Dimethoxy-5-(4-methoxystyryl)benzene (Z-25)

Prepared from 1,3-dimethoxy-5-((4-methoxyphenyl)ethynyl)benzene (**24**, 69 mg, 0.26 mmol, 1.0 equiv) and [IPrCuOH] (6.0 mg, 13  $\mu$ mol, 5.0 mol%) following a modified literature procedure. The reaction mixture was stirred under 100 bar H<sub>2</sub> at 50 °C for 24 h. Then the reaction mixture was filtered through a plug of silica (1 cm), eluted with *tert*-butyl methyl ether (2 mL) and concentrated under reduced pressure. Purification by flash column

chromatography on silica gel using n-pentane/tert-butyl methyl ether = 30:1 as eluent afforded Z-**25** (61 mg, 0.22 mmol, 88%) as a colorless oil.

 $\mathbf{R}_f = 0.64$  (cyclohexane/tert-butyl methyl ether = 2:1).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 3.68 (s, 6H, H-5'), 3.79 (s, 3H, H-7), 6.33 (t,  ${}^{4}J_{4',2'}$  = 2.3 Hz, 1H, H-4'), 6.44 (m<sub>c</sub>, 2H, H-2'), 6.45 (d,  ${}^{3}J_{1,2}$  = 12.3 Hz, 1H, H-1), 6.53 (d,  ${}^{3}J_{2,1}$  = 12.3 Hz, 1H, H-2), 6.78 (m<sub>c</sub>, 2H, H-5), 7.23 (m<sub>c</sub>, 2H, H-4) ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>):  $\delta$  = 55.3 (C-7), 55.3 (C-5'), 99.8 (C-4'), 106.8 (C-2'), 113.7 (C-5), 128.8 (C-1), 129.7 (C-3), 130.3 (C-2), 130.4 (C-4), 139.6 (C-1'), 158.9 (C-6), 160.7 (C-3') ppm. HRMS (ESI) calcd for  $C_{17}H_{19}O_3^+$  [(M+H)+]: 271.1329, found 271.1341.

The analytic data is in accordance with the literature.[47]

# 10 Preparation of Resveratrol (26)

# 10.1 (E)-5-(4-Hydroxystyryl)benzene-1,3-diol (26, Resveratrol)

Mw = 228.25 g/mol

Following a modified literature<sup>[42]</sup> (*E*)-1,3-dimethoxy-5-(4-methoxystyryl)benzene (*E*-**25**, 20 mg, 74 µmol, 1.0 equiv) was dissolved in CH<sub>2</sub>Cl<sub>2</sub> (1 mL) and a solution of BBr<sub>3</sub> (1.0M in CH<sub>2</sub>Cl<sub>2</sub>, 0.67 mmol, 0.67 mL, 9.0 equiv) was added at -78 °C. The mixture was stirred for 1 h at -78 °C. Then the reaction was allowed to warm to rt, H<sub>2</sub>O (5 mL) was added and the mixture was poured into H<sub>2</sub>O (5 mL). Extraction with

EtOAc (3 x 5 mL), washing of the combined organic layers with  $H_2O$  (5 mL), brine (5 mL), drying over MgSO<sub>4</sub> and concentration under reduced pressure gave the crude product which was purified *via* flash chromatography using *n*-pentane/*tert*-butyl methyl ether = 1:1 as eluent to afford **26** (14 mg, 61 µmol, 83%) as an off-white solid.

 $\mathbf{R}_f = 0.57$  (*n*-pentane/*tert*-butyl methyl ether = 1:4).

<sup>1</sup>**H NMR** (500 MHz, acetone- $d_6$ ): δ = 6.30 (t,  ${}^4J_{4',2'}$  = 2.2 Hz, 1H, H-4'), 6.54 (d,  ${}^4J_{2',4'}$  = 2.1 Hz, 2H, H-2'), 6.84 (m<sub>c</sub>, 2H, H-5), 6.88 (d,  ${}^3J_{1,2}$  = 16.3 Hz, 1H, H-1), 7.02 (d,  ${}^3J_{2,1}$  = 16.3 Hz, 1H, H-2), 7.42 (m<sub>c</sub>, 2H, H-4), 8.17 (br s, 2H, 3'-O*H*), 8.42 (br s, 1H, 6-O*H*) ppm.

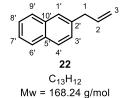
<sup>13</sup>**C NMR** (126 MHz, acetone- $d_6$ ): δ = 102.7 (C-4'), 105.7 (C-2'), 116.4 (C-5), 126.8 (C-1), 128.7 (C-4), 129.1 (C-2), 130.0 (C-3), 140.9 (C-1'), 158.1 (C-6), 159.6 (C-3') ppm.

**HRMS** (APCI) calcd for  $C_{14}H_{13}O_{3}^{+}$  [(M+H)+]: 229.0859, found 229.0855.

The analytic data is in accordance with the literature. [48]

# 11 Control Experiments

#### 11.1 2-Allylnaphthalene (22)



Following a literature procedure<sup>[49]</sup> in a Schlenk tube a mixture of Cul (34 mg, 0.18 mmol, 0.10 equiv), 2,2'-bipyridine (28 mg, 0.18 mmol, 0.10 equiv), 2-(bromomethyl)naphthalene (394 mg, 1.78 mmol, 1.00 equiv) and benzene (1 mL) was cooled to 0 °C. A solution of vinylmagnesium bromide (1.0M in THF, 2.85 mL, 2.85 mmol, 1.60 equiv) was added rapidly. The mixture was

allowed to warm to rt overnight and quenched by the addition of sat. aq. NH<sub>4</sub>Cl (8 mL), aqueous NH<sub>3</sub>-sol. (25 wt%, 3 mL). Extraction with *tert*-butyl methyl ether (3 x 5 mL), washing with brine (10 mL), drying over MgSO<sub>4</sub> and concentration gave the crude product. Purification *via* flash chromatography using *n*-pentane as eluent gave **22** (0.14 g, 0.83 mmol, 47%) as a colorless liquid.

 $R_f = 0.53$  (*n*-pentane).

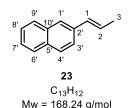
<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 3.57 (d,  ${}^{3}J_{1,2}$  = 6.7 Hz, 2H, H-1), 5.12-5.17 (m, 2H, H-3), 6.07 (m<sub>c</sub>, 1H, H-2), 7.35 (dd,  ${}^{3}J_{3',4'}$  = 8.5 Hz,  ${}^{4}J_{3',1'}$  = 1.4 Hz, 1H, H-3'), 7.45 (m<sub>c</sub>, 2H, H-7', H-8'), 7.64 (s, 1H, H-1'), 7.79 (m<sub>c</sub>, 2H, H-4', H-9'), 7.82 (m<sub>c</sub>, 1H, H-6') ppm.

<sup>13</sup>**C NMR** (126 MHz, CDCl<sub>3</sub>):  $\delta$  = 40.5 (C-1), 116.2 (C-3), 125.4 (C-7'), 126.1 (C-8'), 126.8 (C-1'), 127.5 (C-3'), 127.6 (C-6')\*, 127.8 (C-4')\*, 128.1 (C-9')\*, 132.3 (C-5'), 133.8 (C-10'), 137.5 (C-2), 137.7 (C-2') ppm.

**HRMS** (EI) calcd for  $C_{13}H_{12}^+$  [(M)<sup>+</sup>]: 168.0934, found 168.0932.

The analytic data is in accordance with the literature.<sup>[50]</sup>

## 11.2 (*E*)-2-(Prop-1-en-1-yl)naphthalene (**23**)



as a white solid.

Prepared from 2-Allylnaphthalene (22, 22 mg, 0.13 mmol, 1.0 equiv) using Nil $_2$  (2.0 mg, 6.4 µmol, 5.0 mol%) and dppf (4.3 mg, 8.0 µmol, 6.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 20 bar H $_2$  according to **GP5**. After 16 h the reaction was quenched, purification of the crude product via flash chromatography using n-pentane as eluent gave 23 (14 mg, 83 µmol, 65%)

 $R_f = 0.68$  (*n*-pentane).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.95 (dd,  ${}^{3}J_{3,2}$  = 6.6 Hz,  ${}^{4}J_{3,1}$  = 1.7 Hz, 3H, H-3), 6.38 (dq,  ${}^{3}J_{2,1}$  = 15.7 Hz,  ${}^{3}J_{2,3}$  = 6.6 Hz, 1H, H-2), 6.58 (dq,  ${}^{3}J_{1,2}$  = 15.7 Hz,  ${}^{4}J_{1,3}$  = 1.7 Hz, 1H, H-1), 7.43 (m<sub>c</sub>, 2H, H-7', H-8'), 7.58 (dd,  ${}^{3}J_{3',4'}$  = 8.5 Hz,  ${}^{4}J_{3',1'}$  = 1.8 Hz, 1H, H-3'), 7.67 (s, 1H, H-1'), 7.77 (d,  ${}^{3}J_{4',3'}$  = 8.6 Hz, 1H, H-4'), 7.79 (m<sub>c</sub>, 2H, H-6', H-9') ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>):  $\delta$  = 18.8 (C-3), 123.7 (C-3'), 125.3 (C-1'), 125.6 (C-7')\*, 126.2 (C-8')\*, 126.3 (C-2), 127.8 (C-9')\*\*, 128.0 (C-6')\*\*, 128.2 (C-4'), 131.3 (C-1), 132.8 (C-5'), 133.9 (C-10'), 135.6 (C-2') ppm.

**HRMS** (EI) calcd for  $C_{13}H_{12}^+$  [(M)<sup>+</sup>]: 168.0934, found 168.0932.

The analytic data is in accordance with the literature.<sup>[51]</sup>

11.3 (*E*)-2-(Prop-1-en-1-yl)naphthalene- $d_1$ , (*E*)-2-(Prop-1-en-1-yl)naphthalene- $d_2$ , (*E*)-2-(Prop-1-en-1-yl)naphthalene- $d_3$  (**23**- $d_1$ ,  $d_2$ ,  $d_3$ )

Prepared from 2-Allylnaphthalene (**22**, 22 mg, 0.13 mmol, 1.0 equiv) using Nil<sub>2</sub> (2.0 mg, 6.4  $\mu$ mol, 5.0 mol%) and dppf (4.3 mg, 8.0  $\mu$ mol, 6.0 mol%) in 1,4-dioxane (1 mL) at 100 °C and 20 bar D<sub>2</sub> according to **GP5**. After 16 h the reaction was quenched, purification of the crude product *via* flash chromatography using *n*-pentane as eluent gave **23**- $d_1, d_2, d_3$  (15 mg, 89  $\mu$ mol, 68%) as a white solid.

 $R_f = 0.68$  (*n*-pentane).

<sup>1</sup>**H NMR** (500 MHz, CDCl<sub>3</sub>):  $\delta$  = 1.95 (dd,  ${}^{3}J_{3,2}$  = 6.7 Hz,  ${}^{4}J_{3,1}$  = 1.6 Hz, 2H, H-3), 6.38 (m<sub>c</sub>, 1H, H-2), 6.58 (m<sub>c</sub>, 1H, H-1), 7.43 (m<sub>c</sub>, 2H, H-7', H-8'), 7.58 (dd,  ${}^{3}J_{3',4'}$  = 8.5 Hz,  ${}^{4}J_{3',1'}$  = 1.8 Hz, 1H, H-3'), 7.67 (s, 1H, H-1'), 7.77 (d,  ${}^{3}J_{4',3'}$  = 8.6 Hz, 1H, H-4'), 7.79 (m<sub>c</sub>, 2H, H-6', H-9') ppm.

<sup>2</sup>**H NMR** (500 MHz, 95% CHCl<sub>3</sub> + 5% CDCl<sub>3</sub>):  $\delta$  = 1.92 (br s), 6.39 (br s), 6.58 (br s) ppm.

<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>):  $\delta$  = 18.8 (C-3), 123.7 (C-3'), 125.3 (C-1'), 125.6 (C-7')\*, 126.2 (C-8')\*, 126.3 (C-2), 127.8 (C-9')\*\*, 128.0 (C-6')\*\*, 128.2 (C-4'), 131.3 (C-1), 132.8 (C-5'), 133.9 (C-10'), 135.6 (C-2') ppm.

**HRMS** (EI) calcd for  $C_{13}H_{11}D^+$  [(M)+]: 169.0996, found 169.0986.

 $C_{13}H_{10}D_2^+$  [(M)+]: 170.1059, found 170.1049.

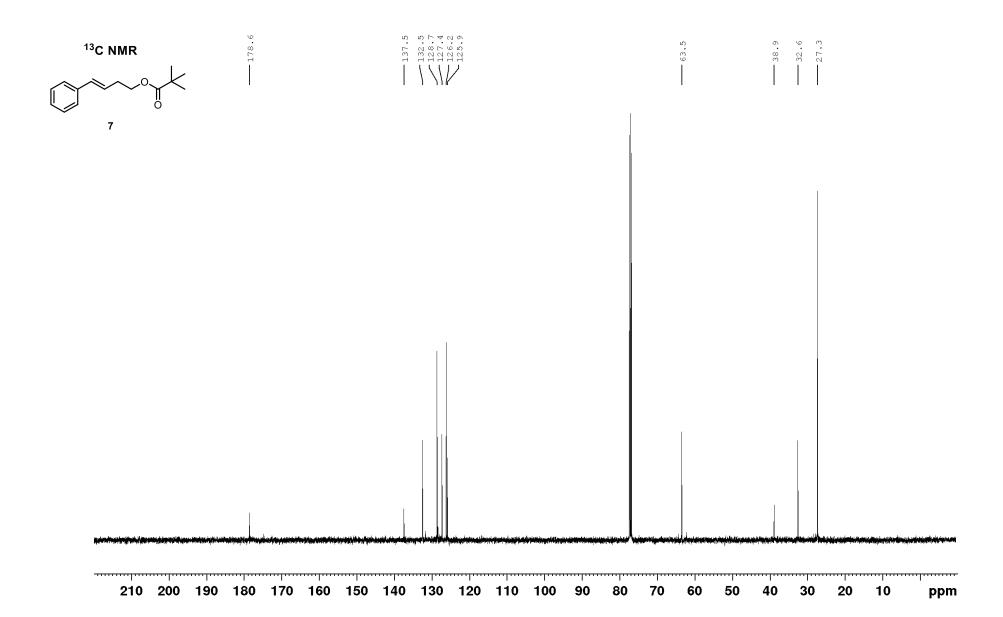
 $C_{13}H_9D_3^+$  [(M)+]: 171.1122, found 171.1113.

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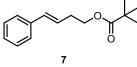
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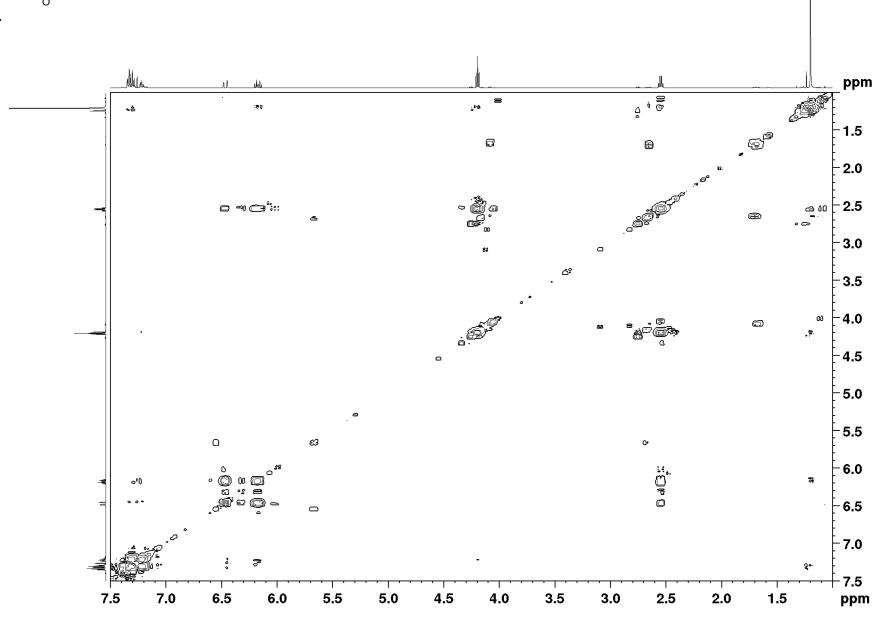
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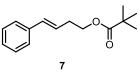


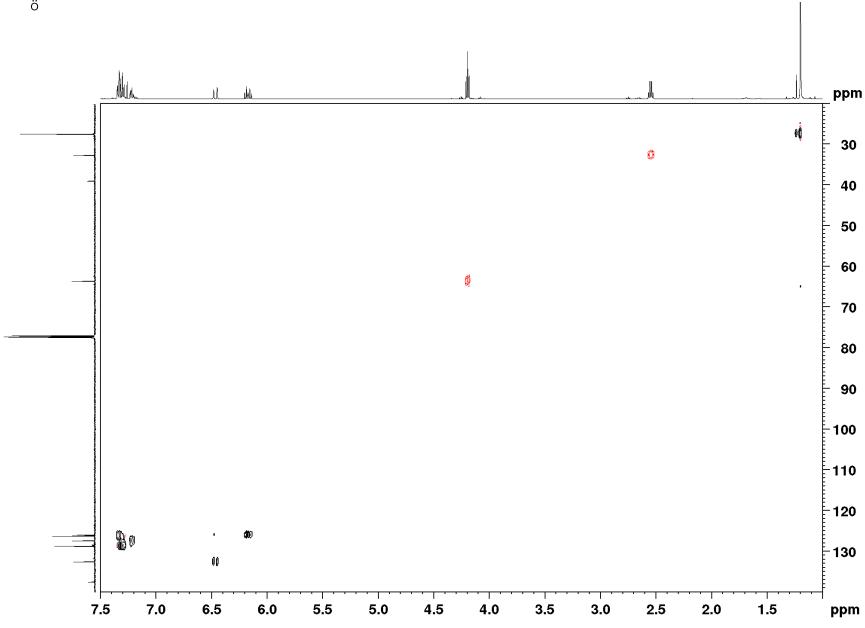


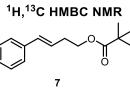


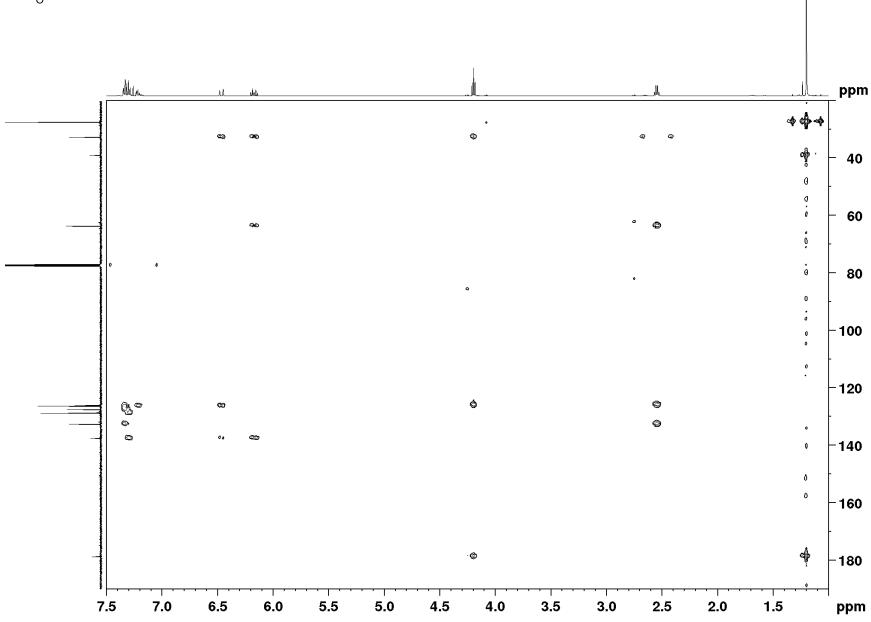




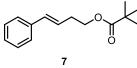


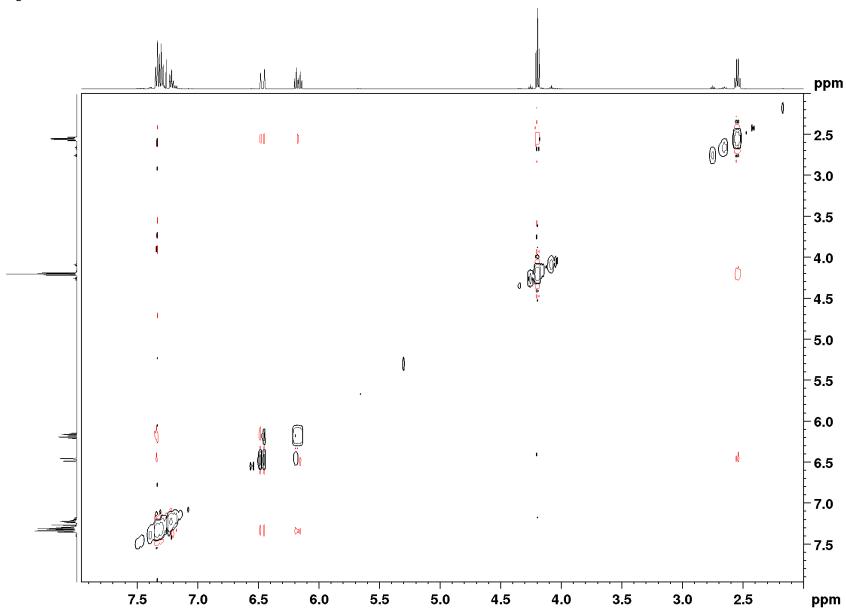


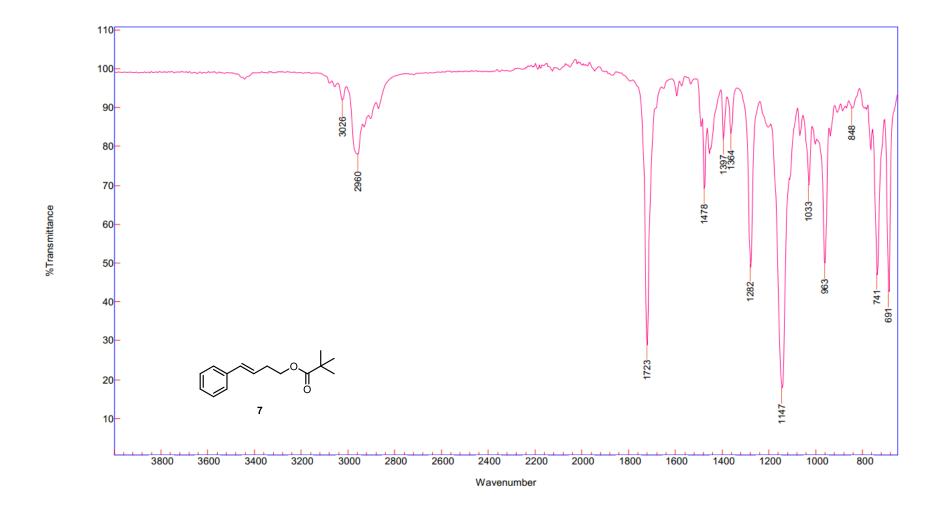


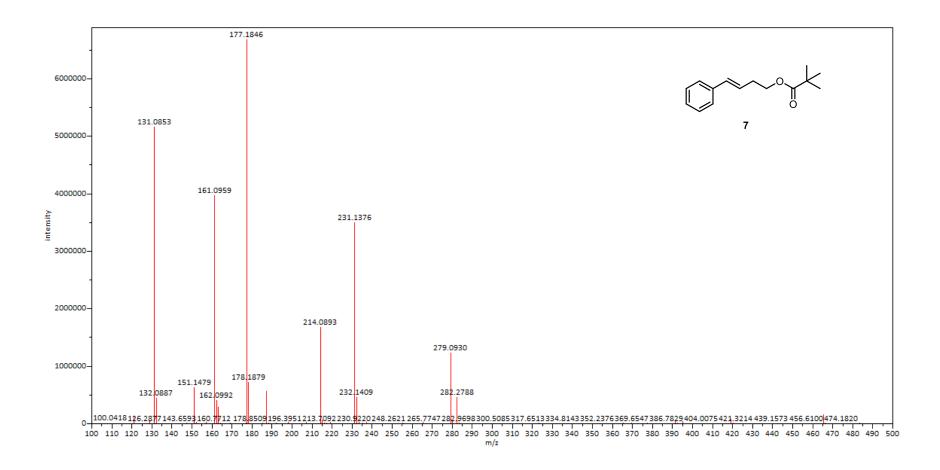


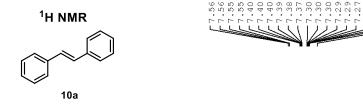


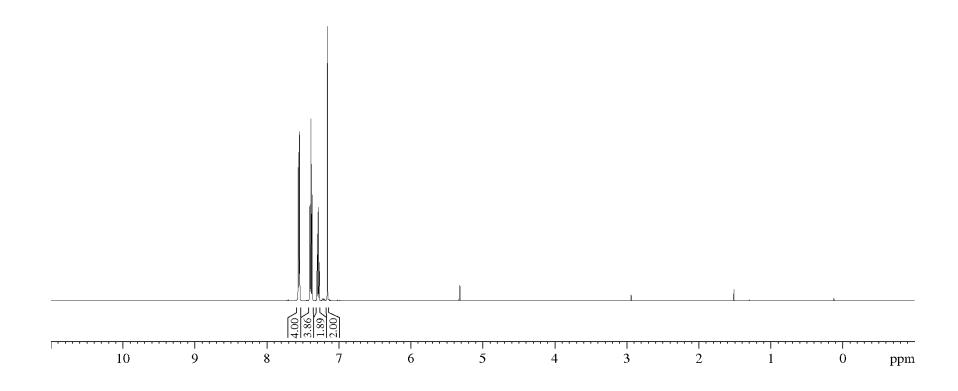




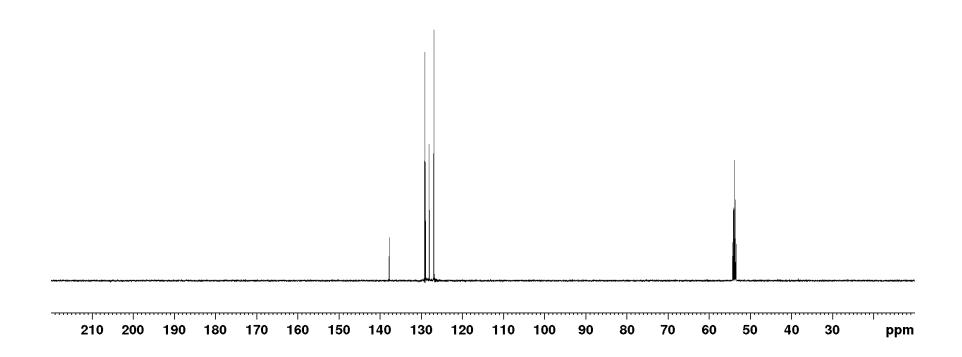


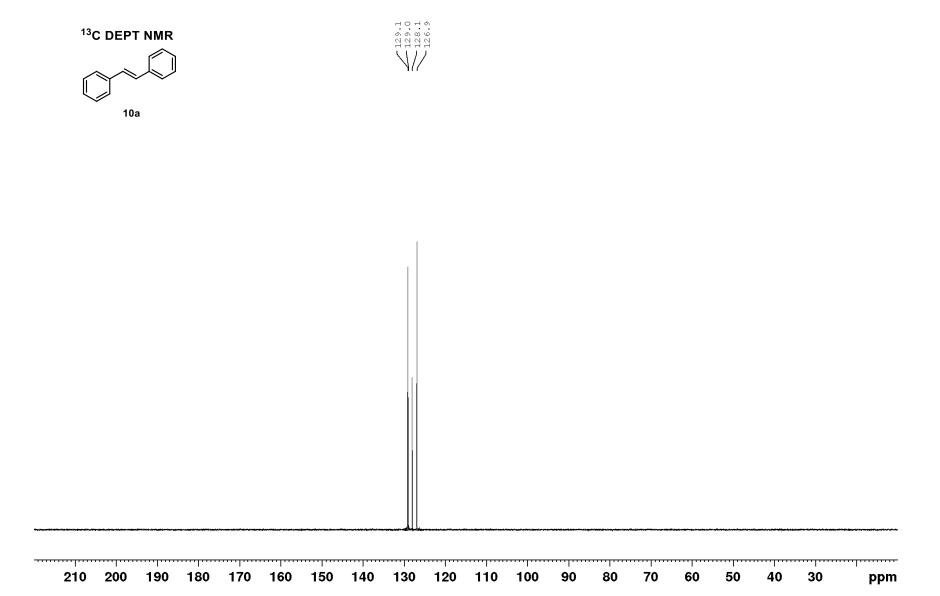




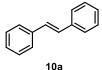


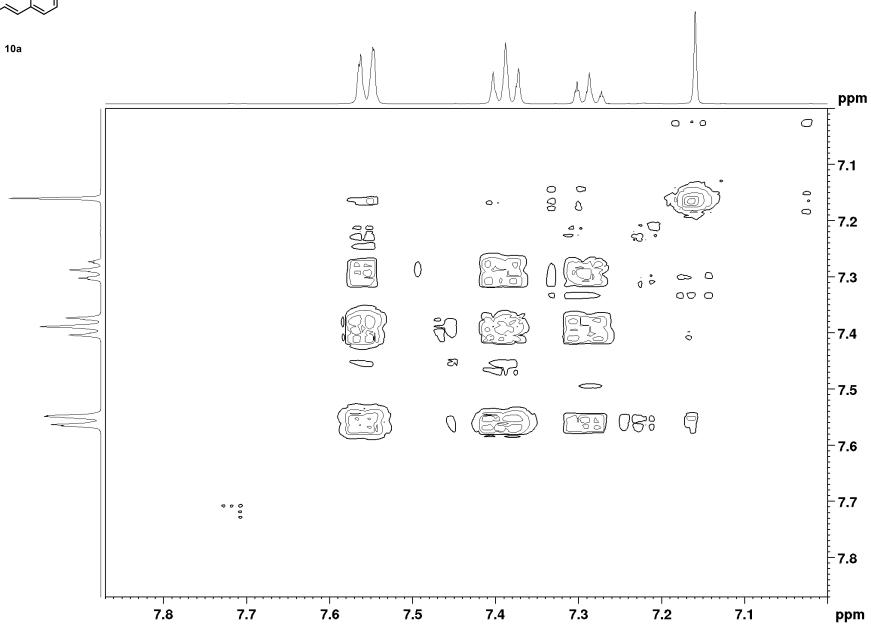




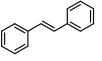




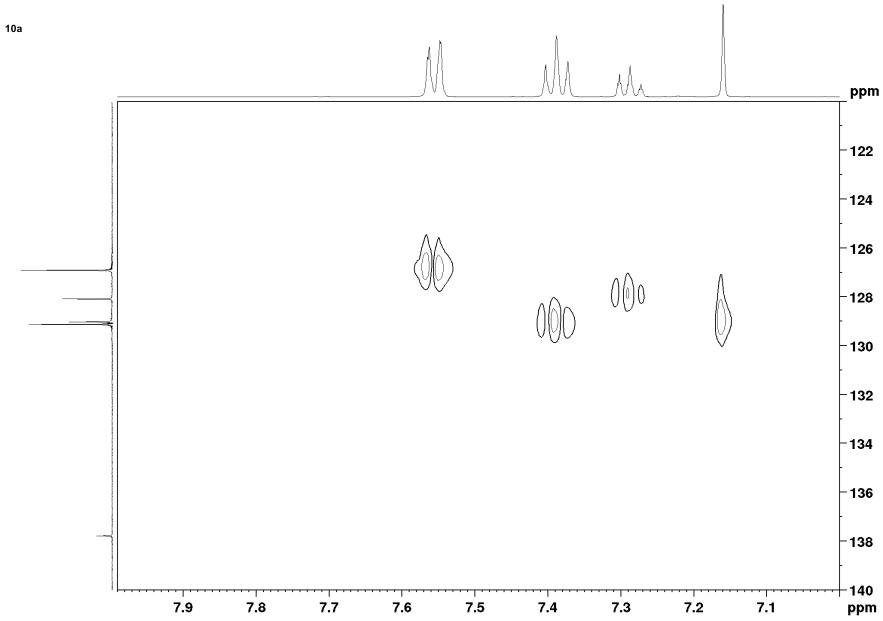




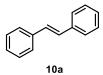


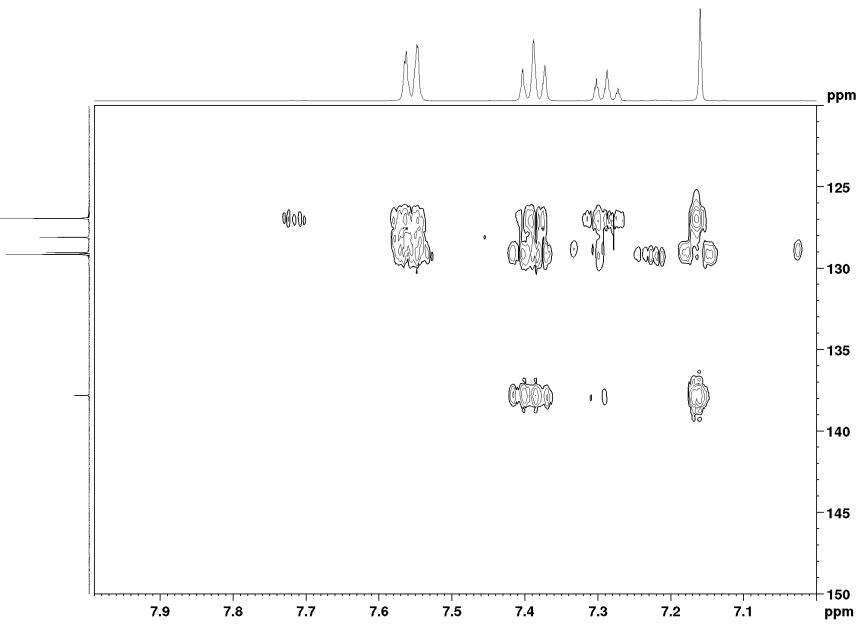




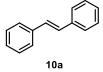


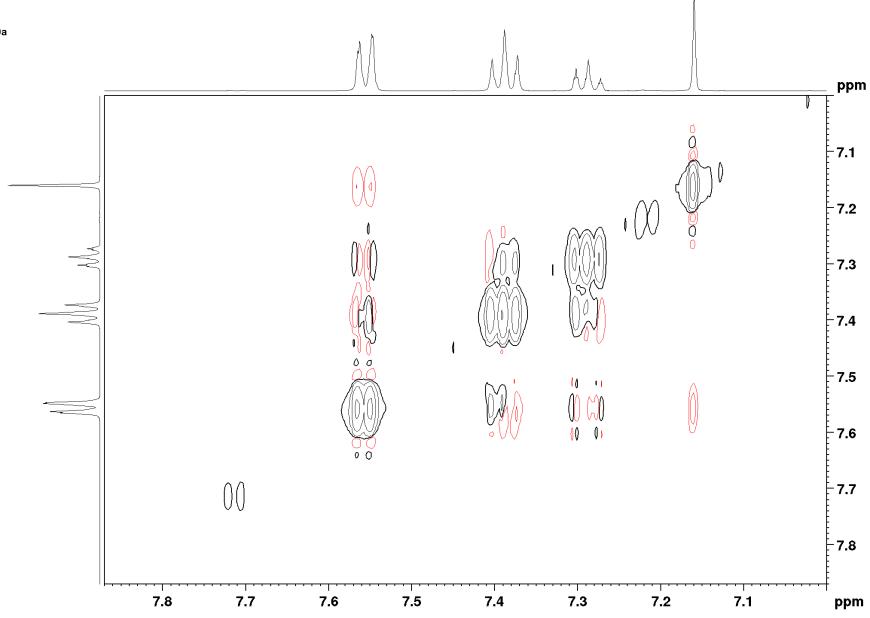


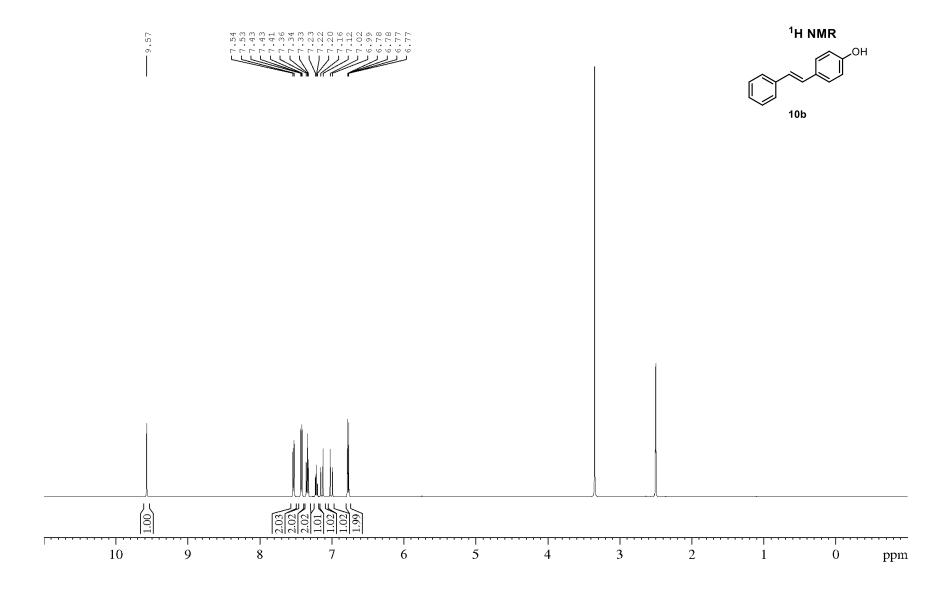


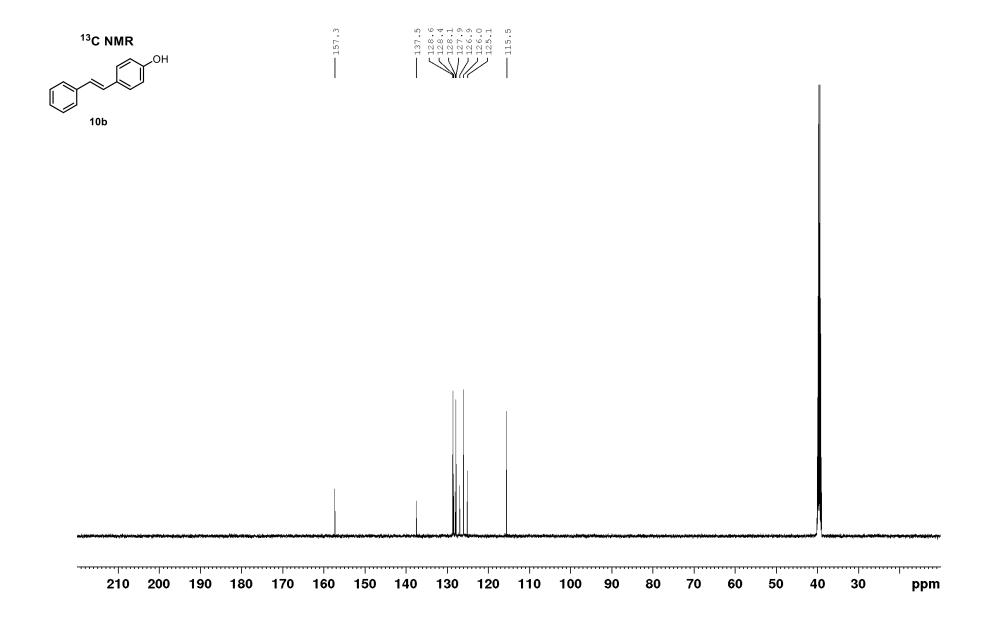




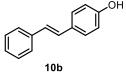


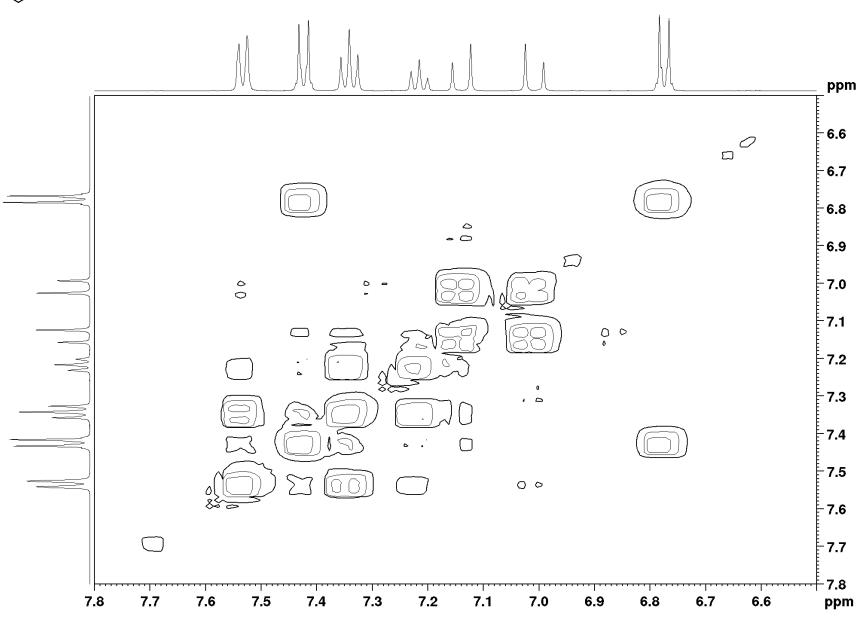




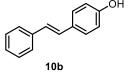


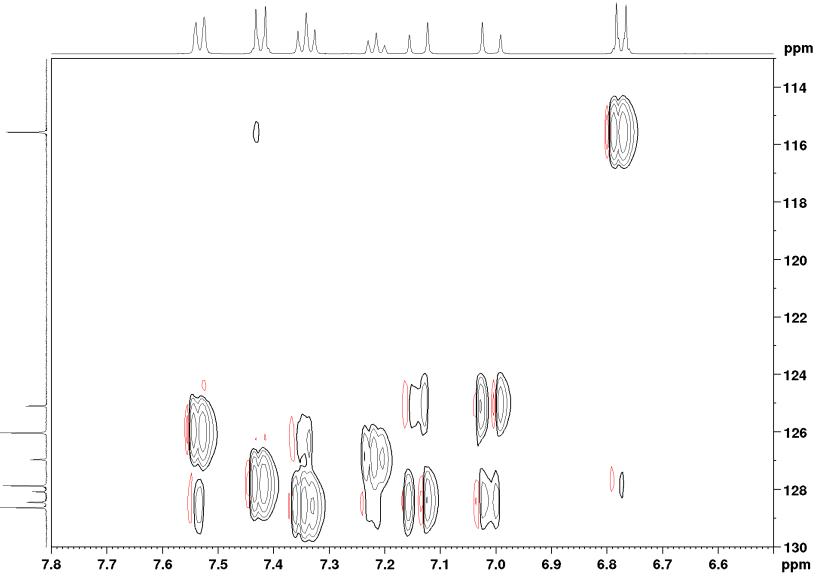




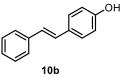


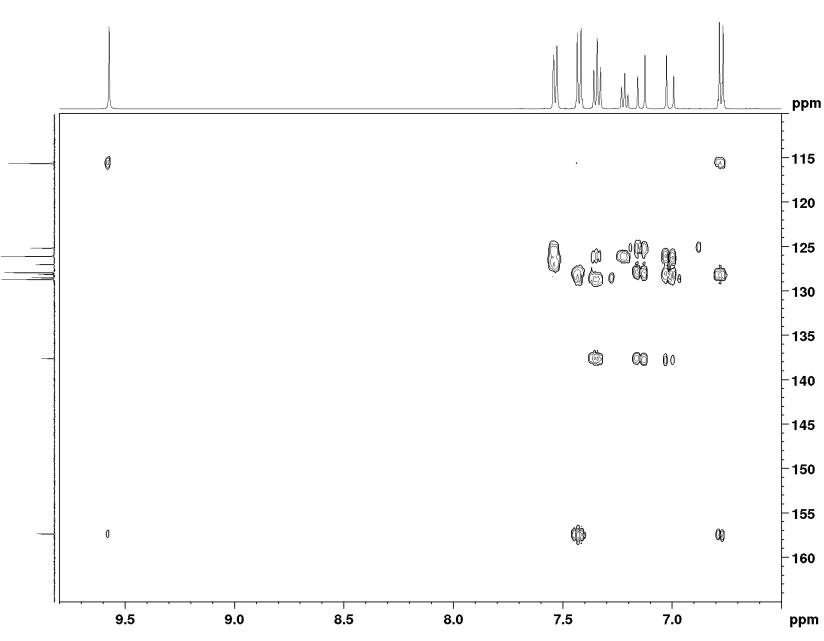




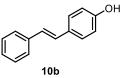


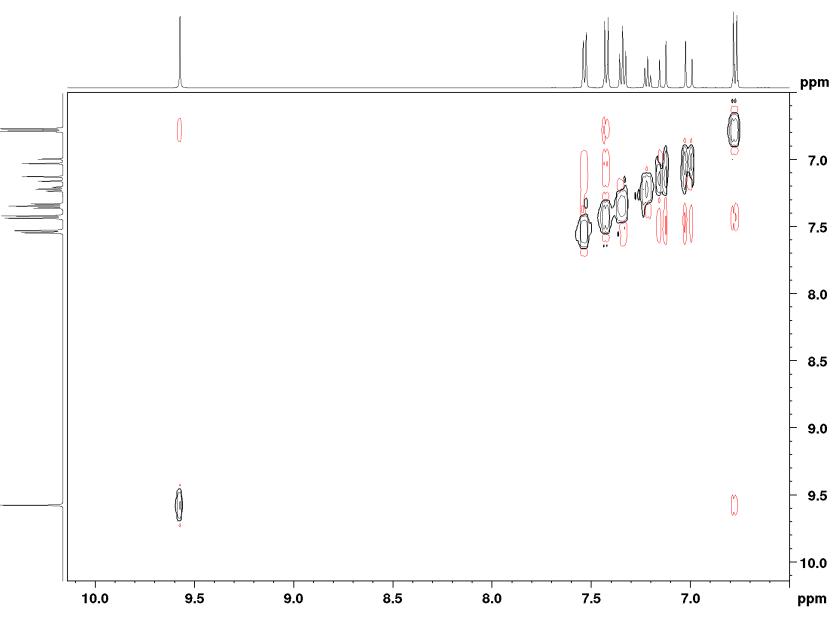


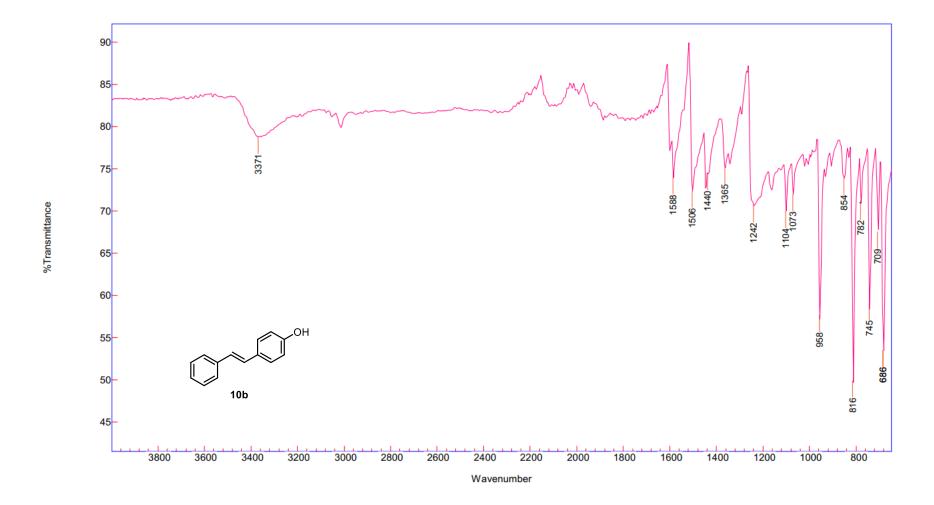




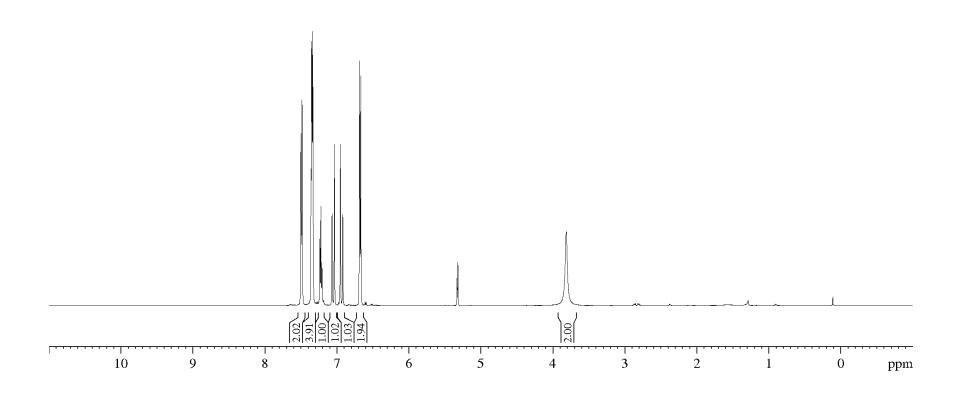


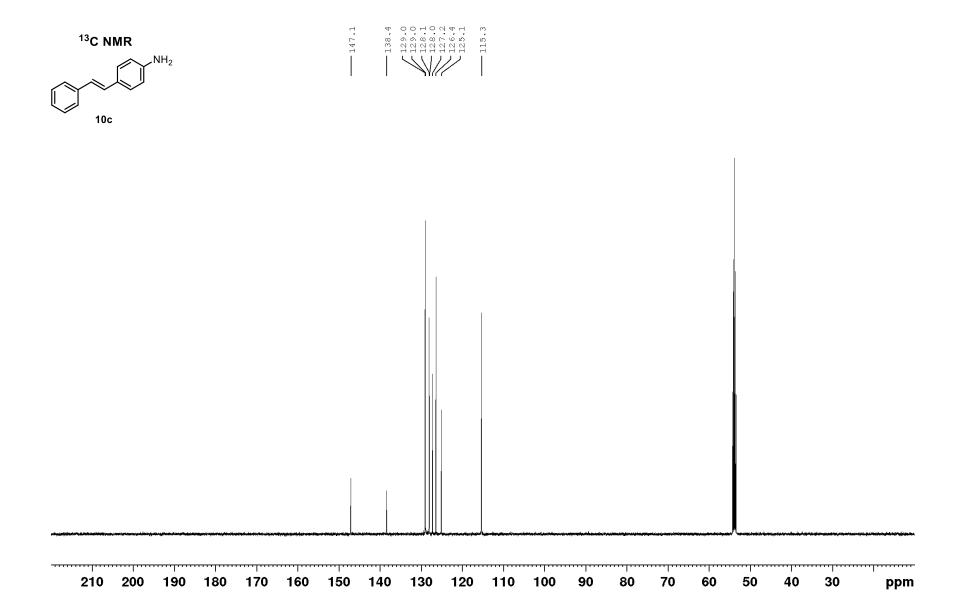


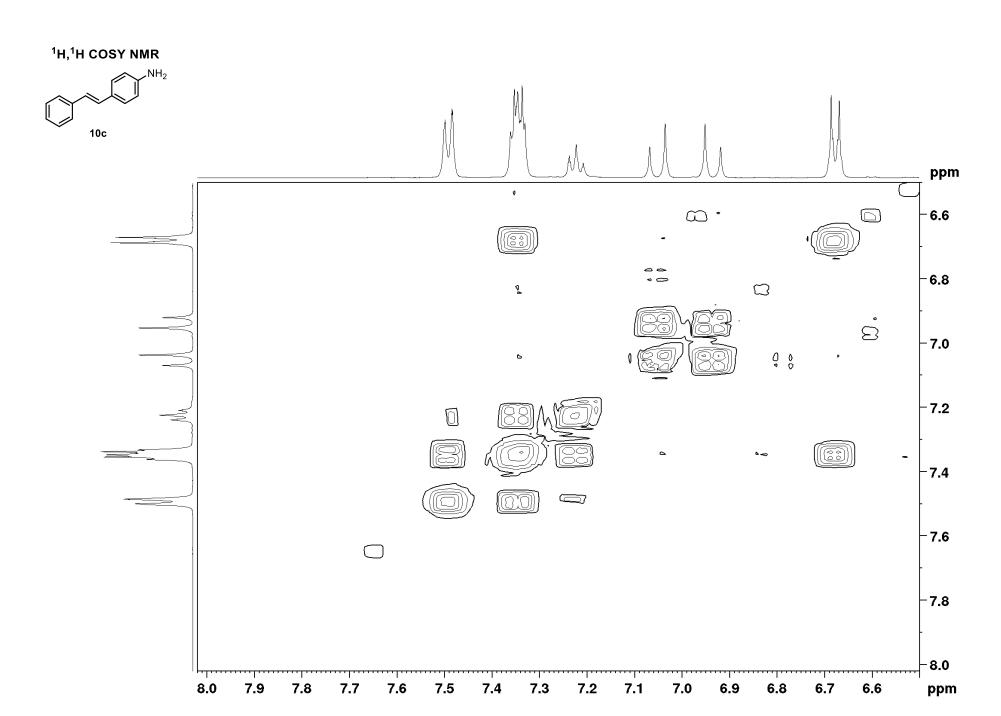


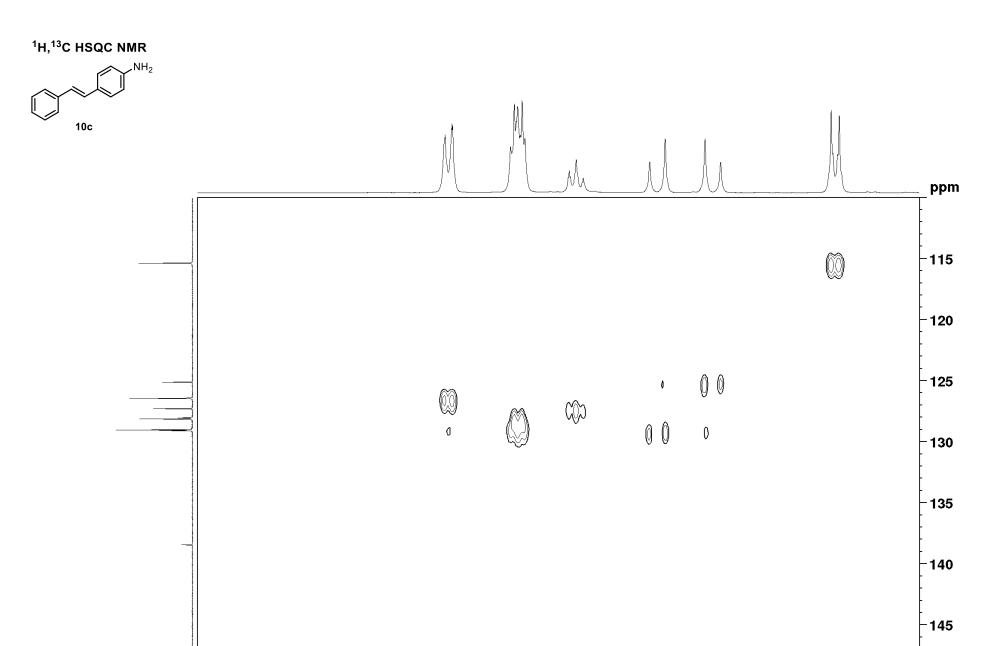












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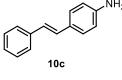
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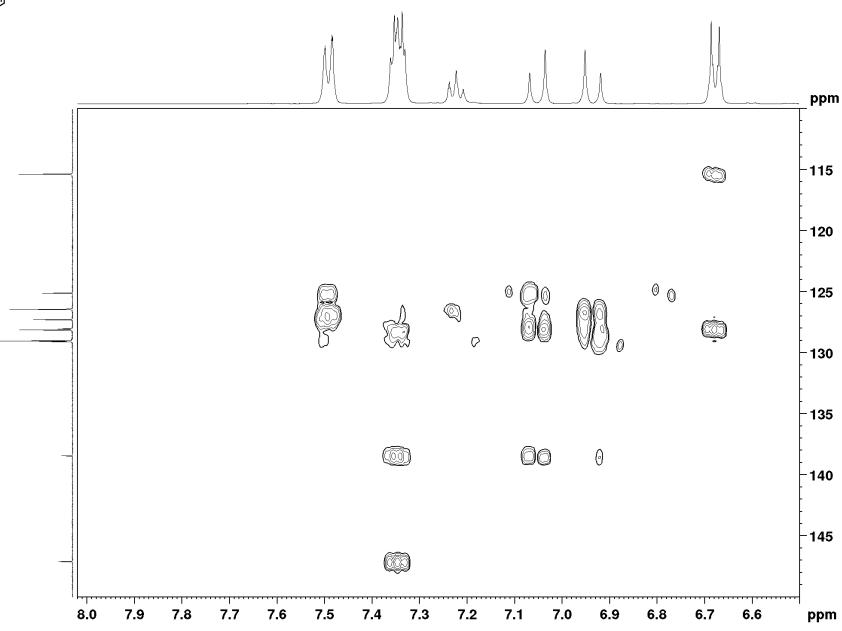
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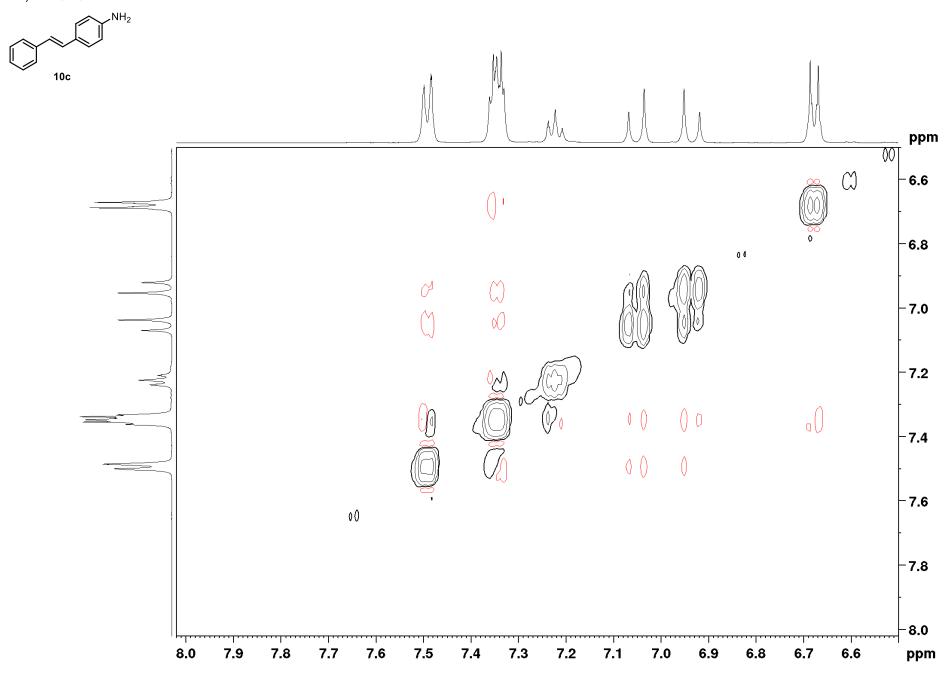
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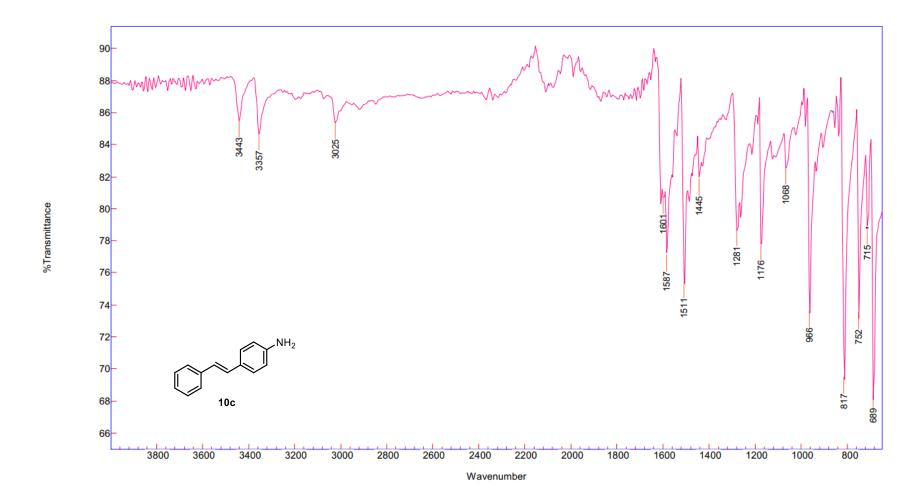


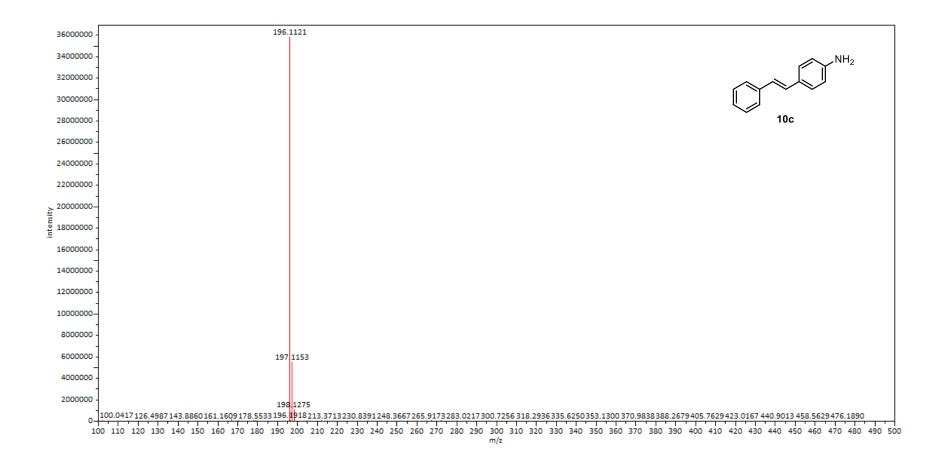




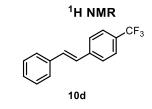


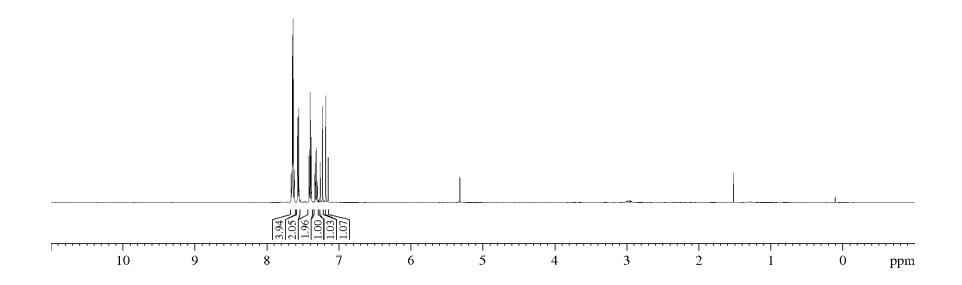


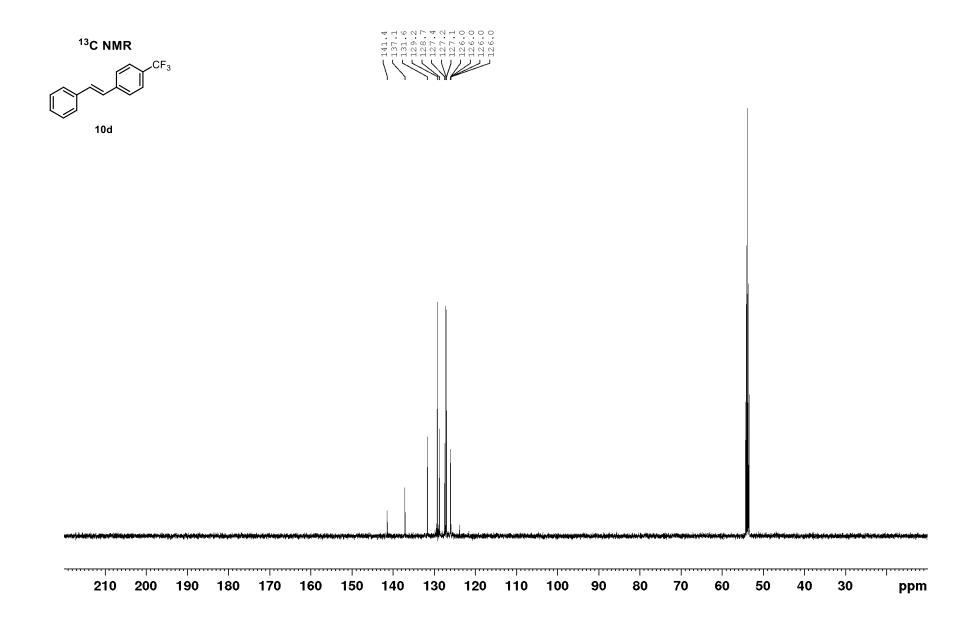




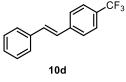


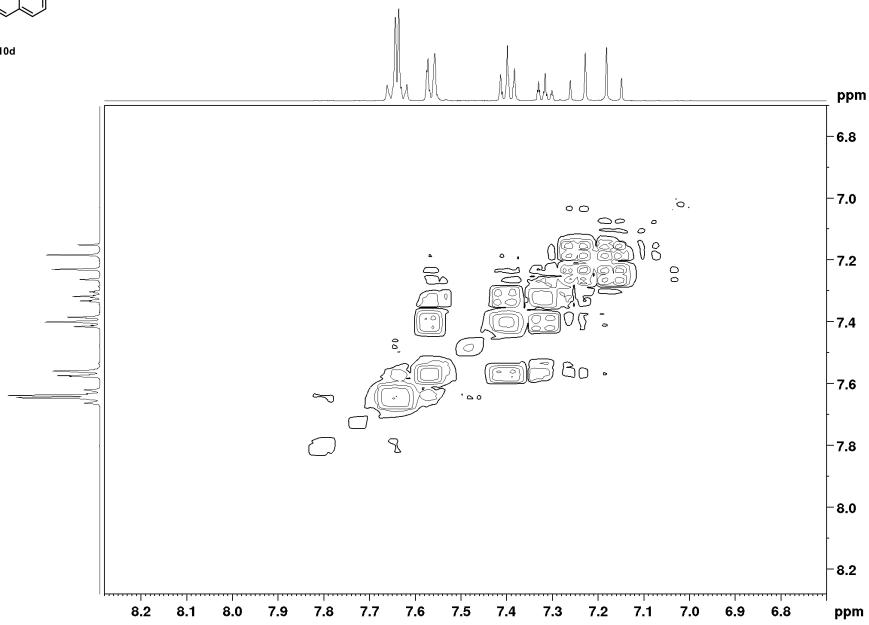




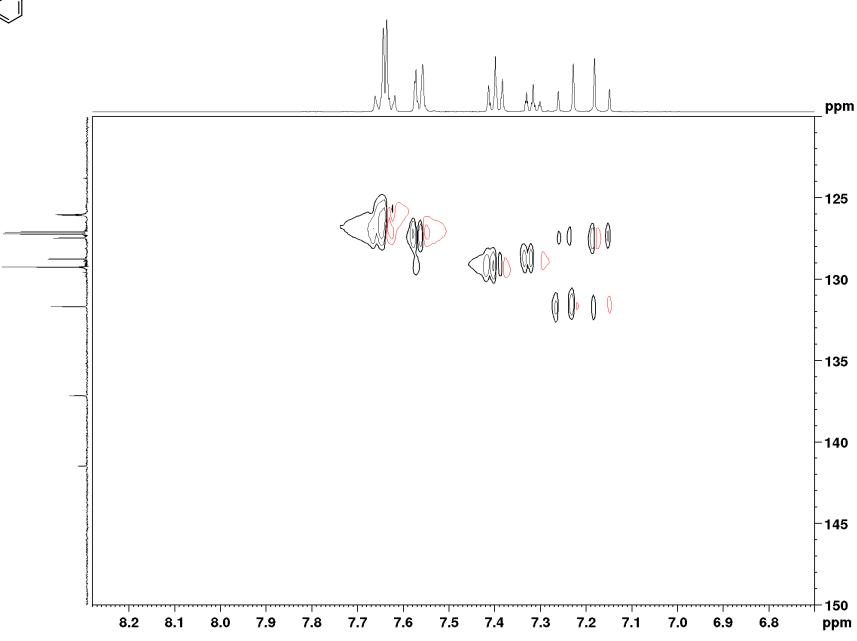




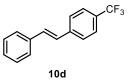


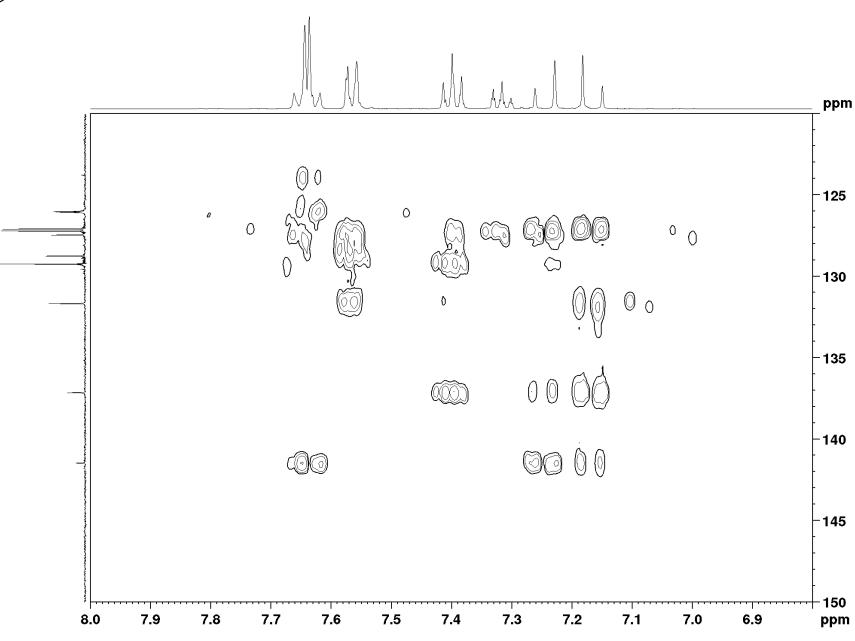




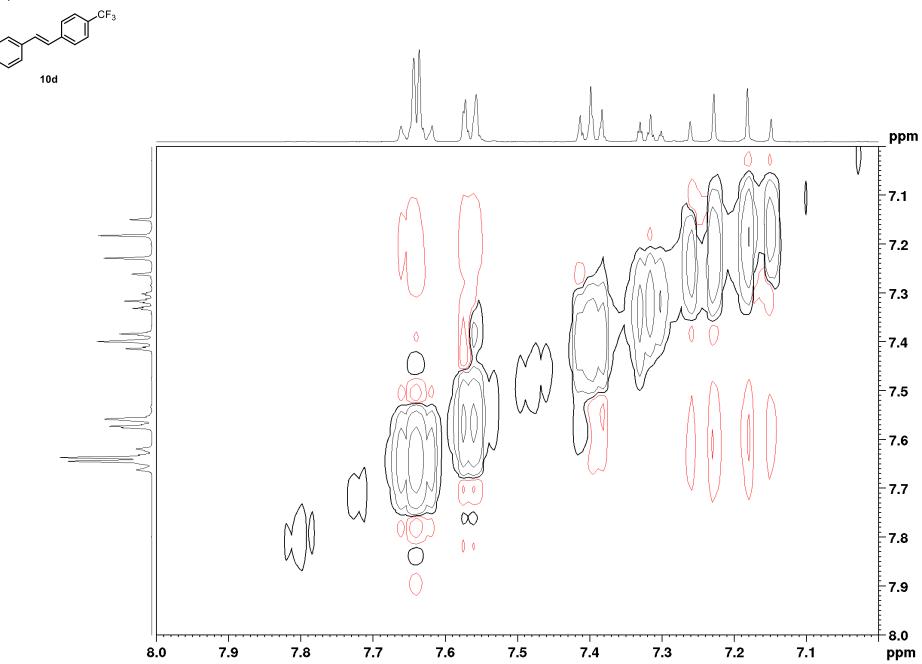


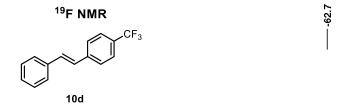


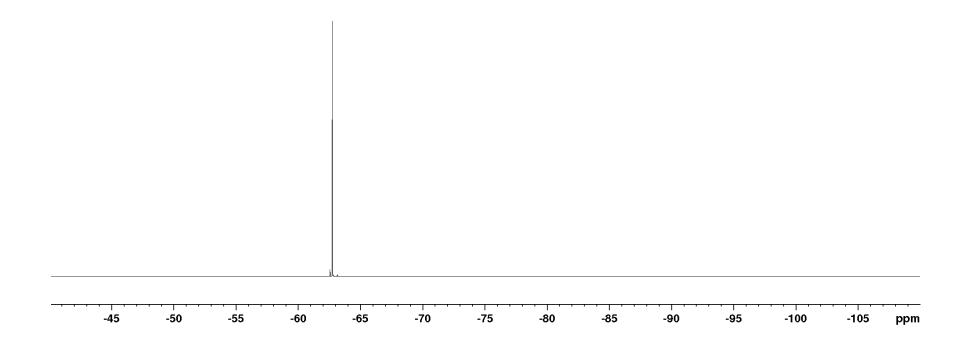


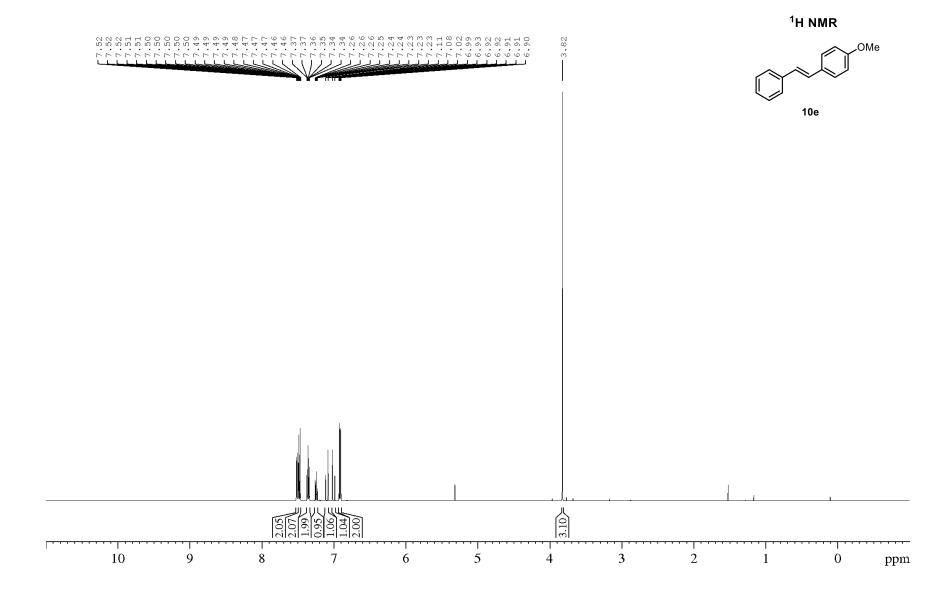


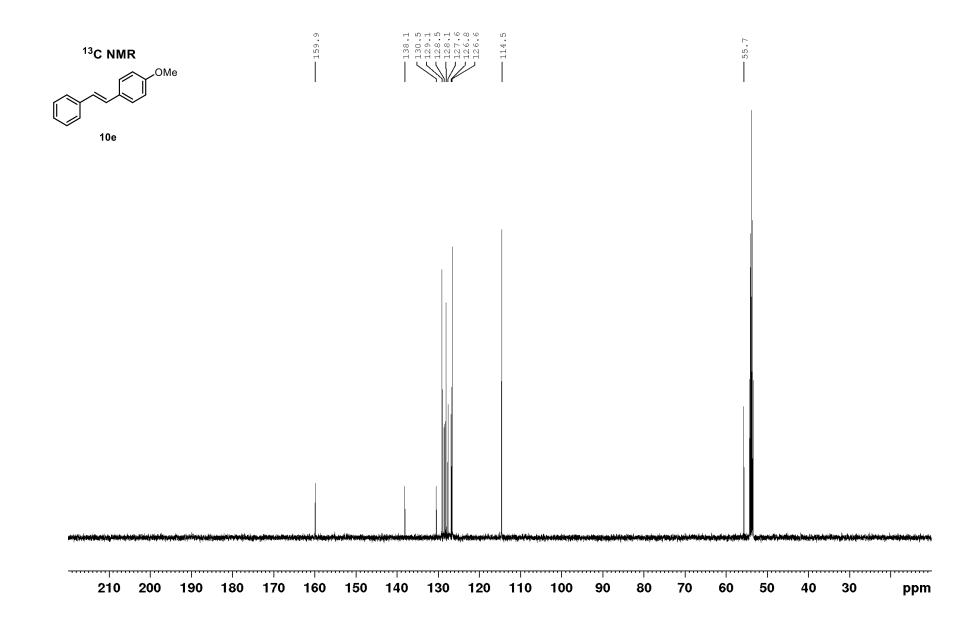


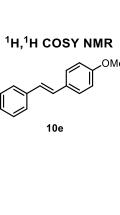


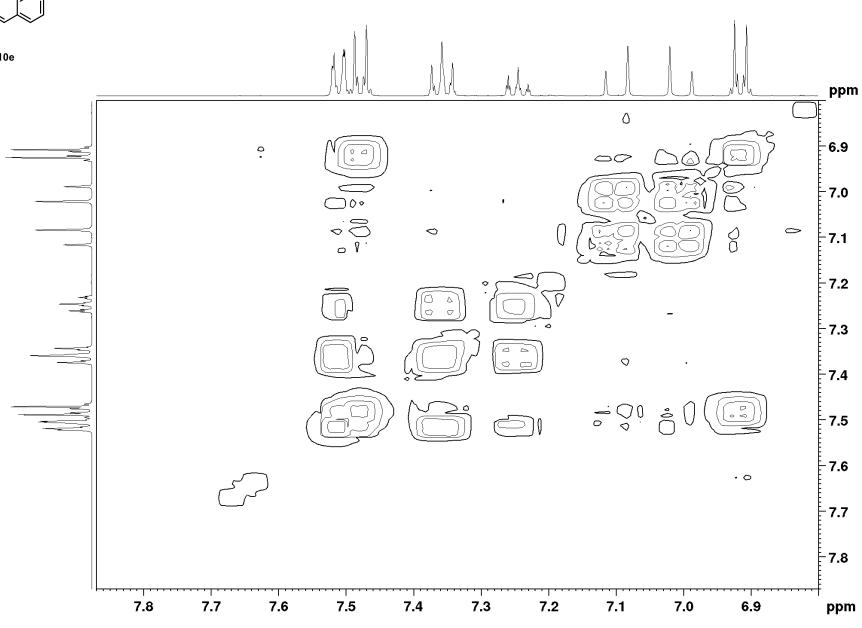




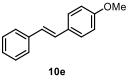


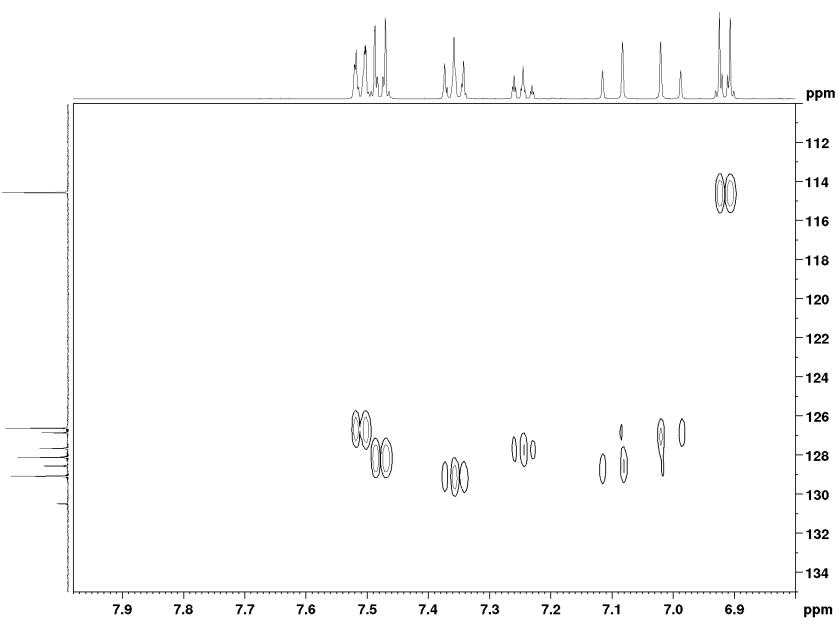




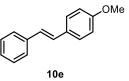


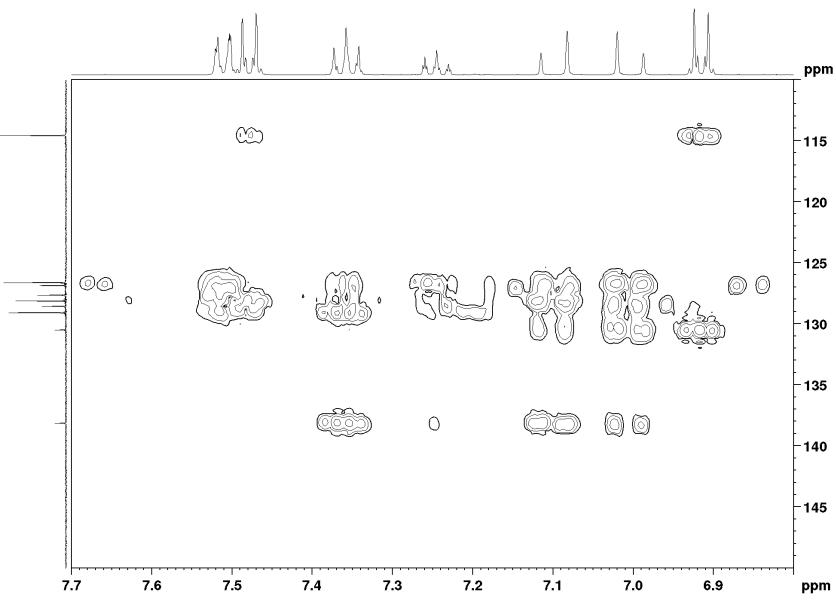




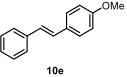


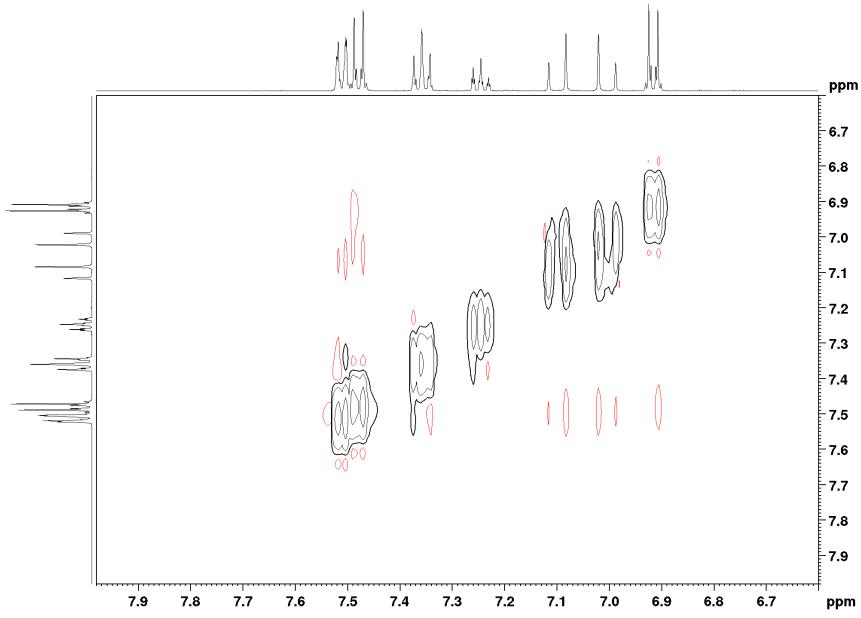


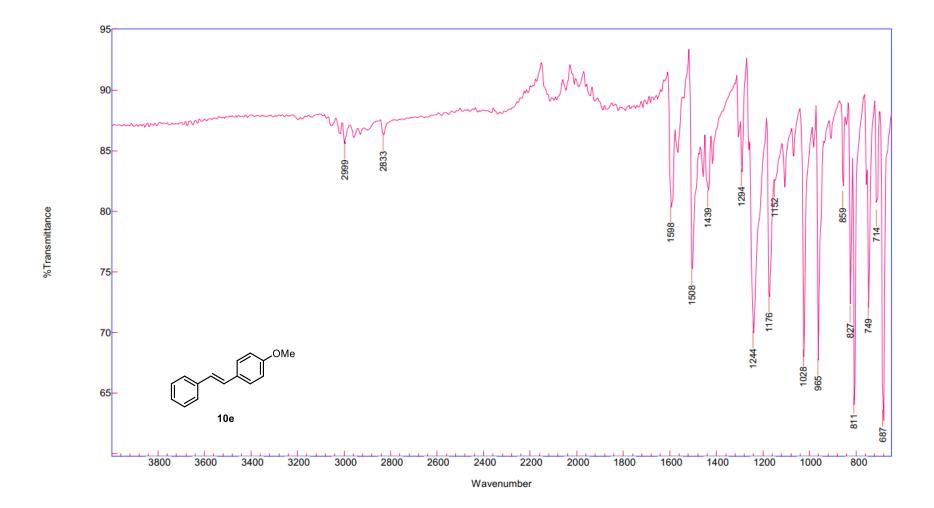




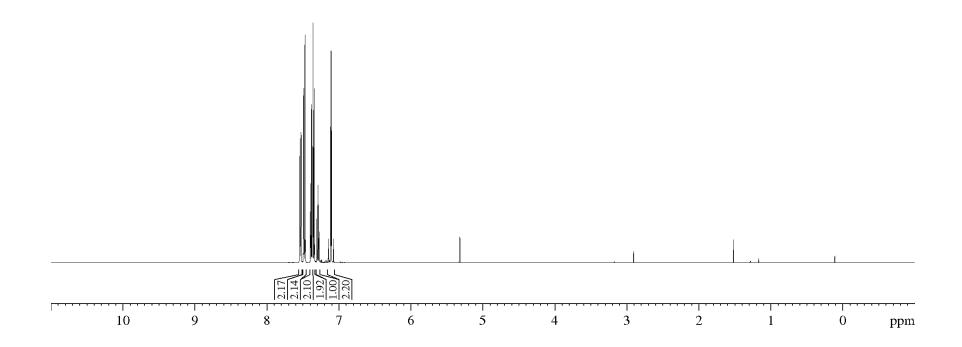


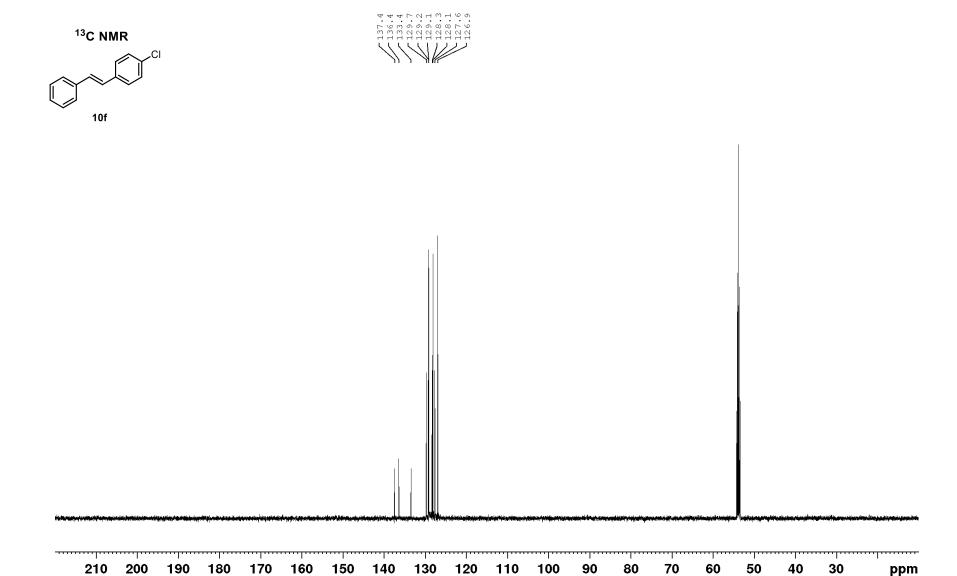




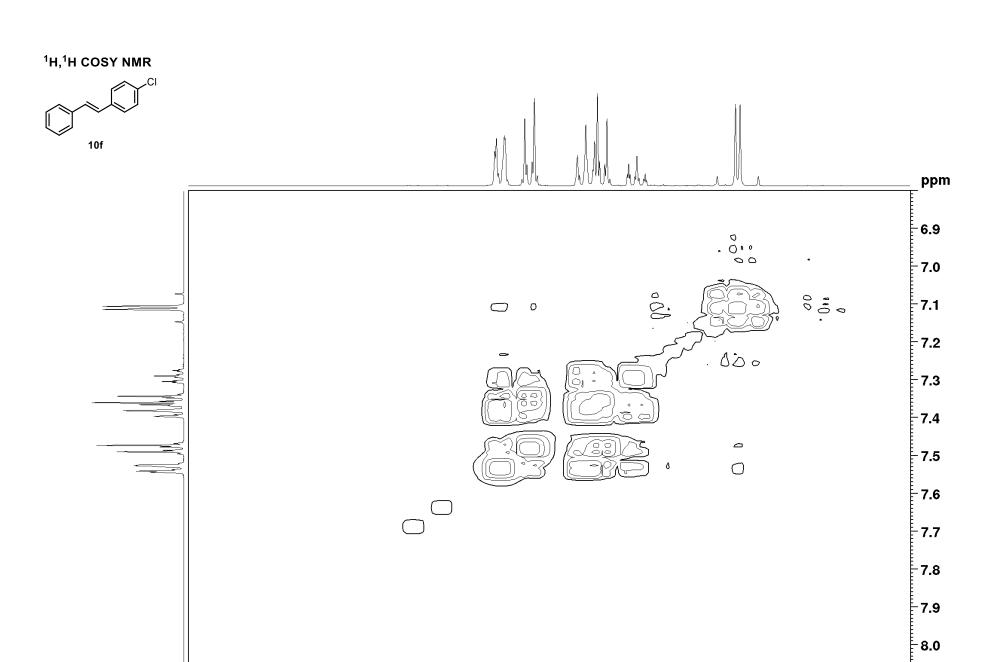








ppm



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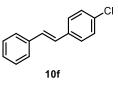
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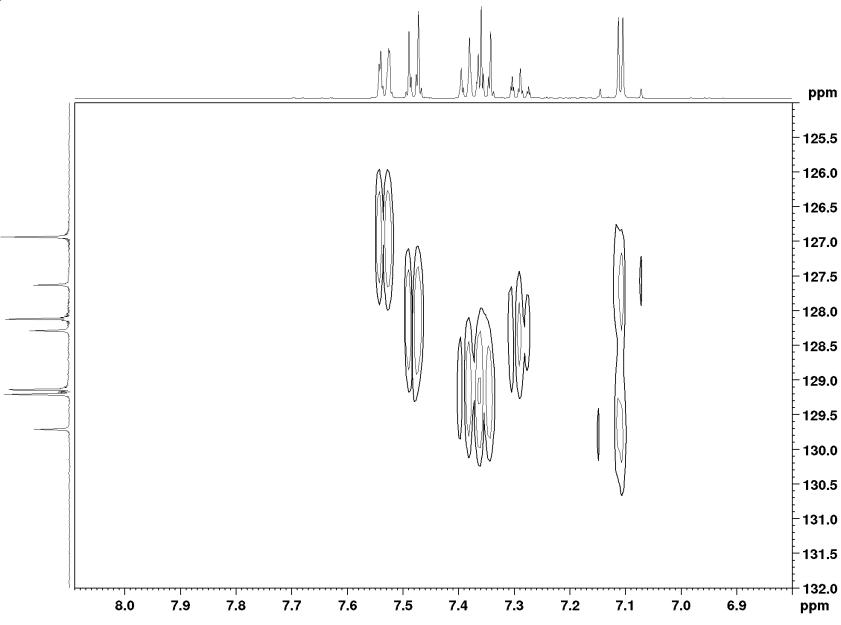
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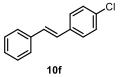
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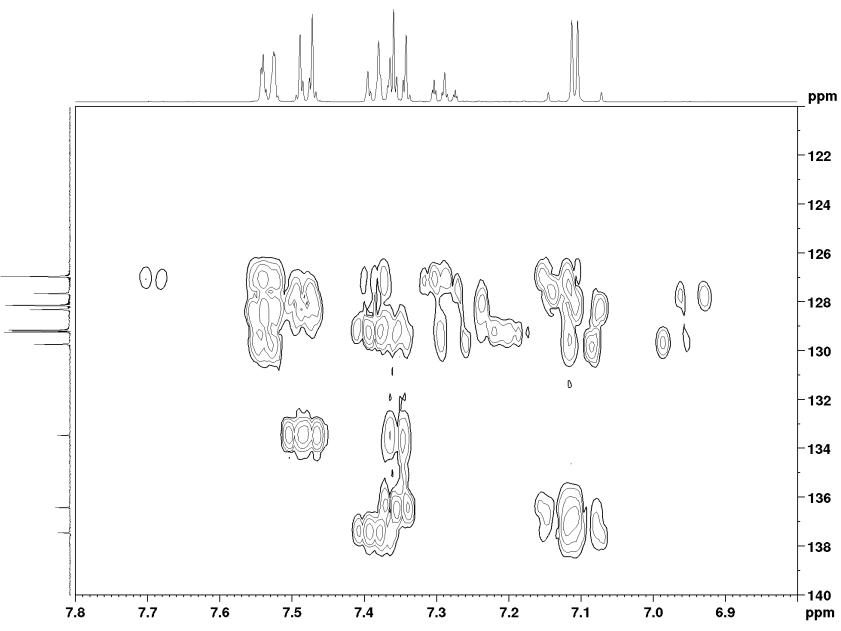




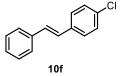


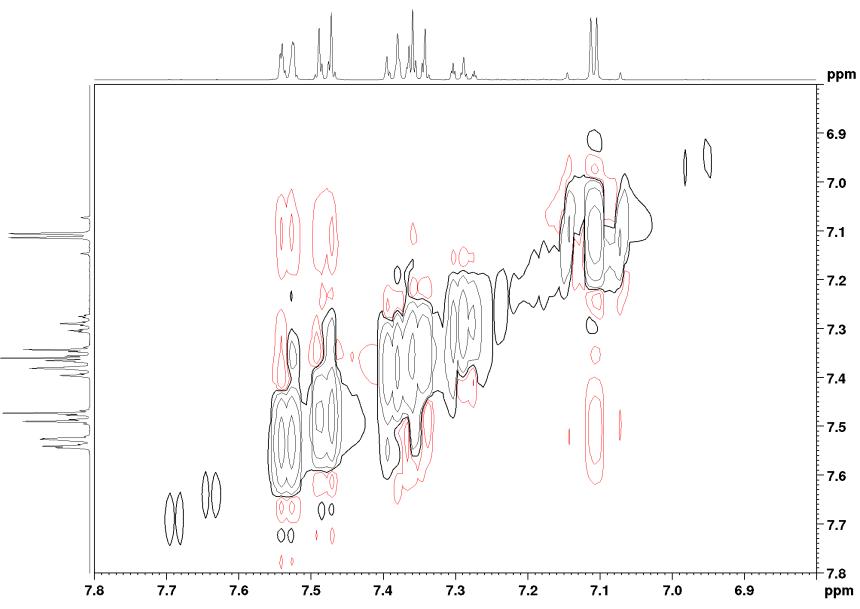




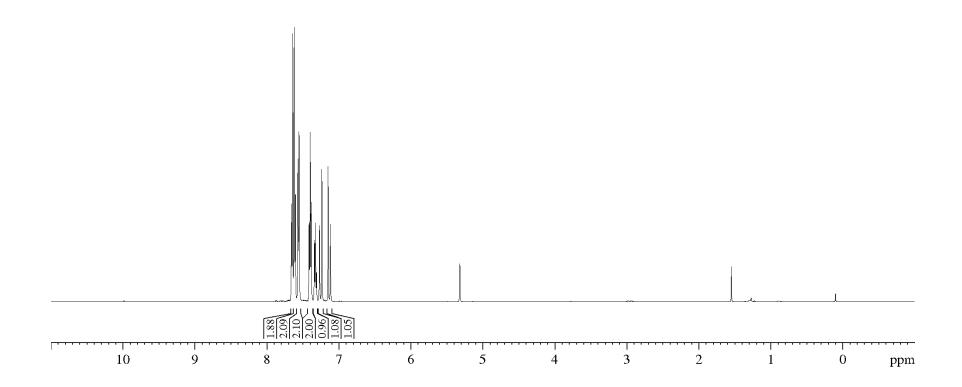




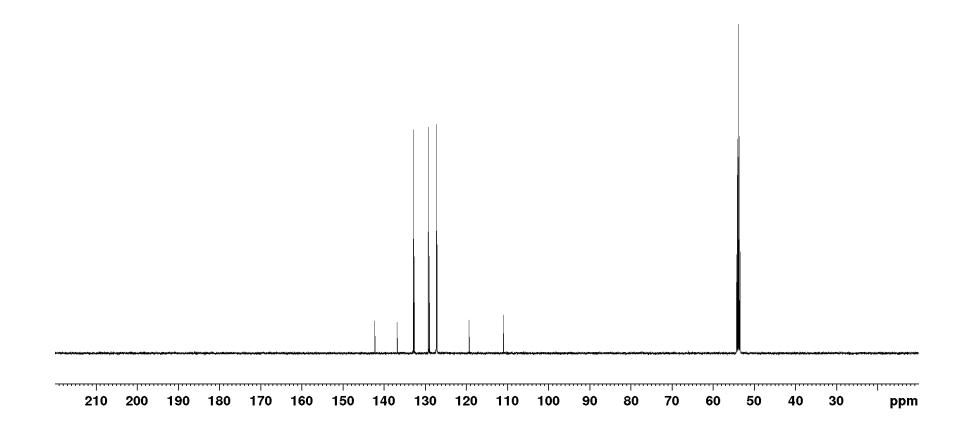


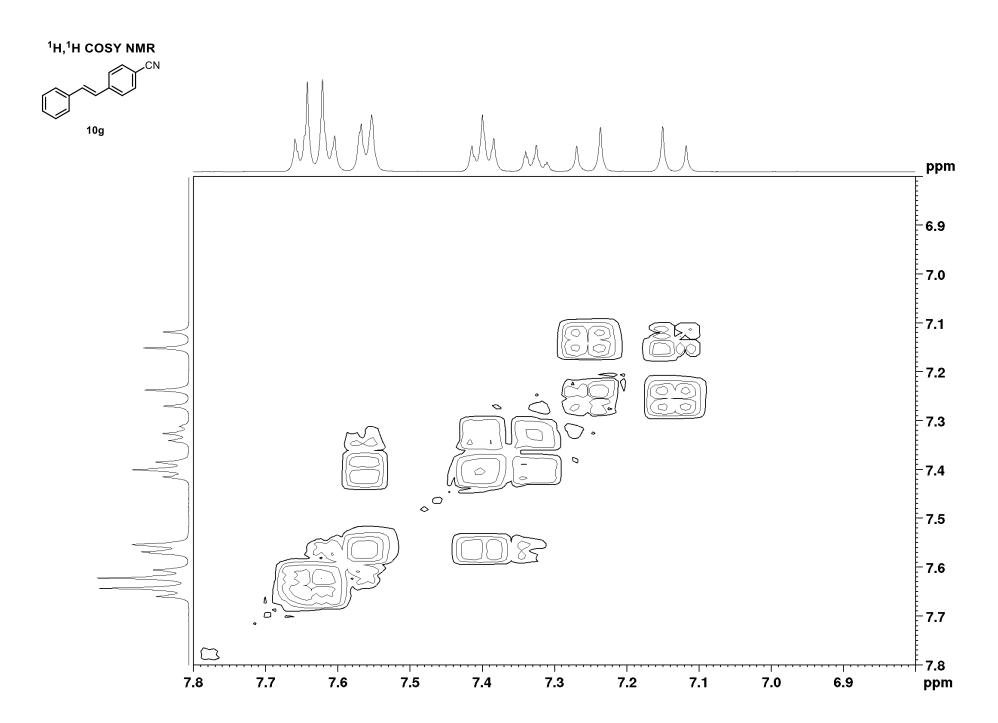




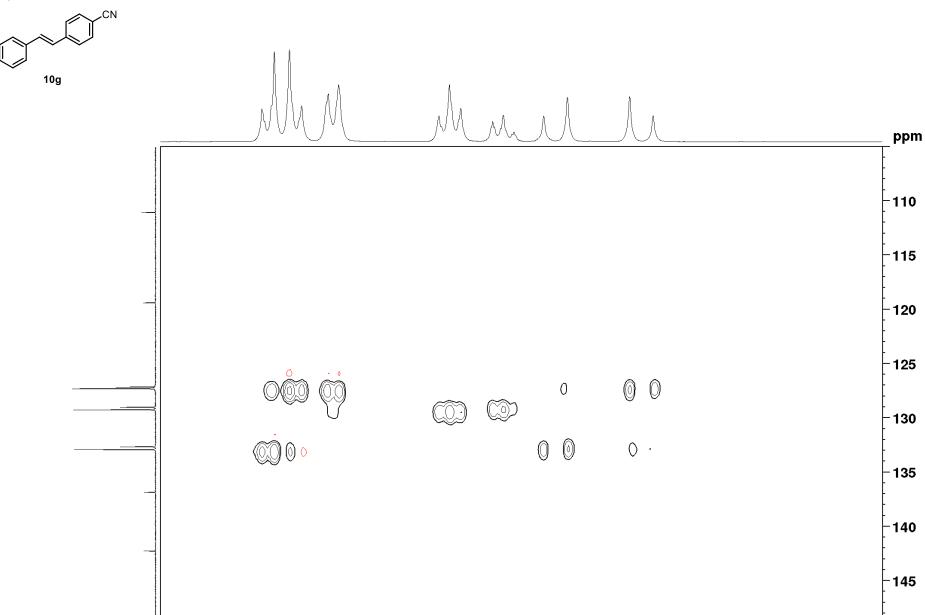












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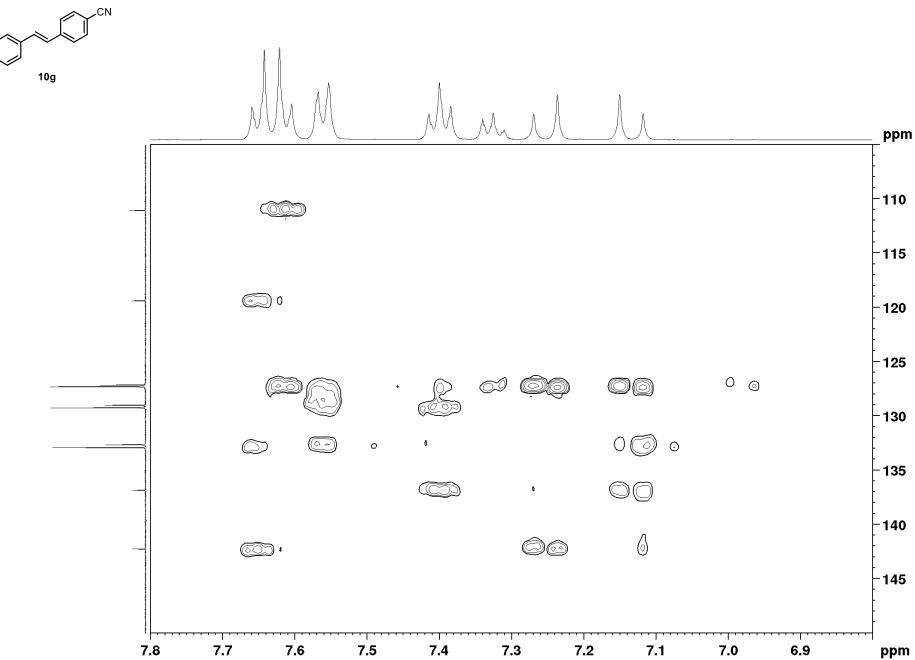
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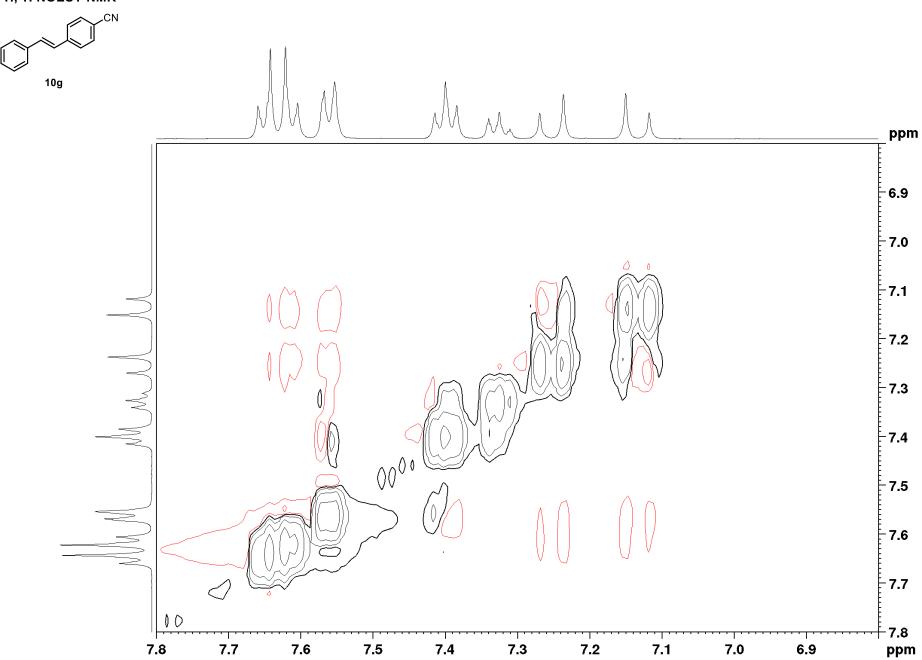
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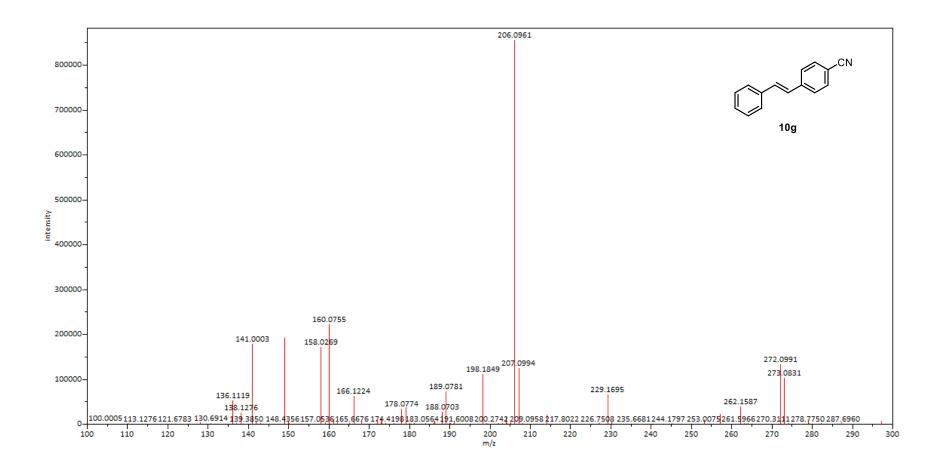
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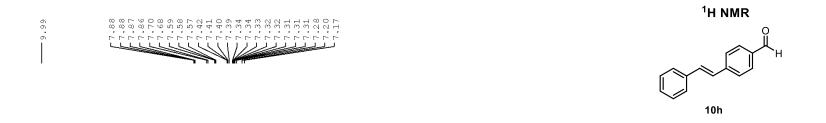


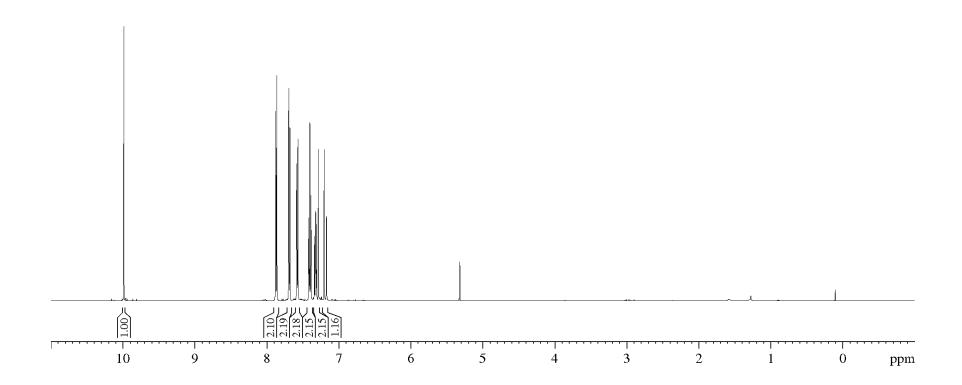


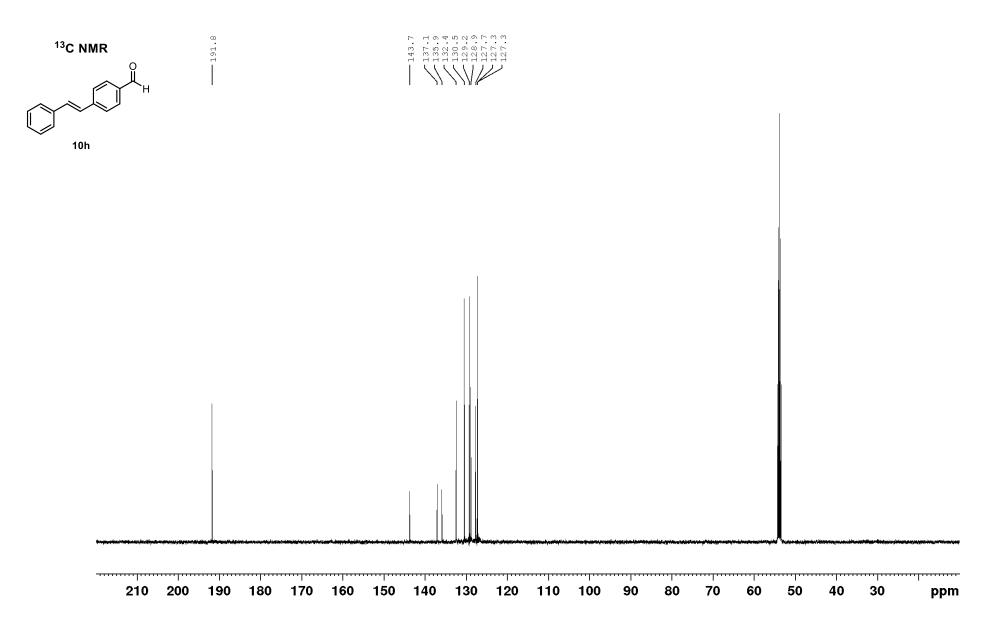




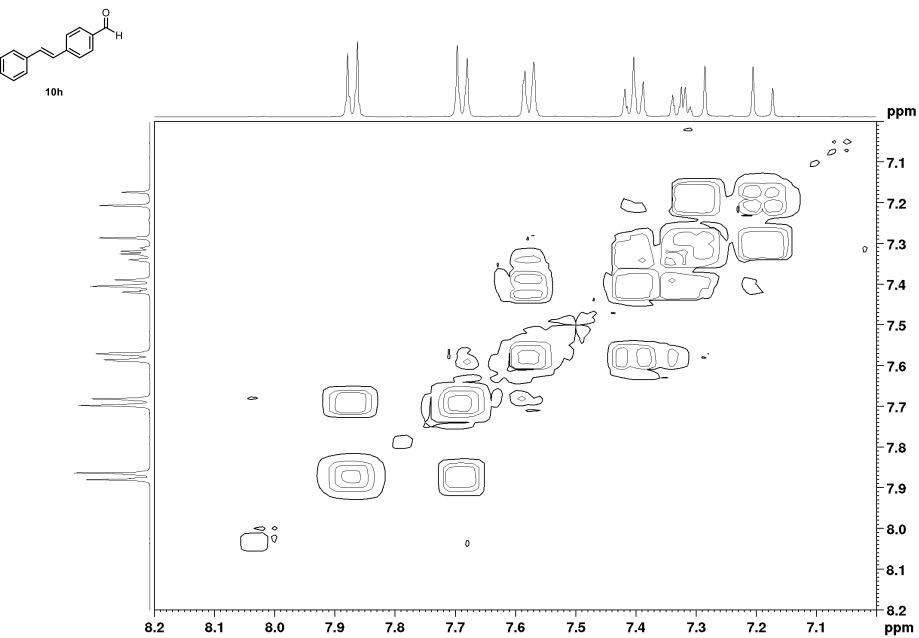




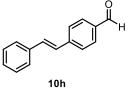


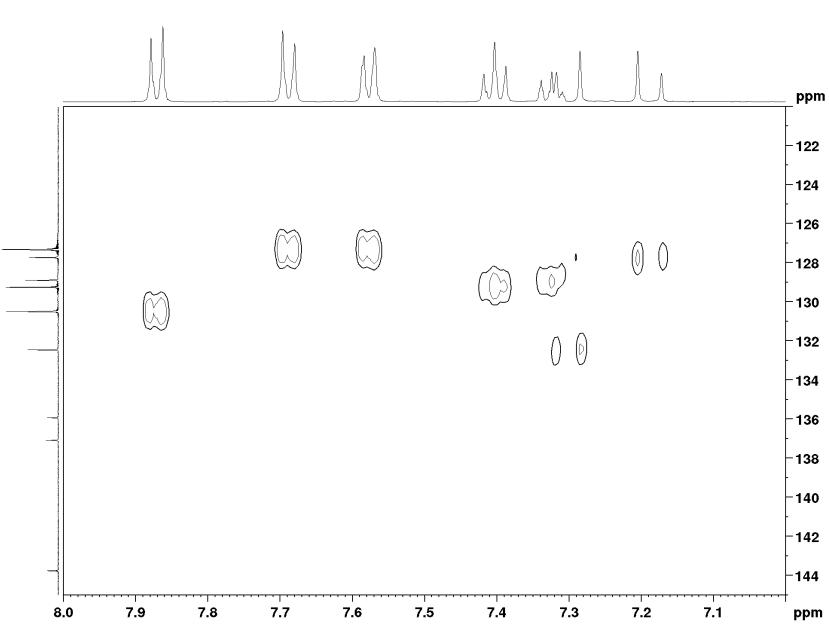




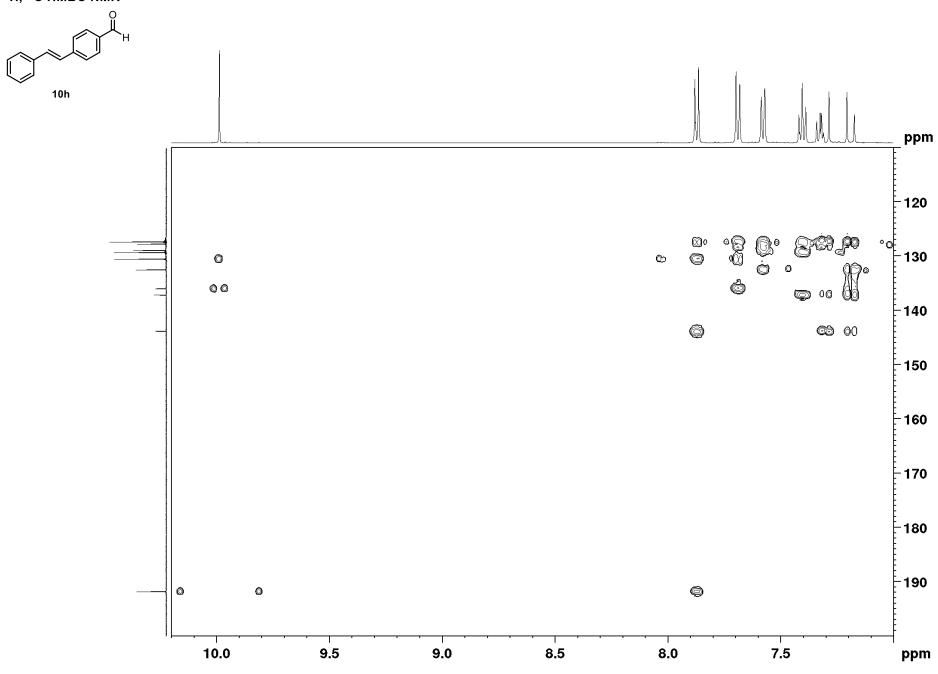


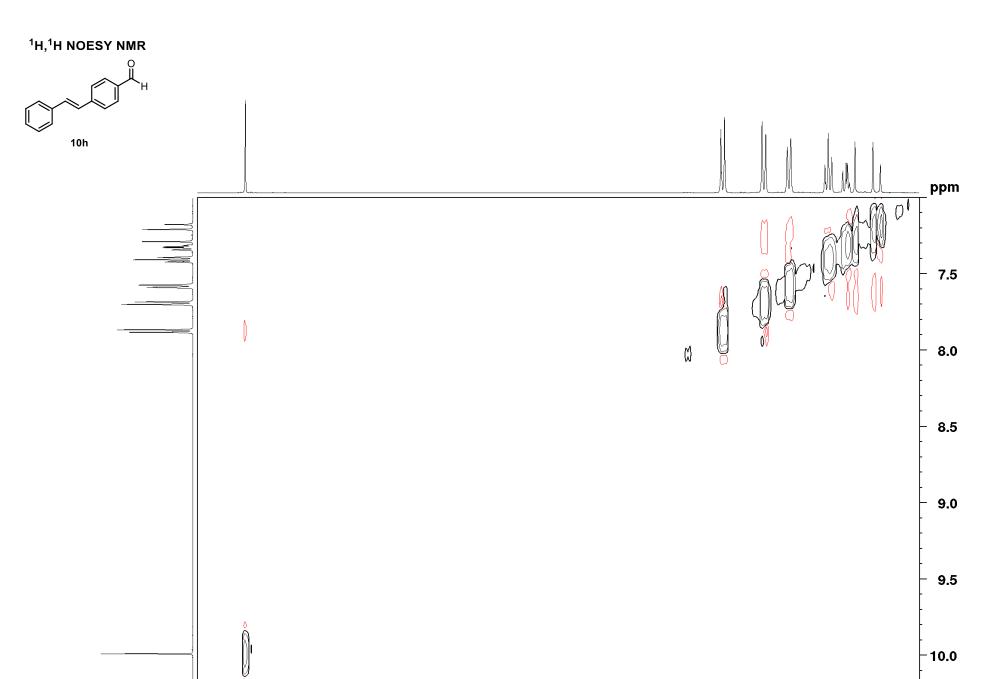












8.5

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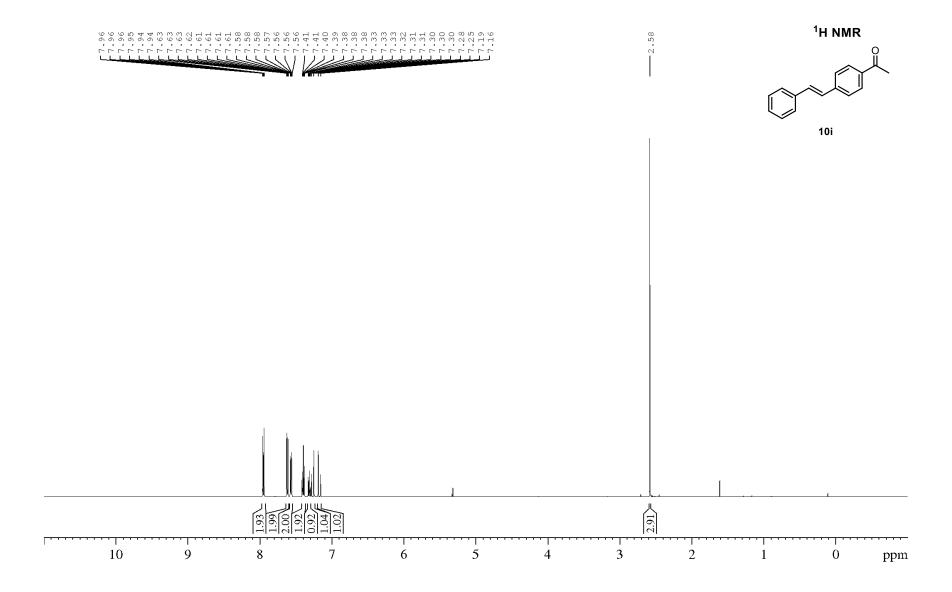
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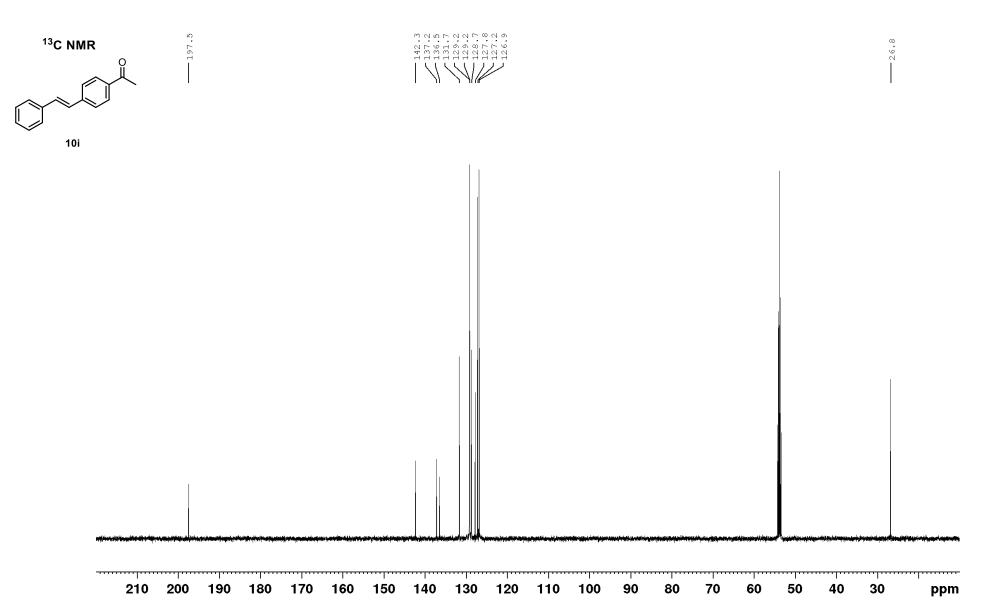
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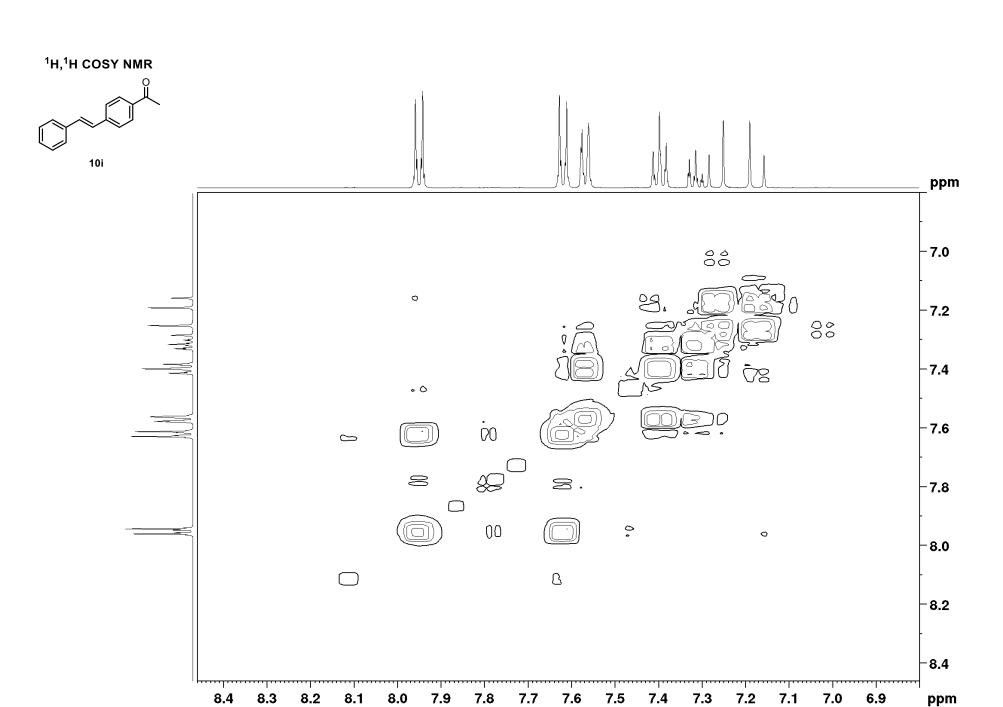
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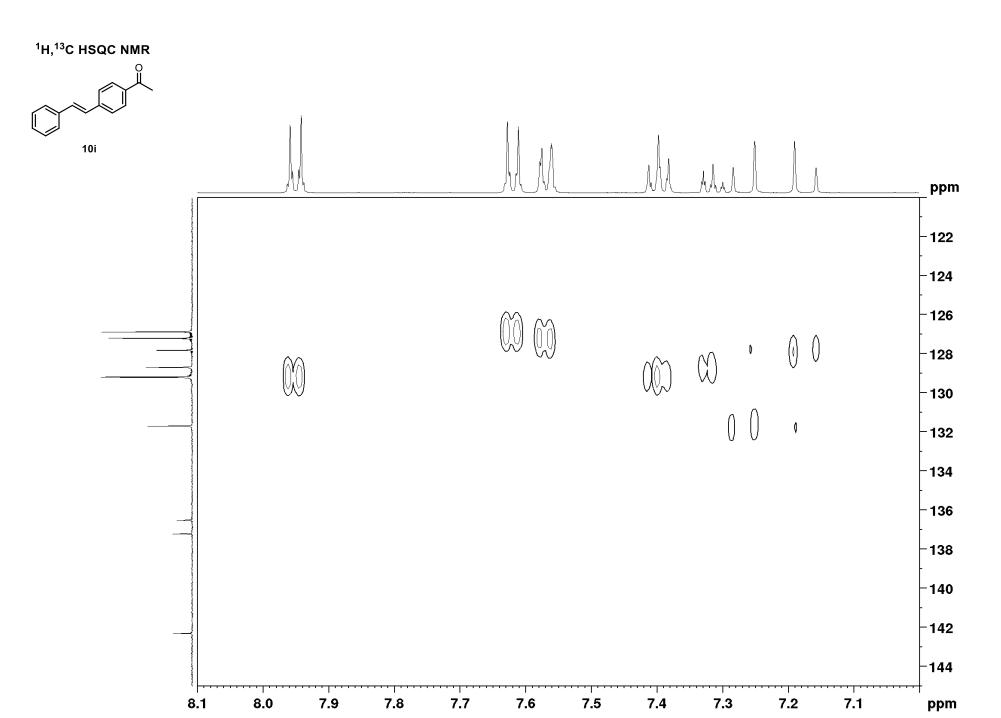
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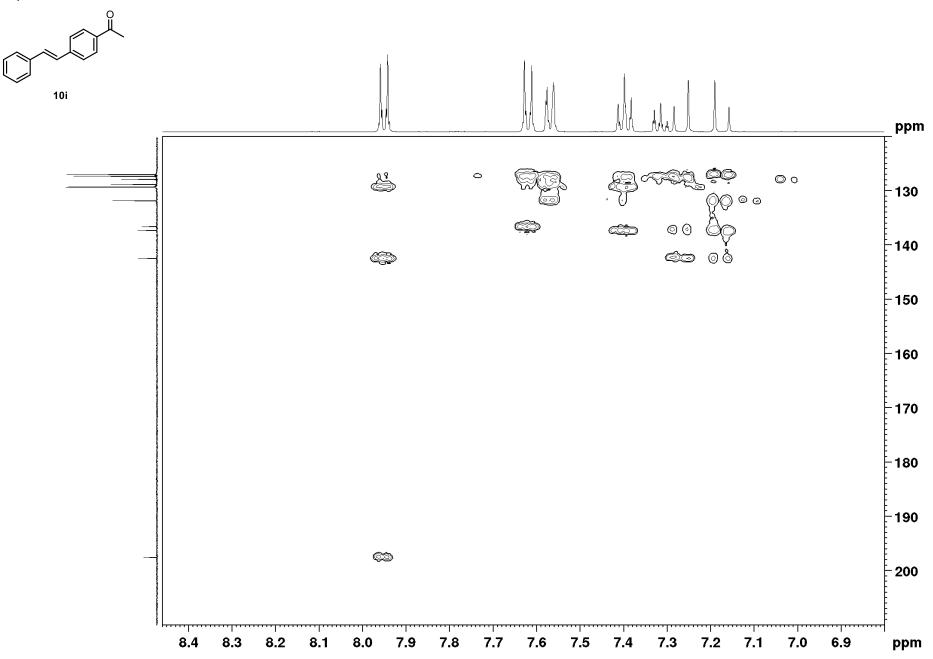




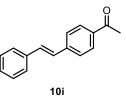


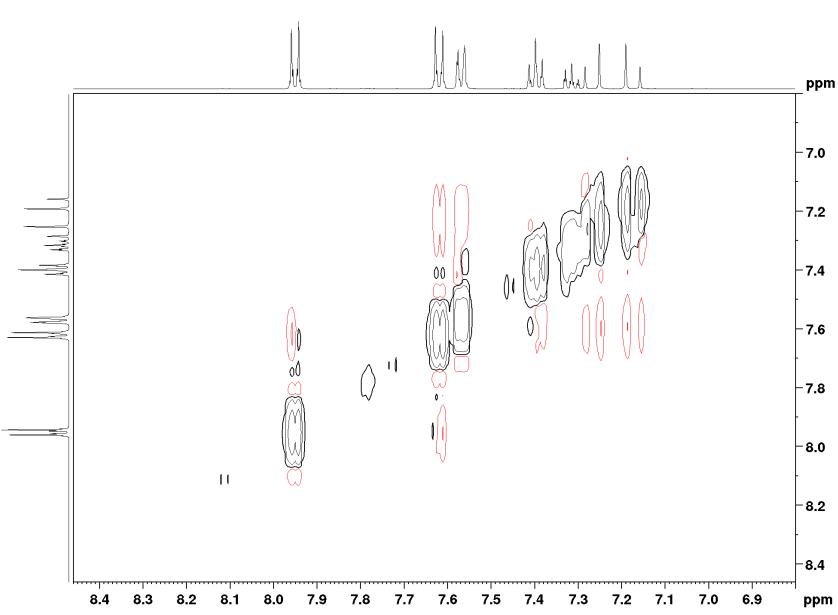


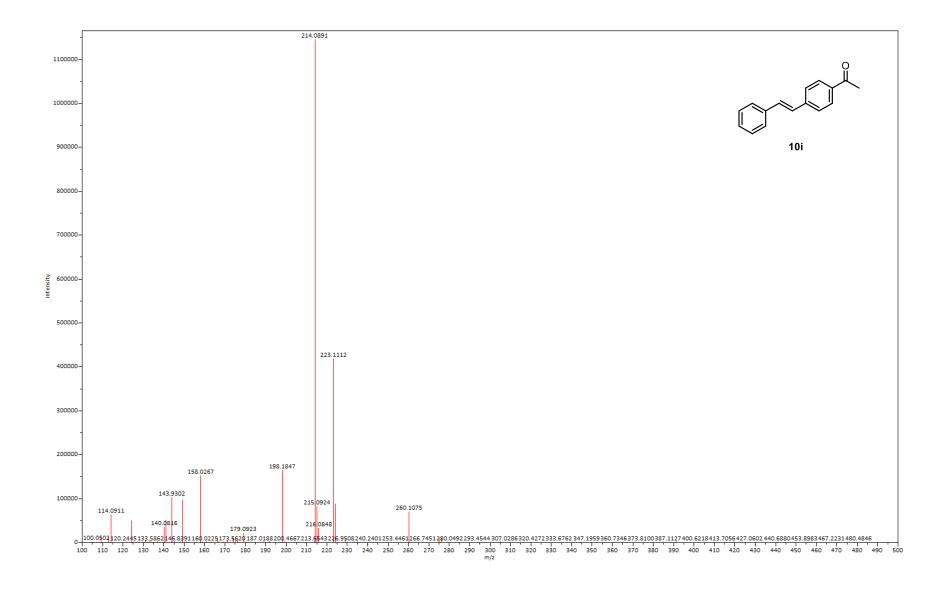


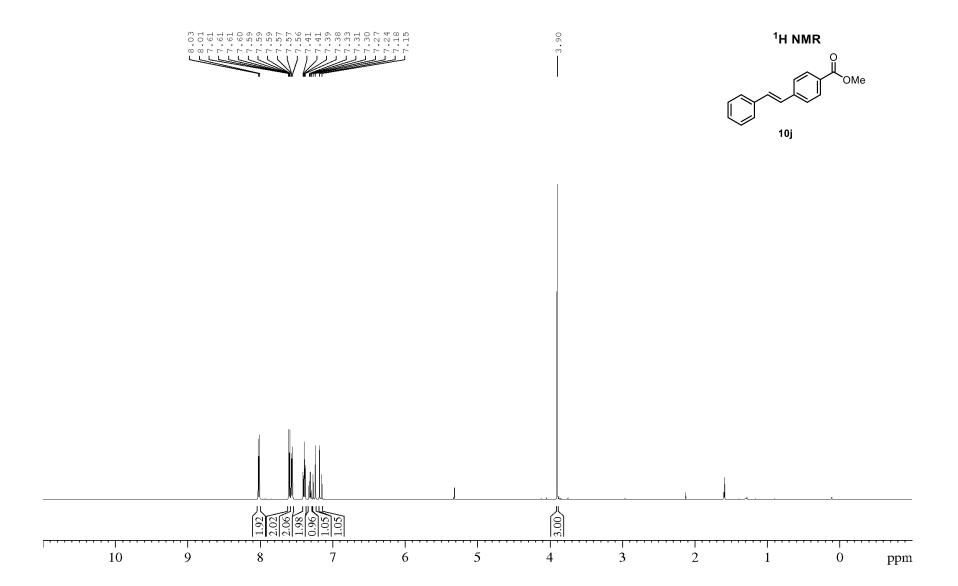


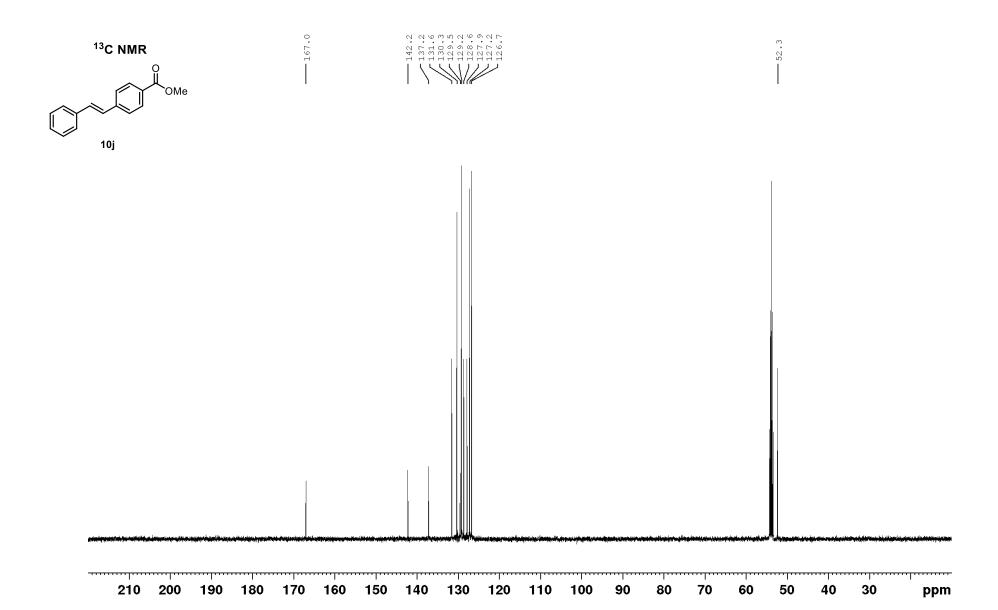


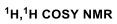


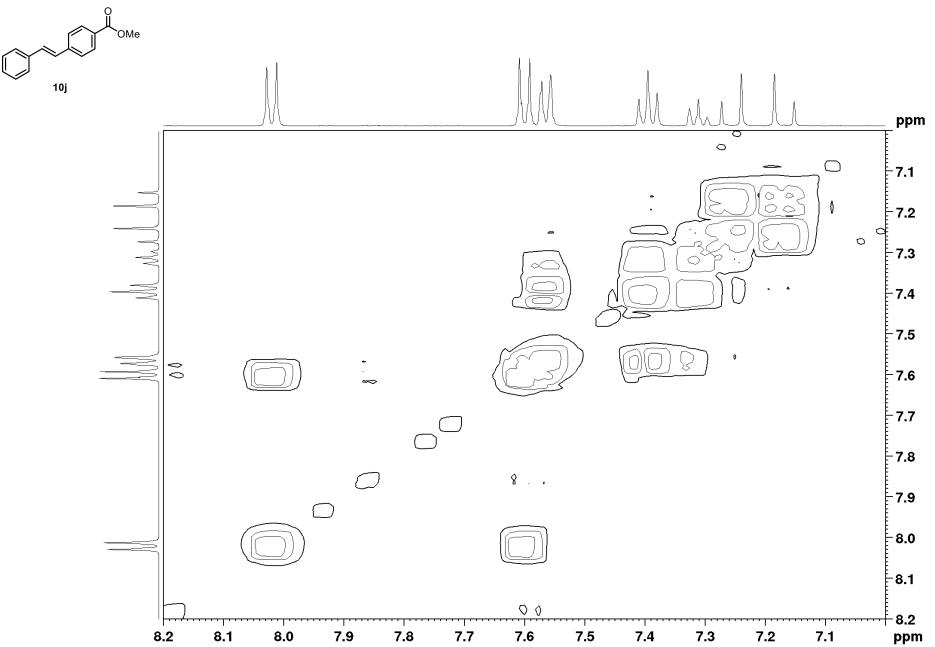




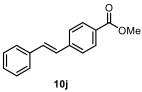


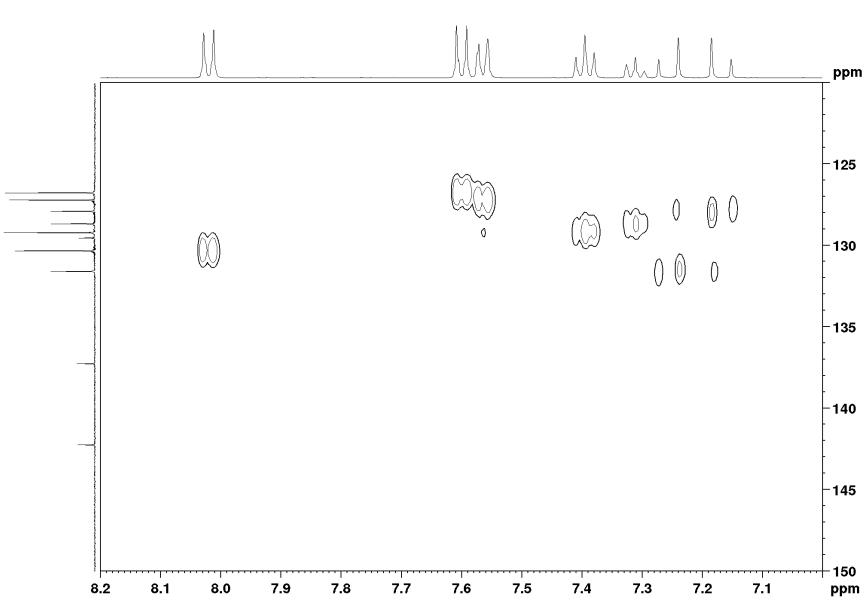




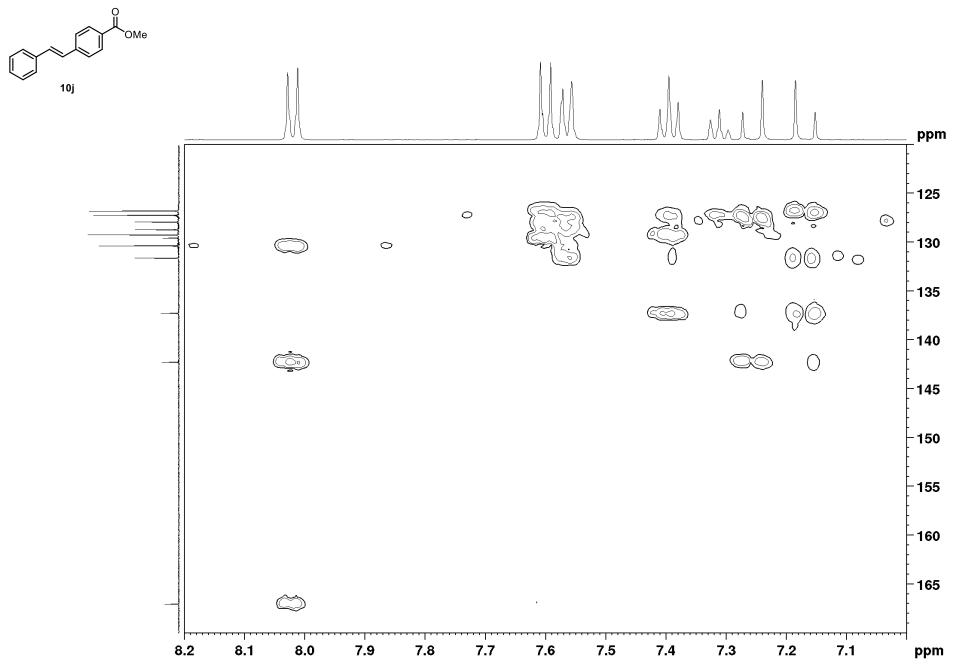




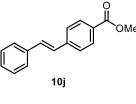


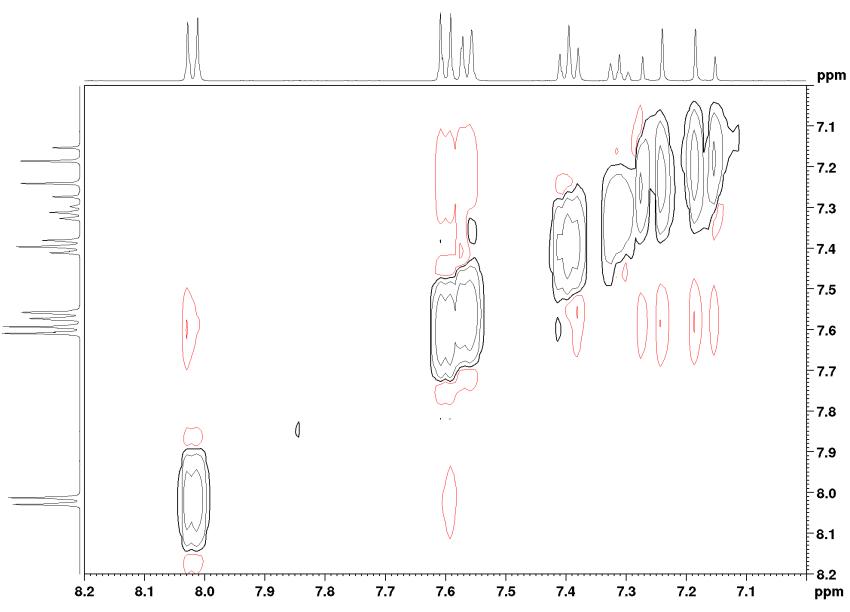




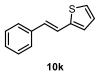




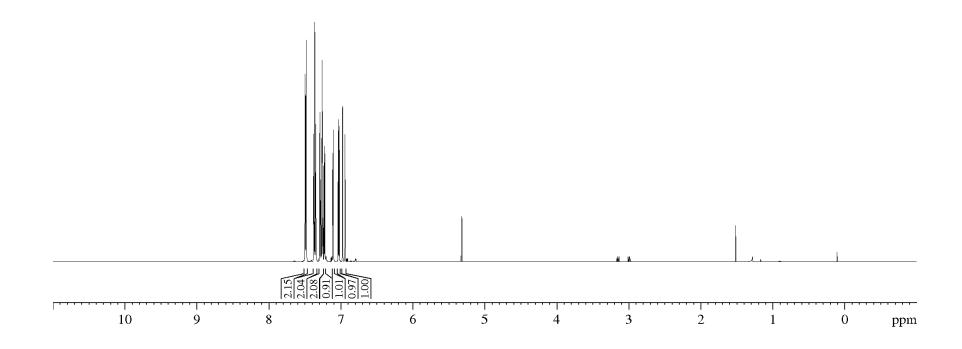




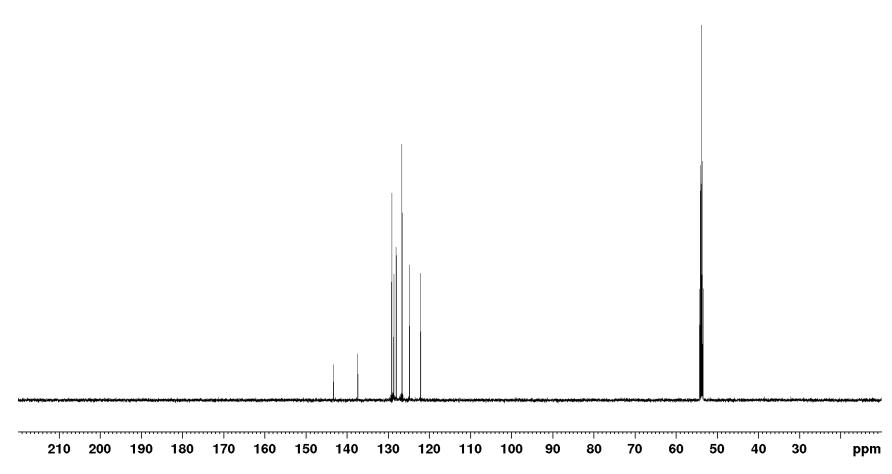




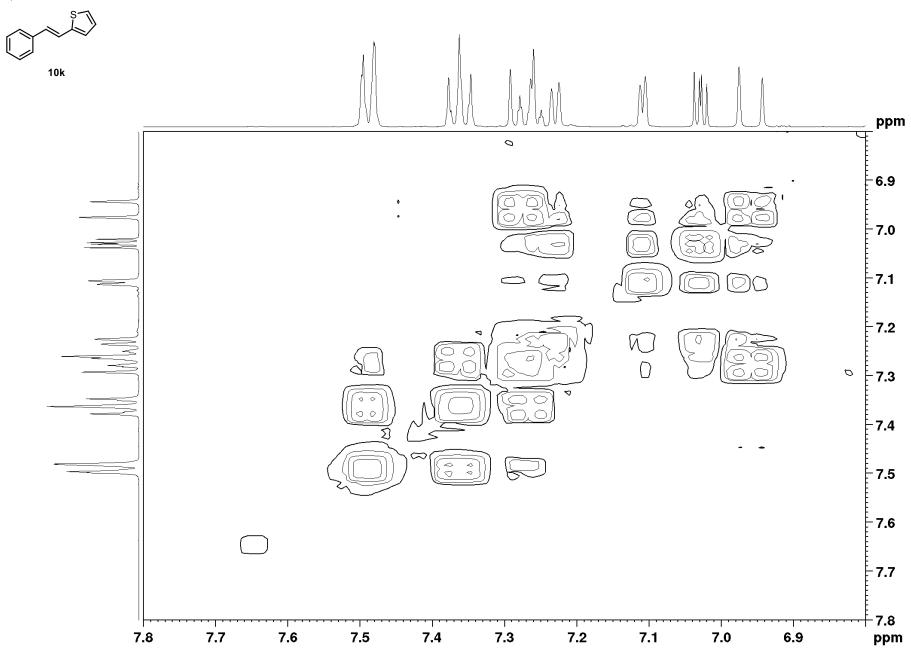




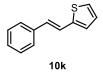


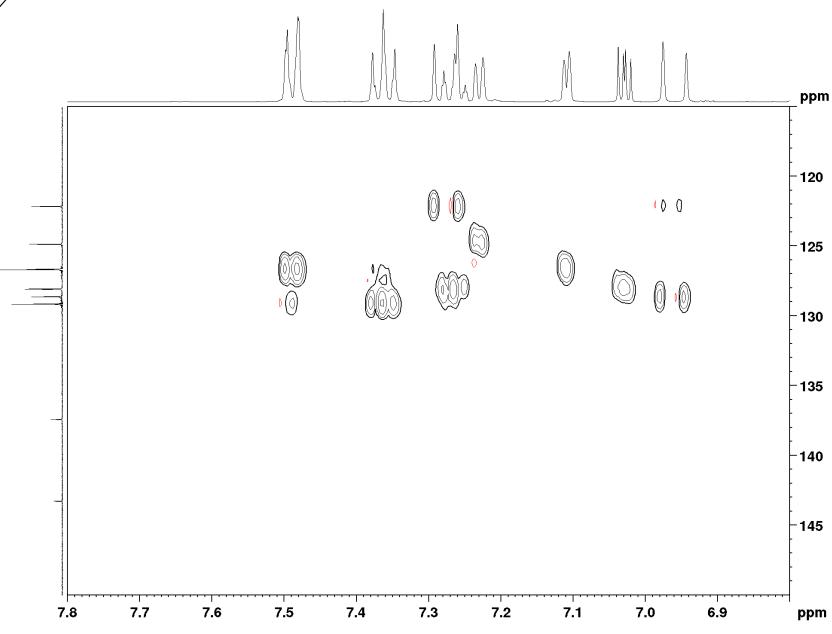




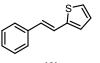




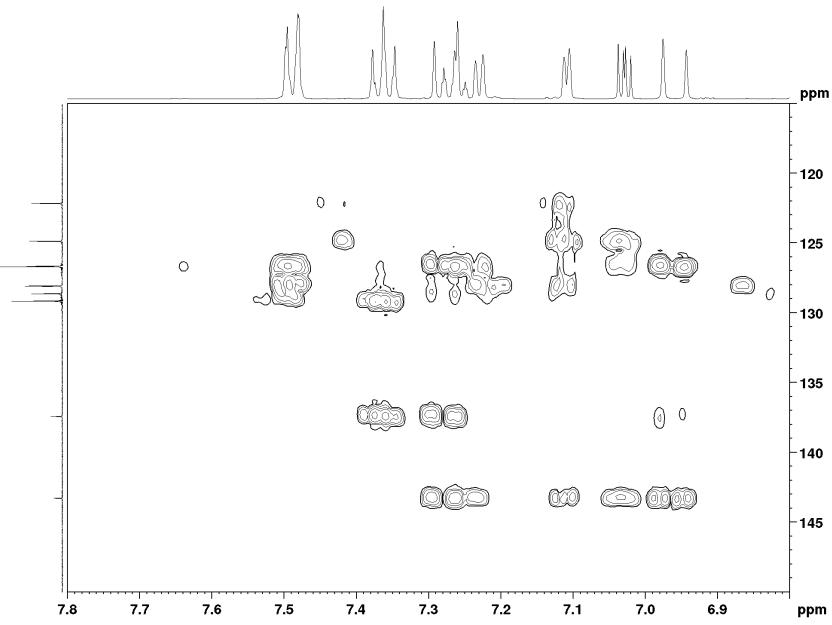








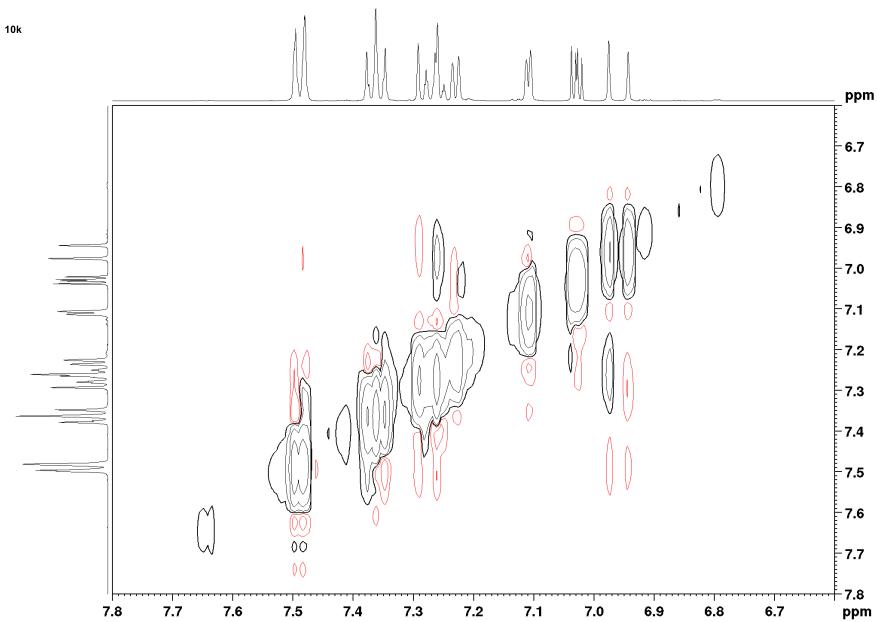




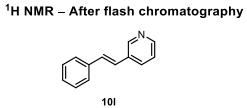


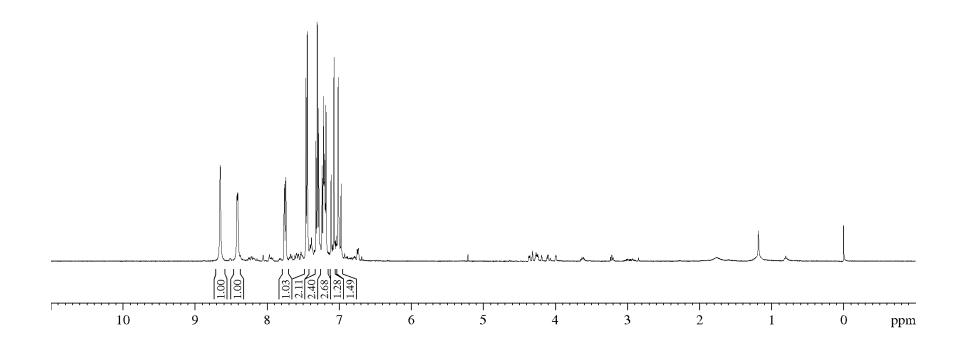


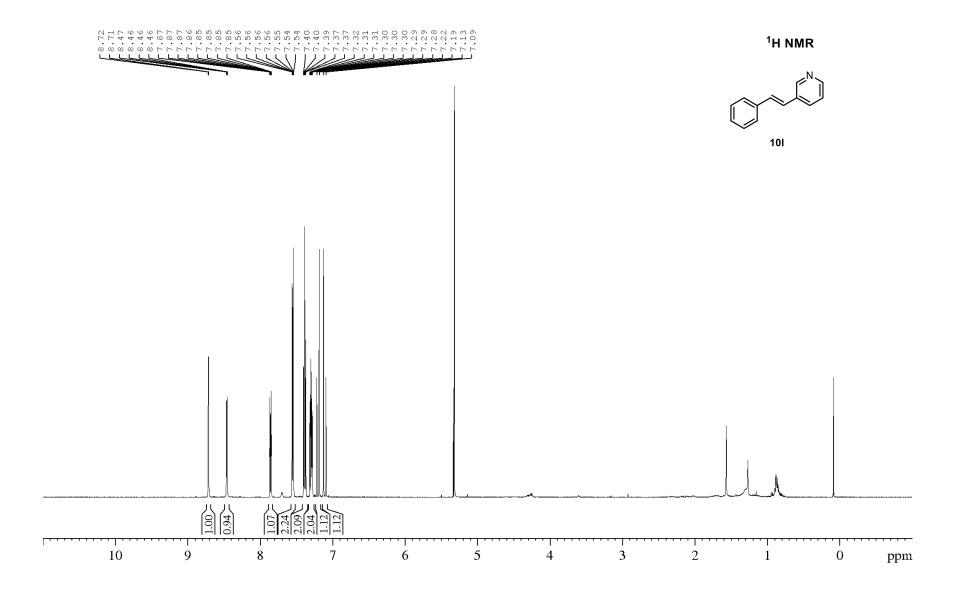


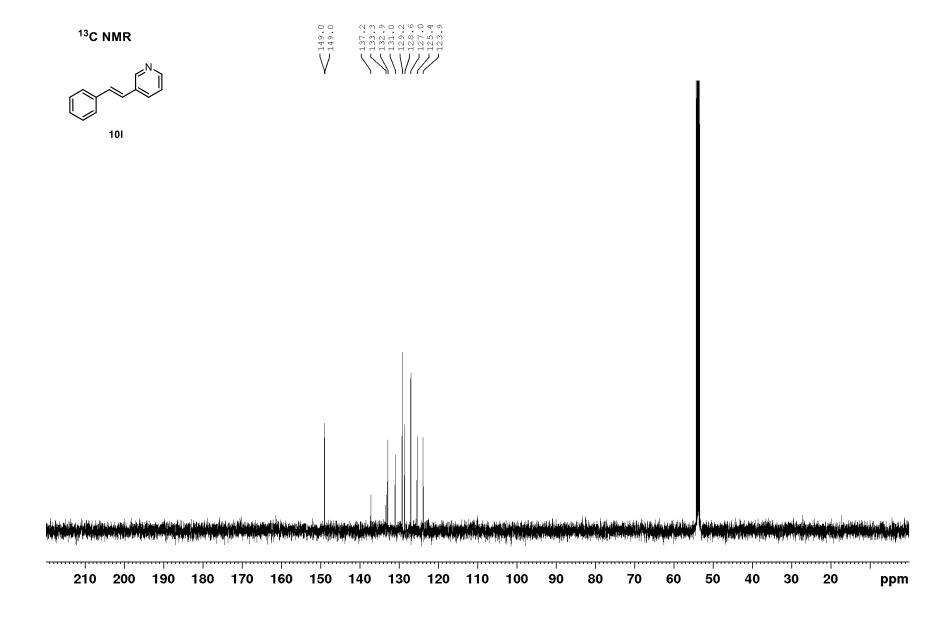


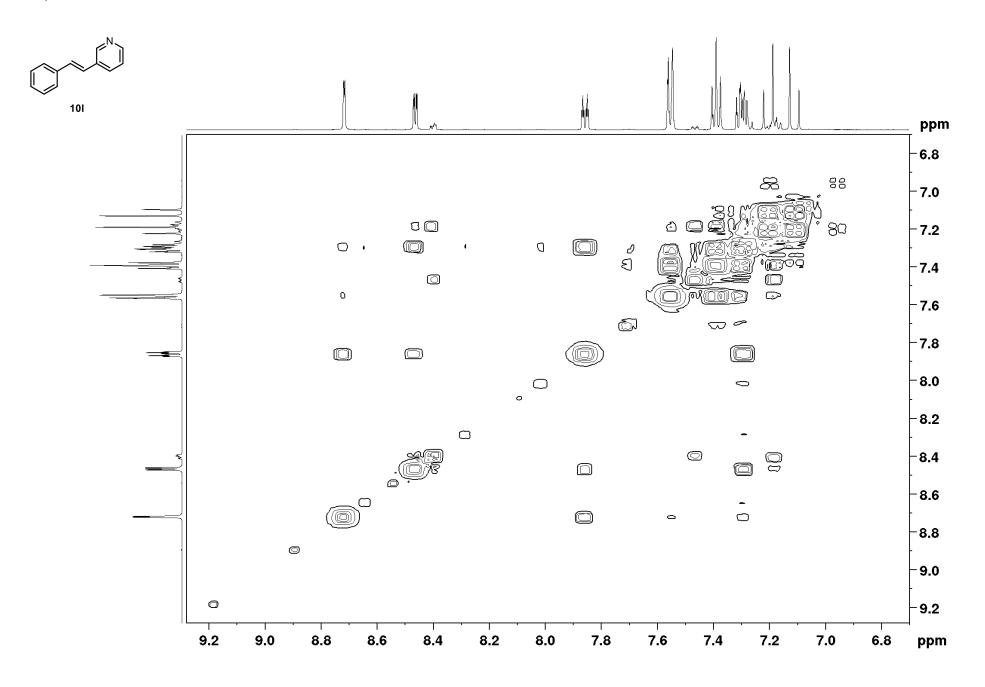


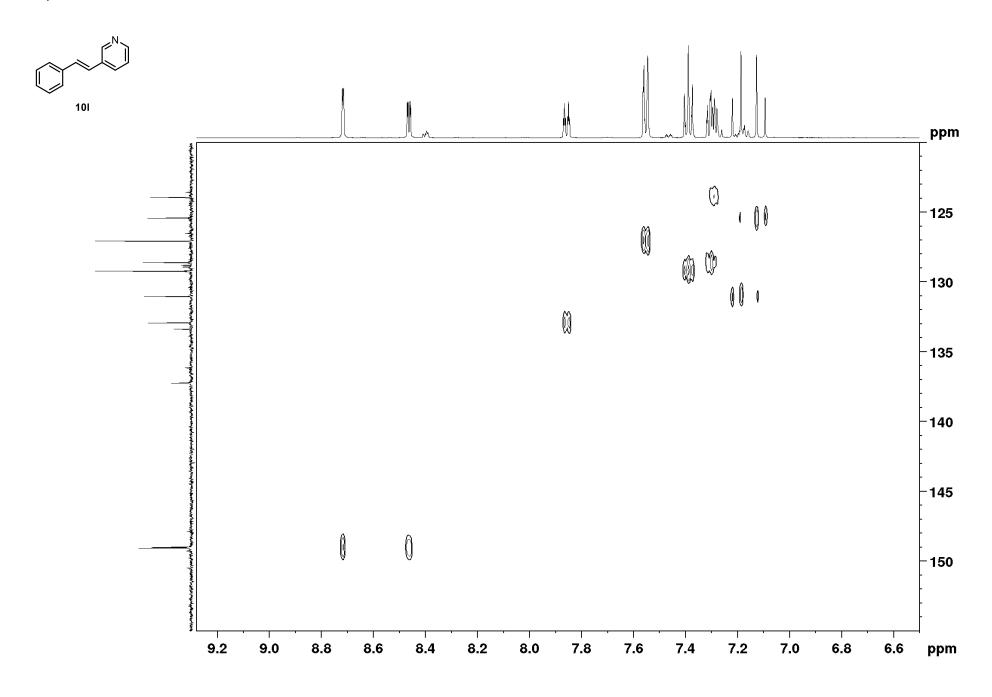




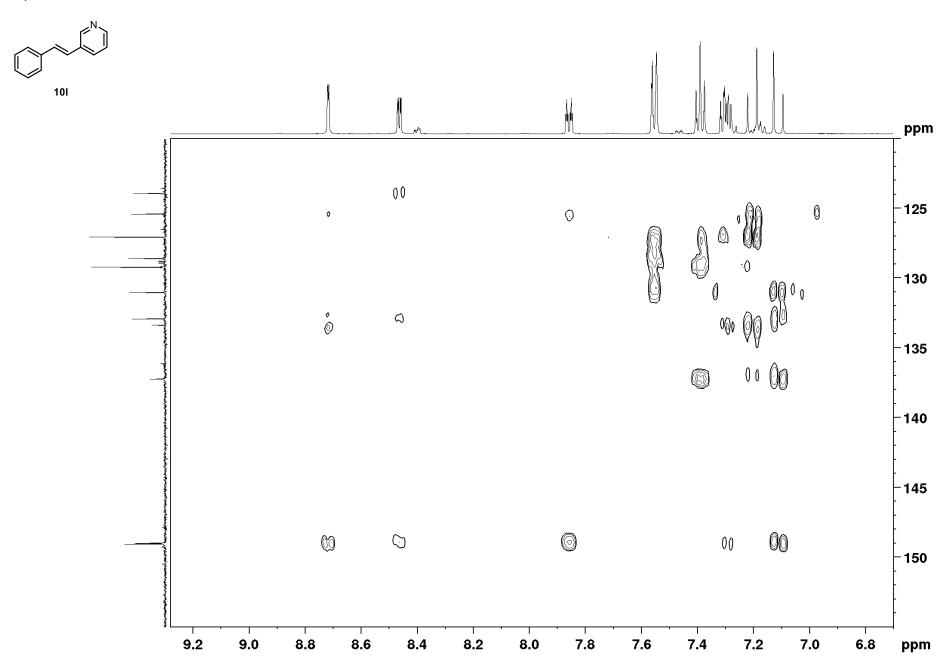


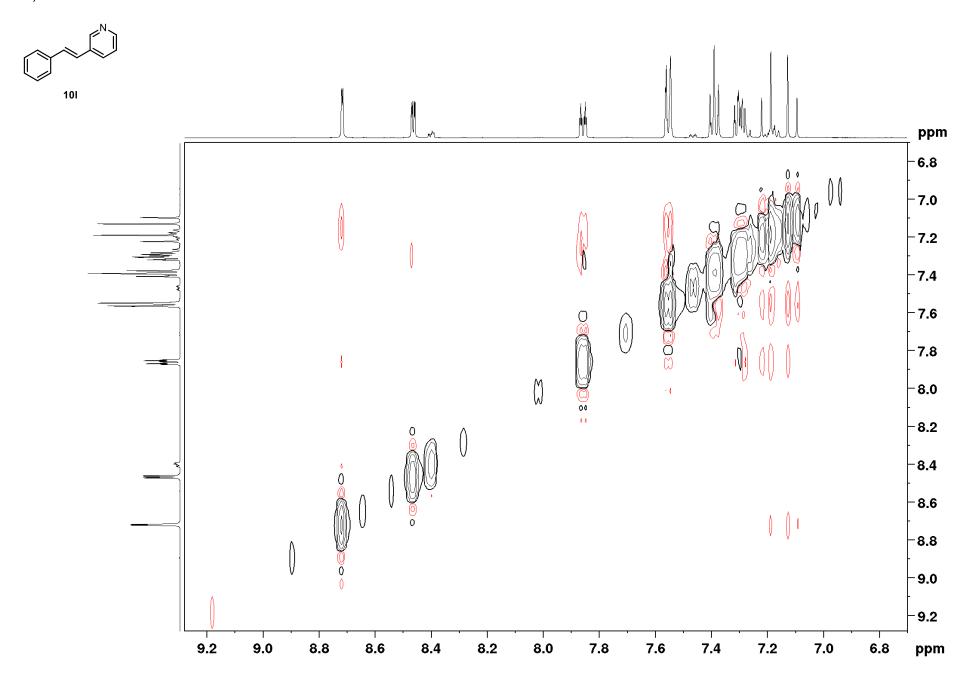


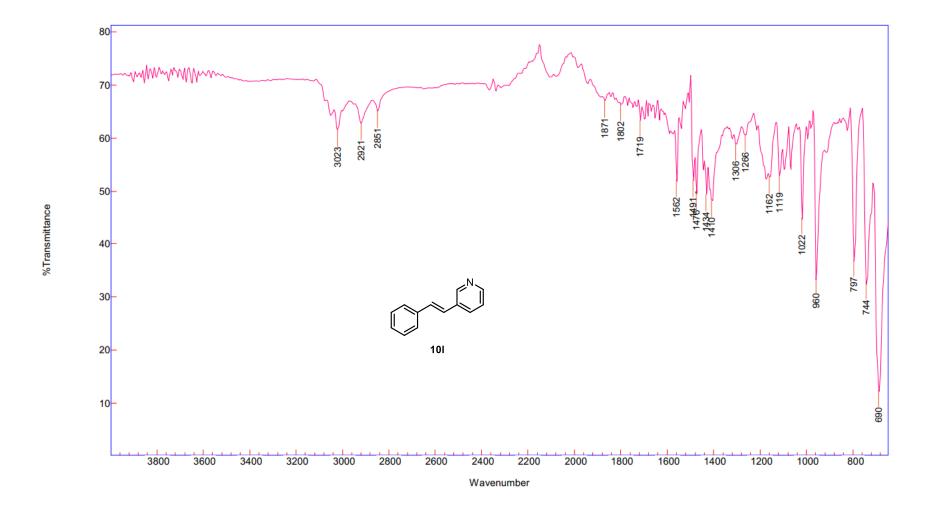


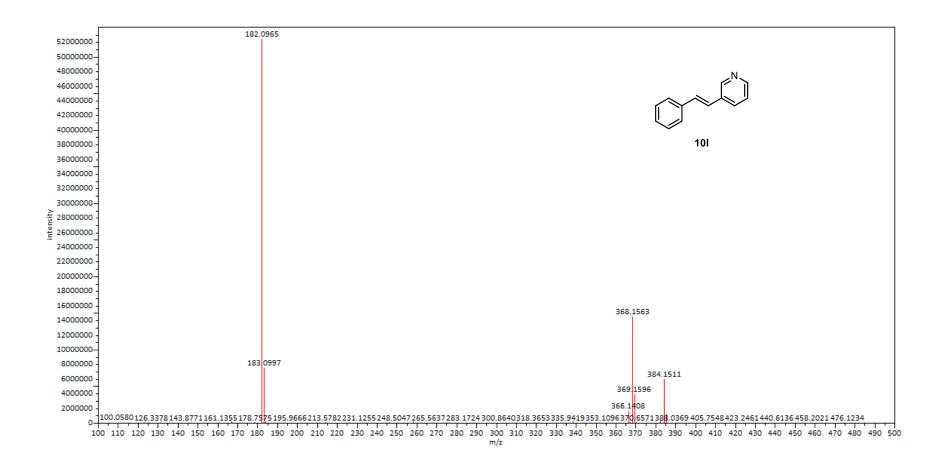


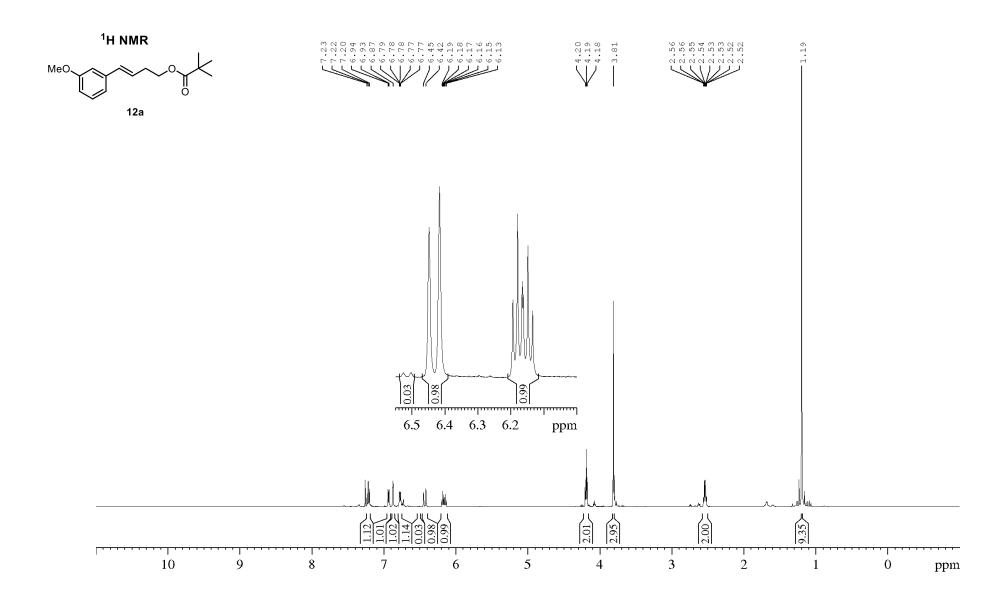


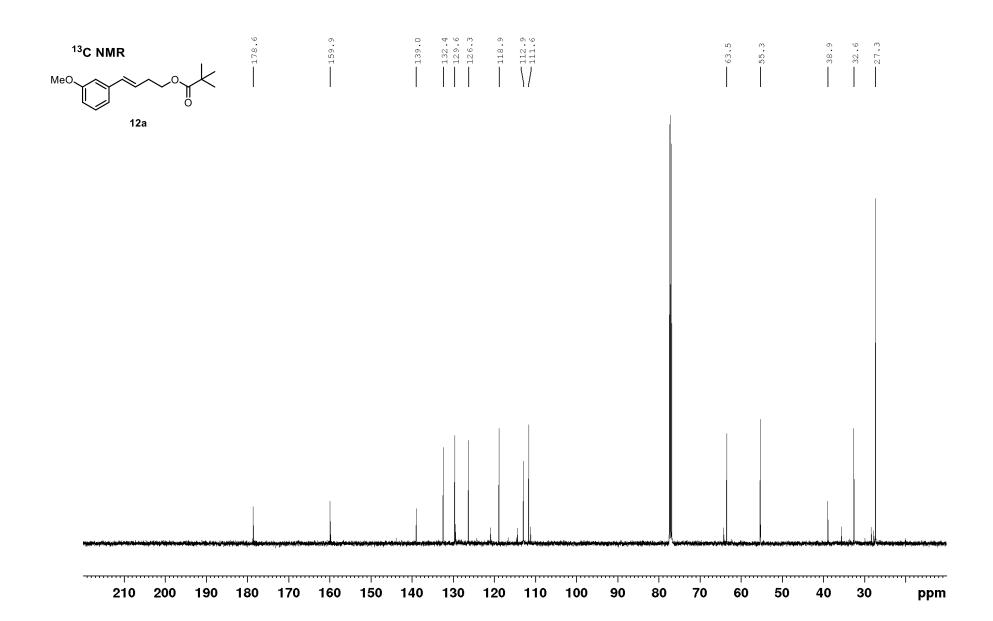


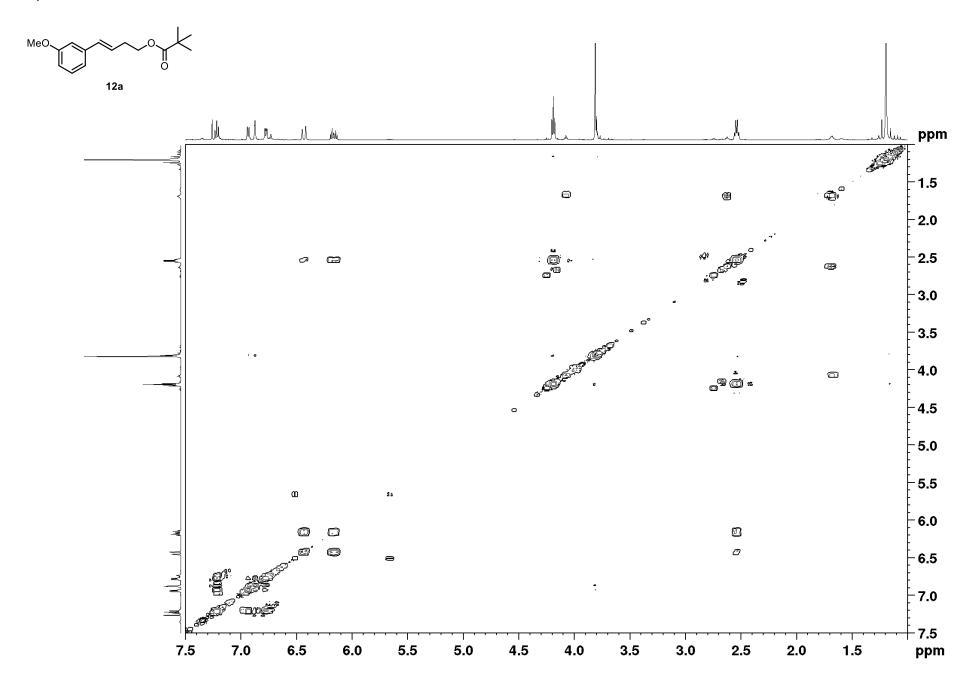




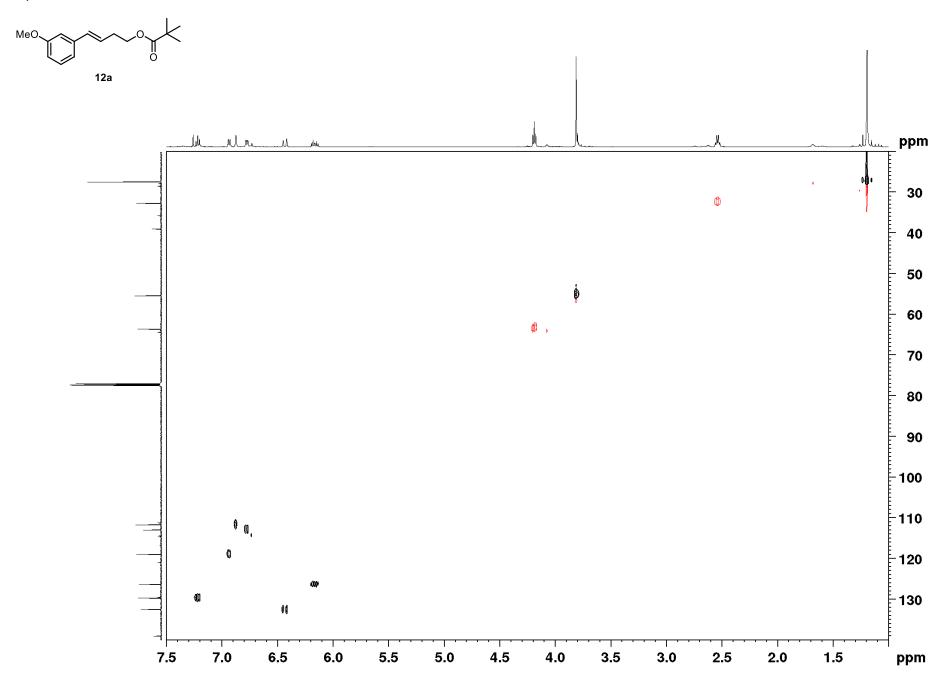




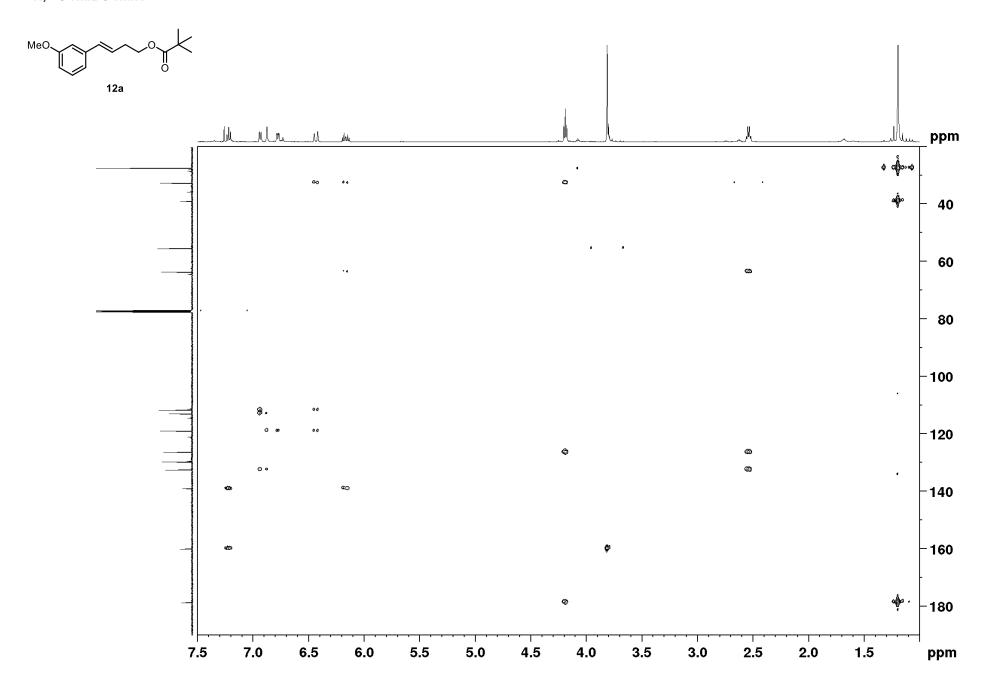


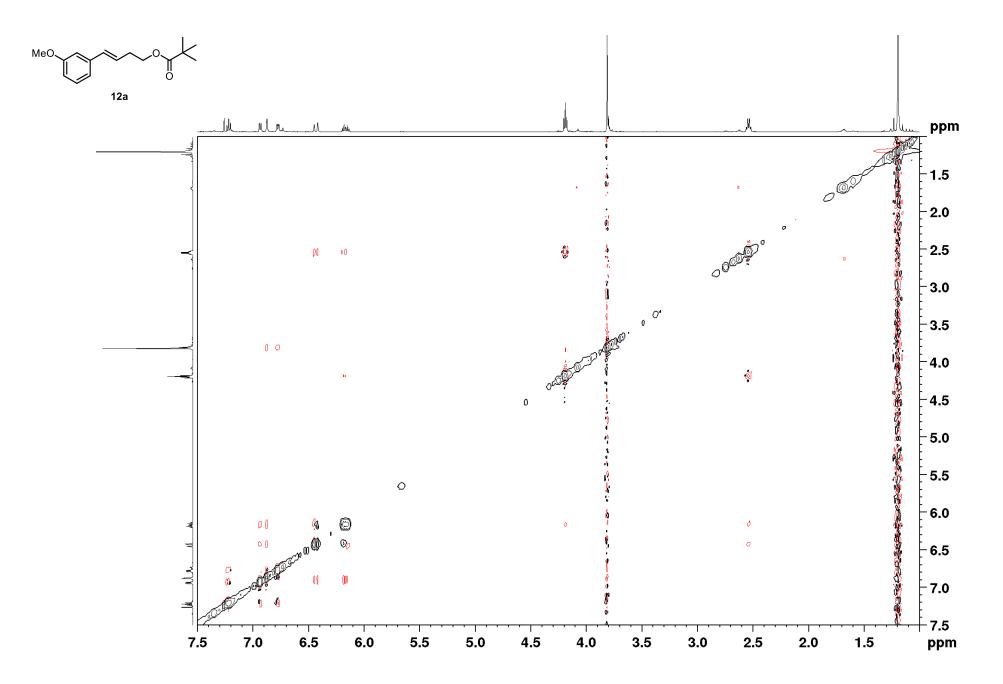


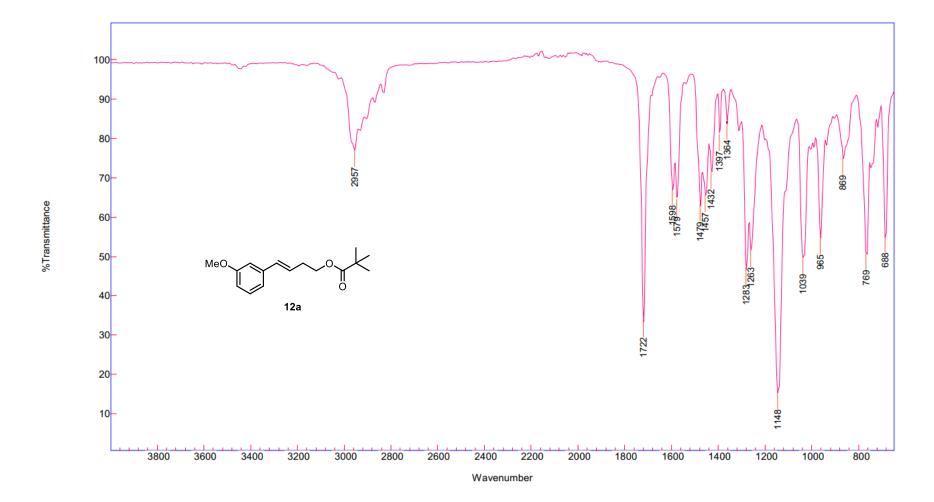


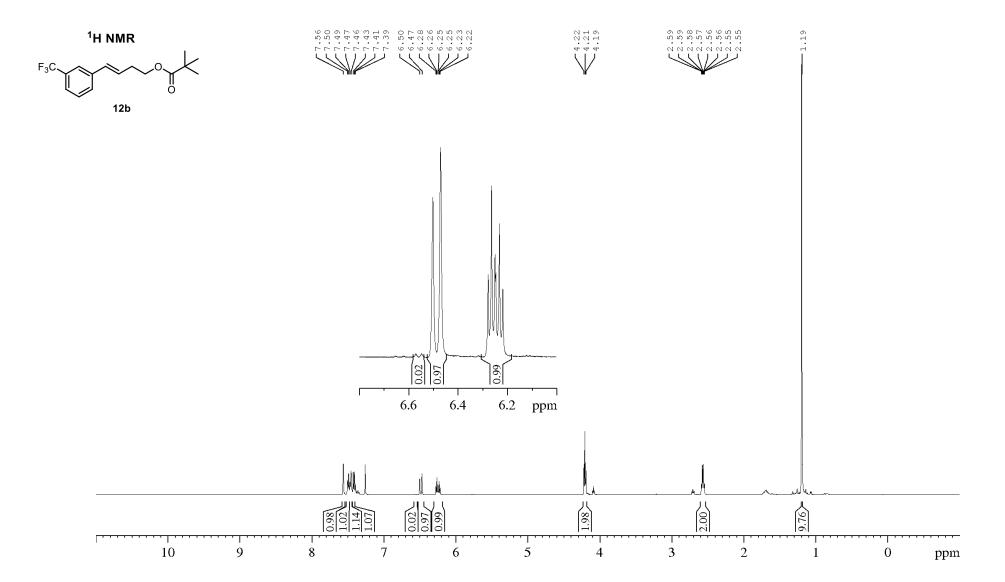


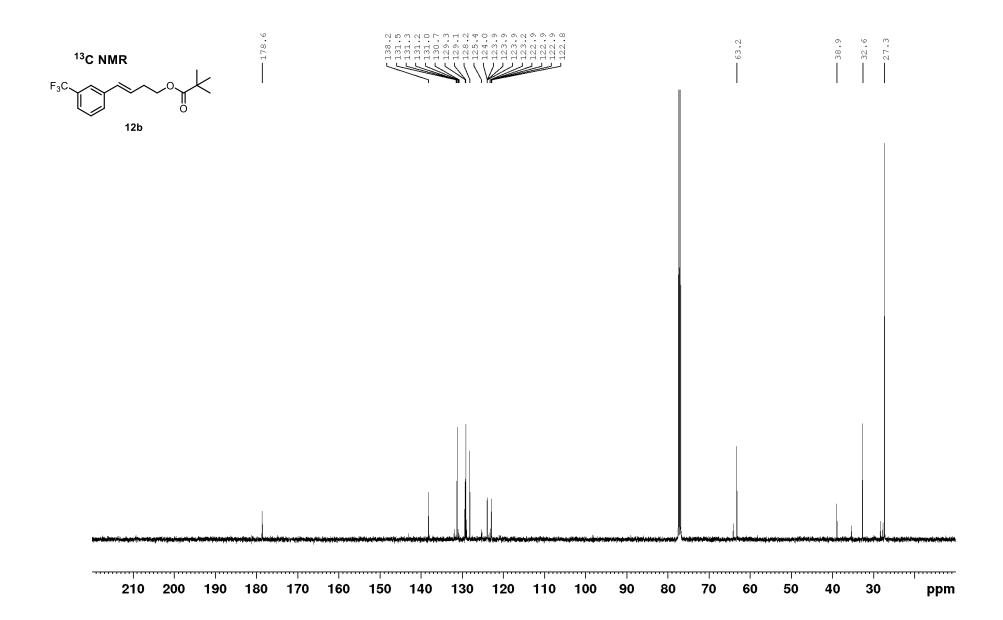
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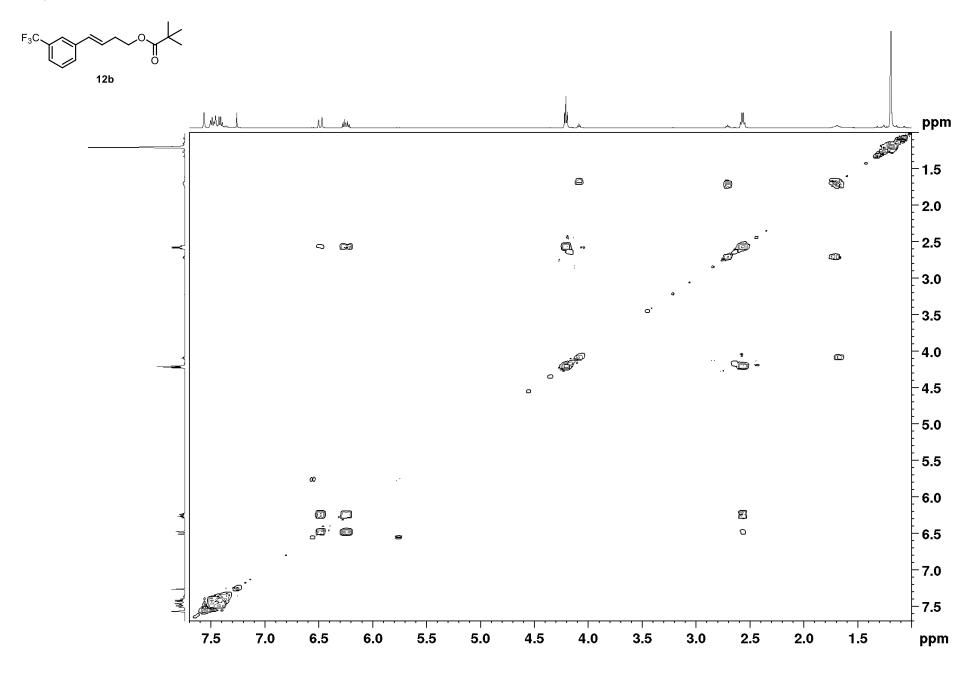


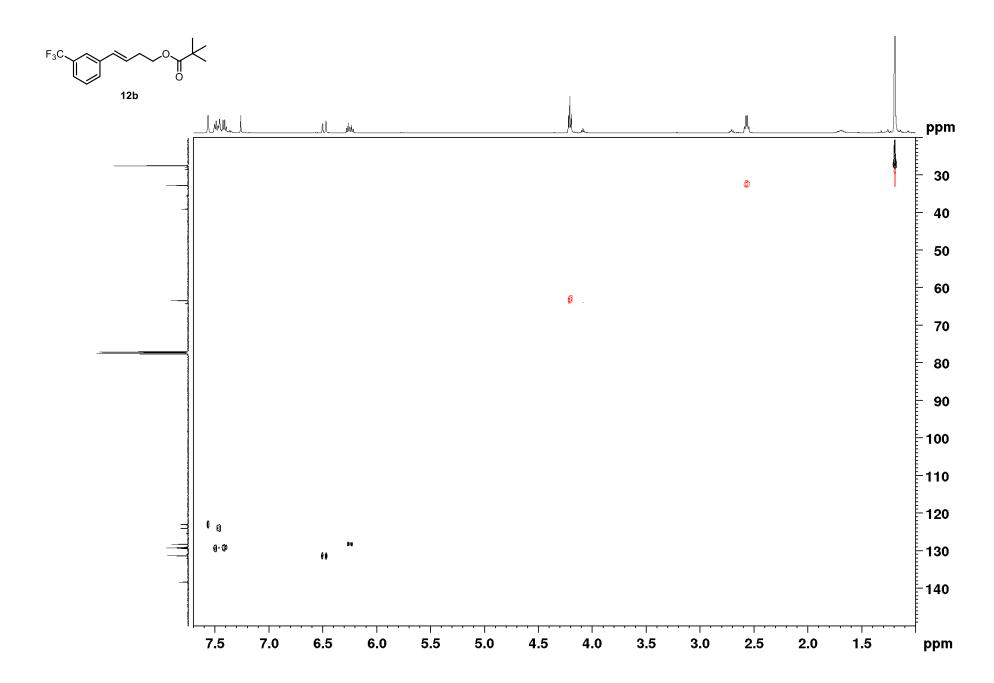


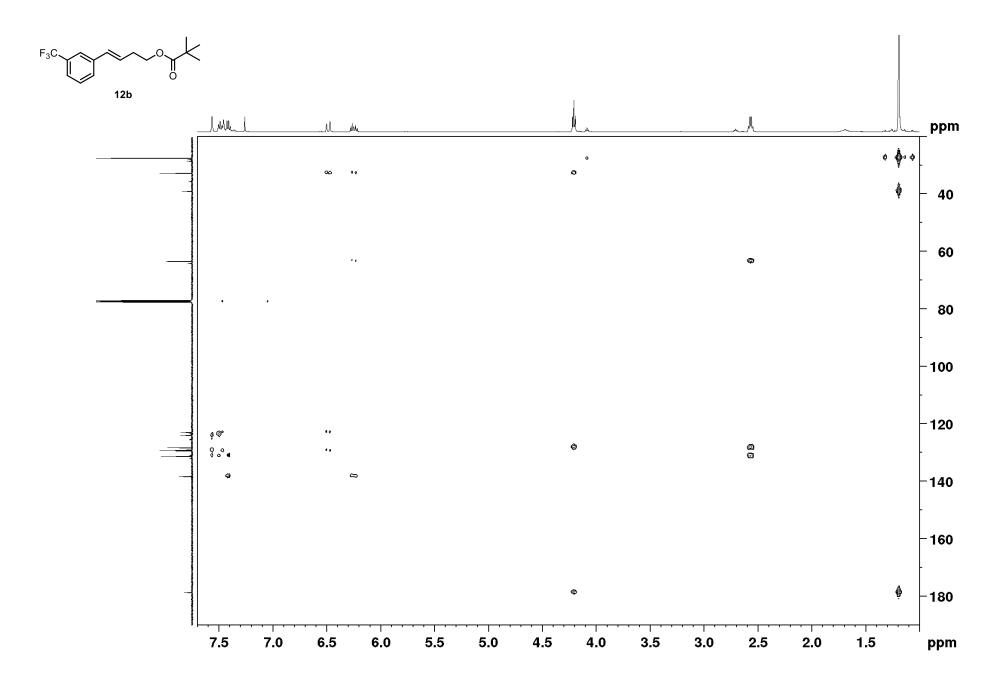


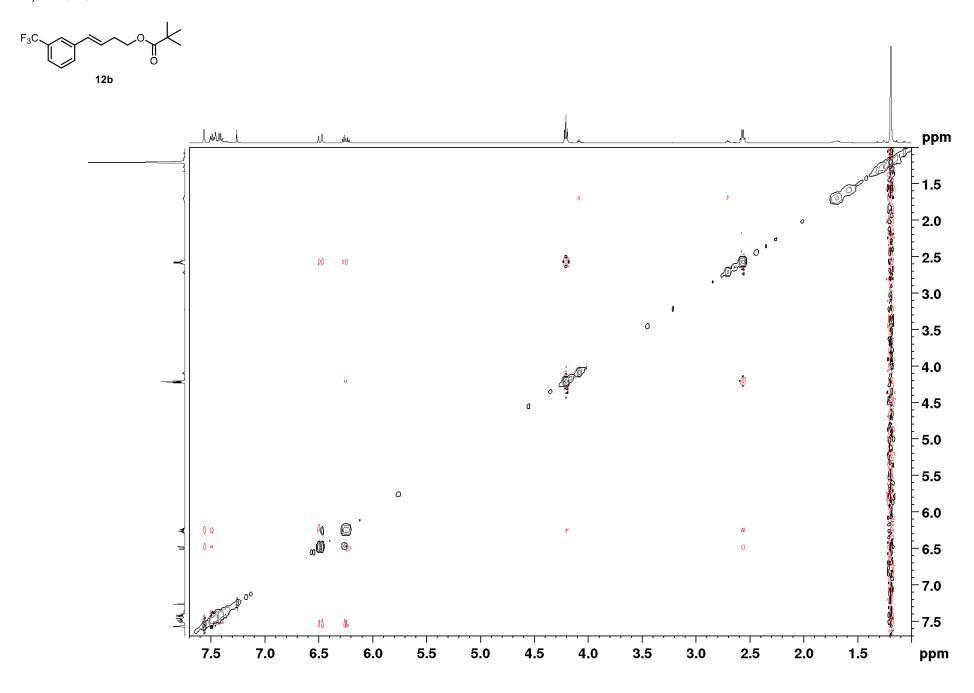


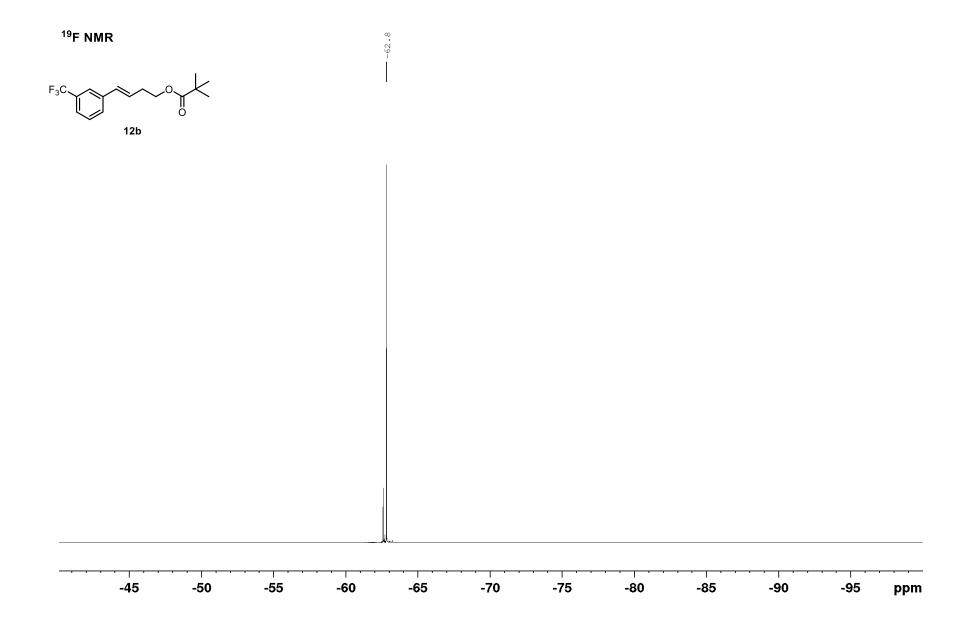


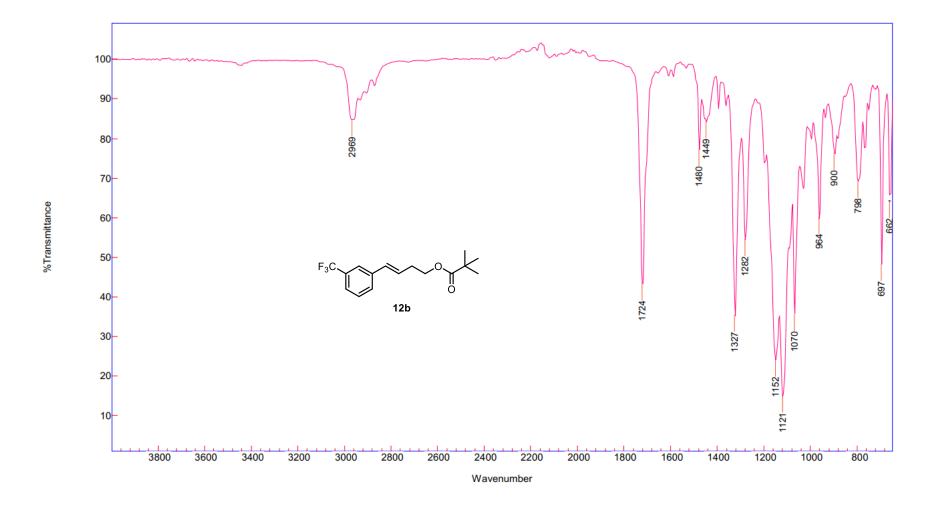


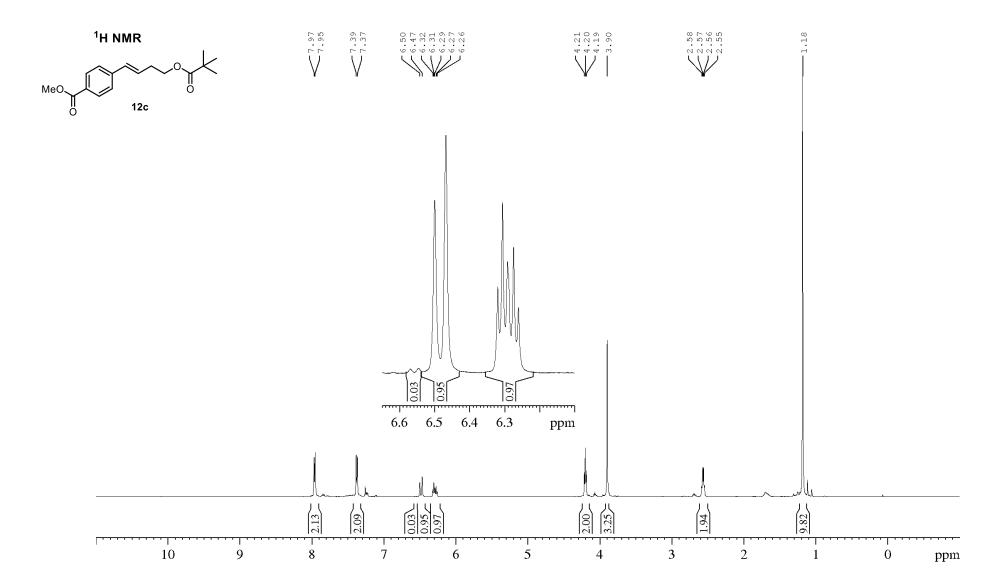


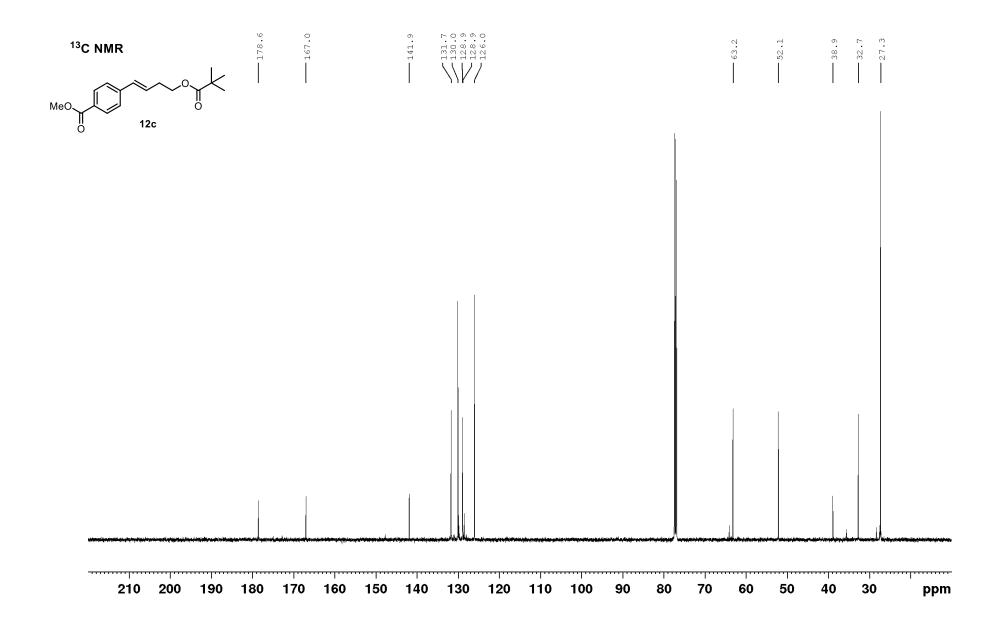


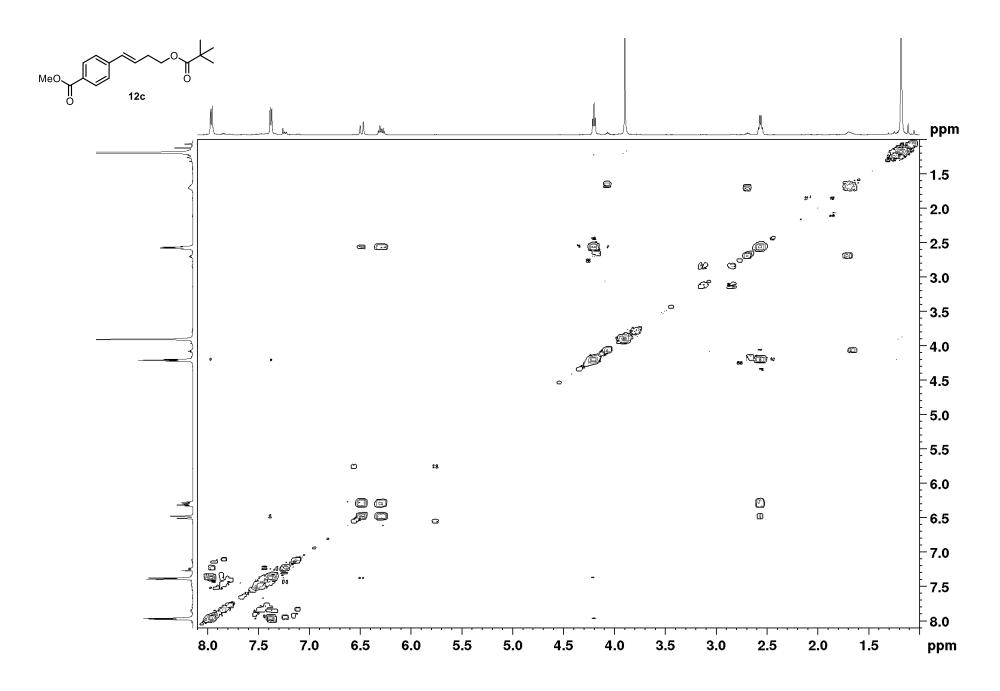


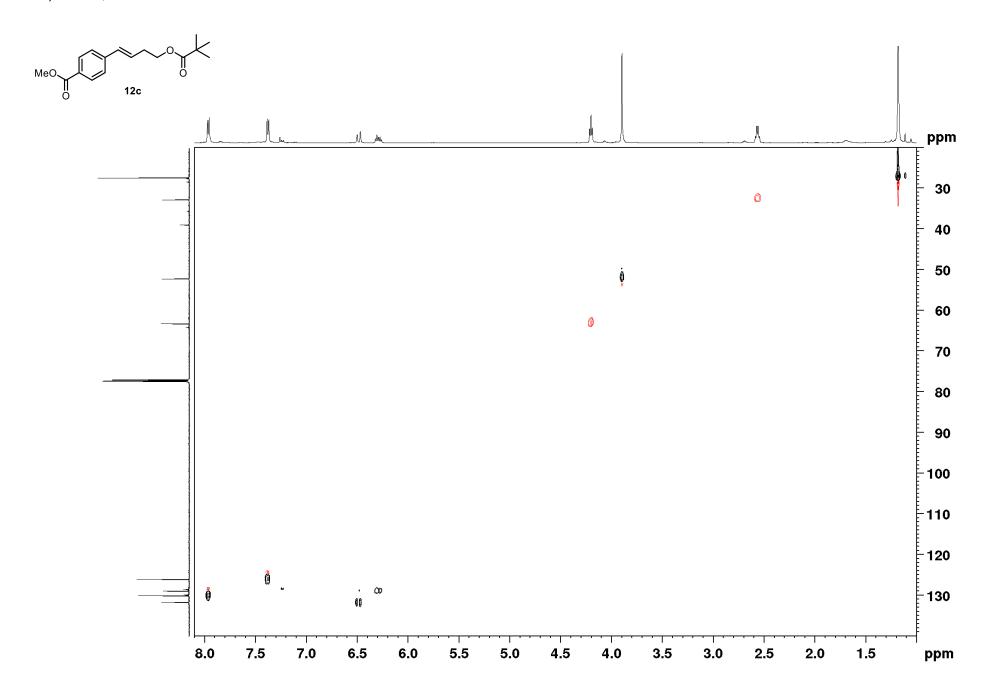




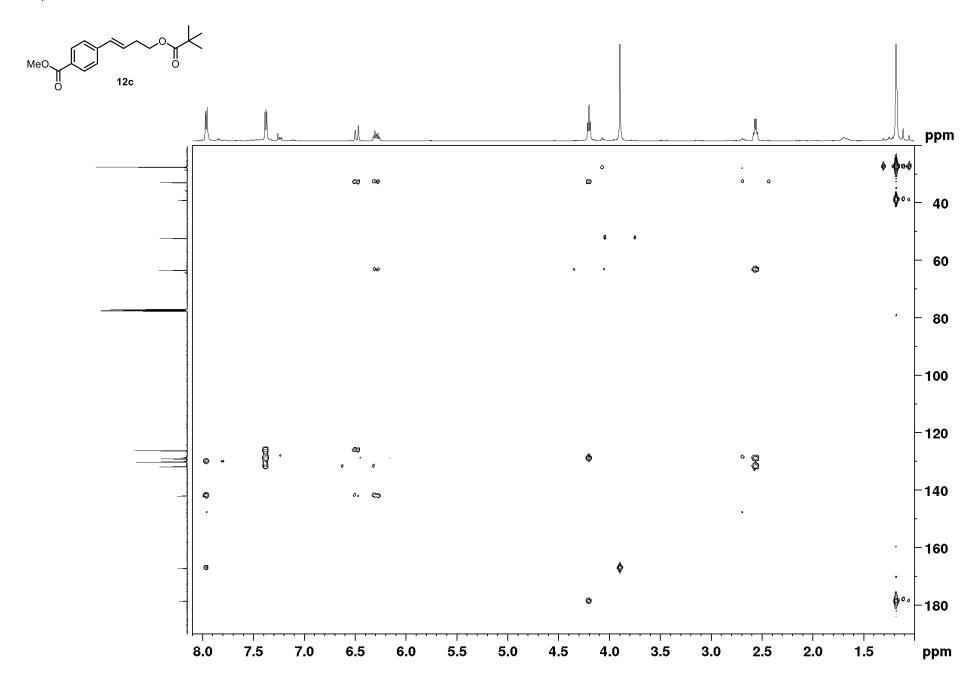


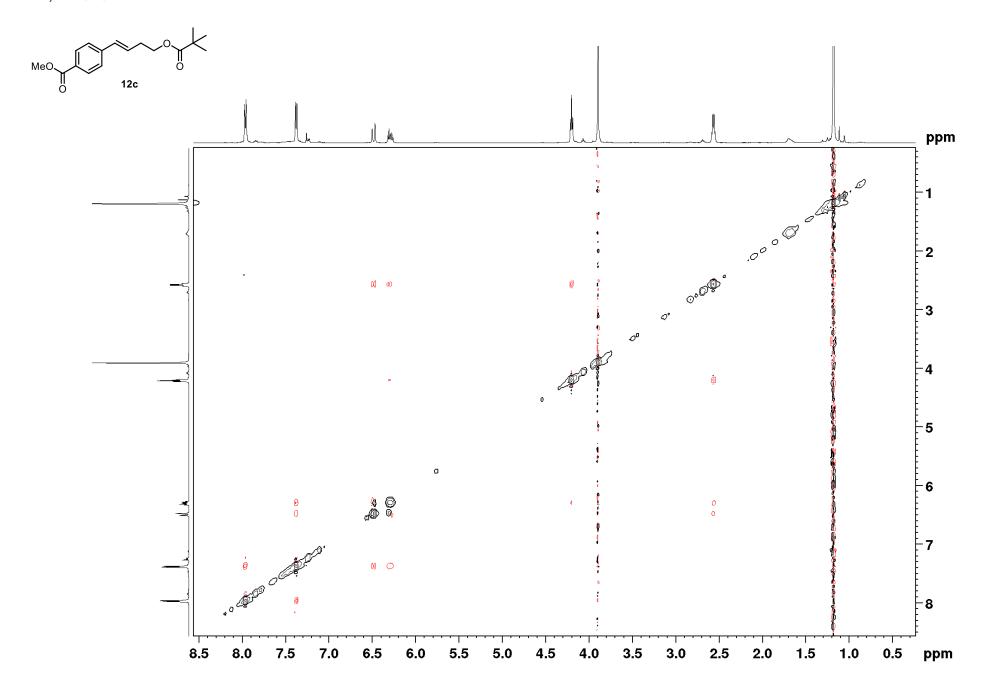


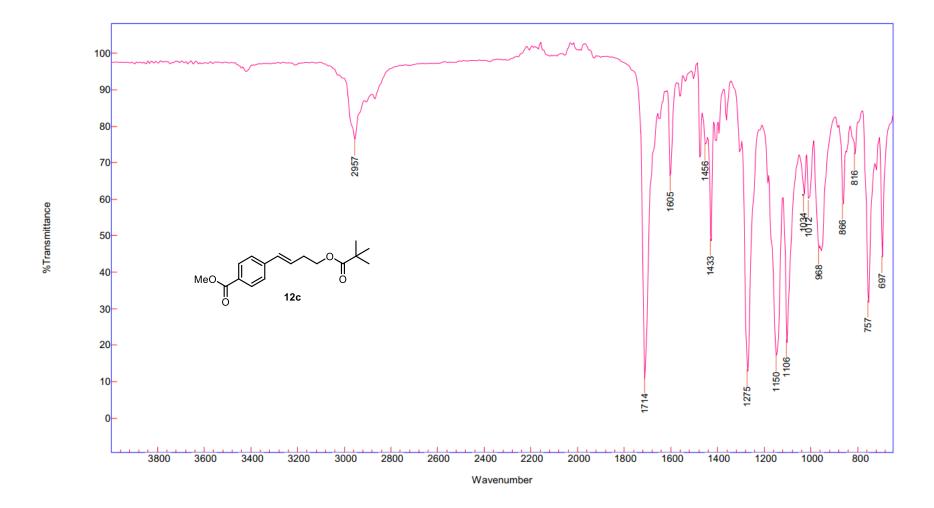


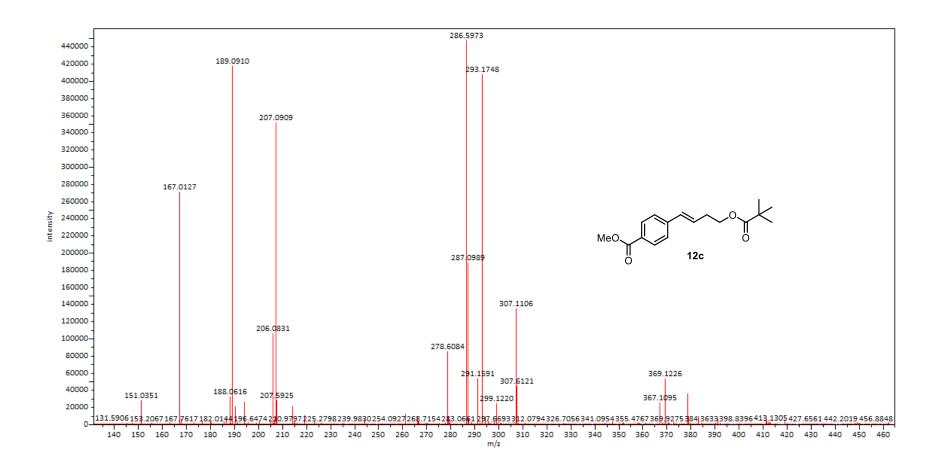


<sup>1</sup>H,<sup>13</sup>C HMBC NMR

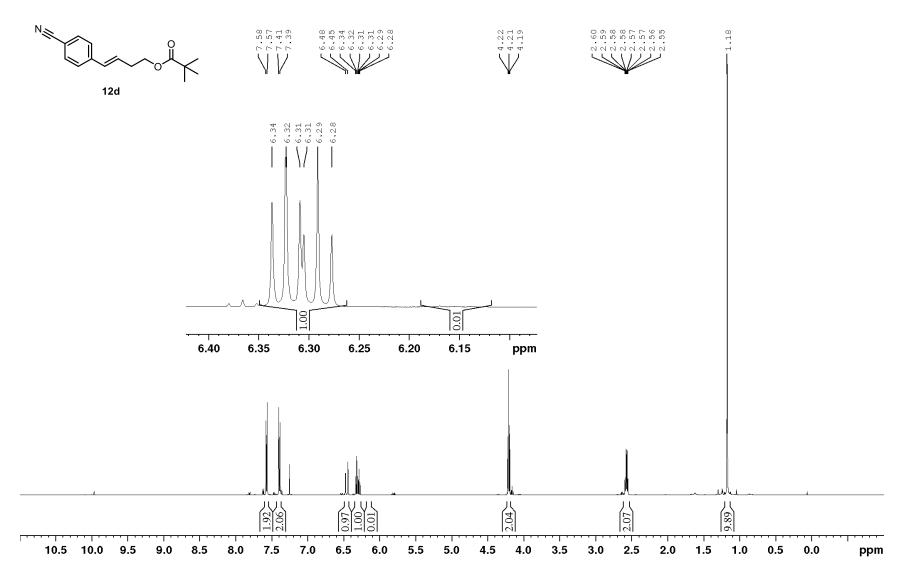


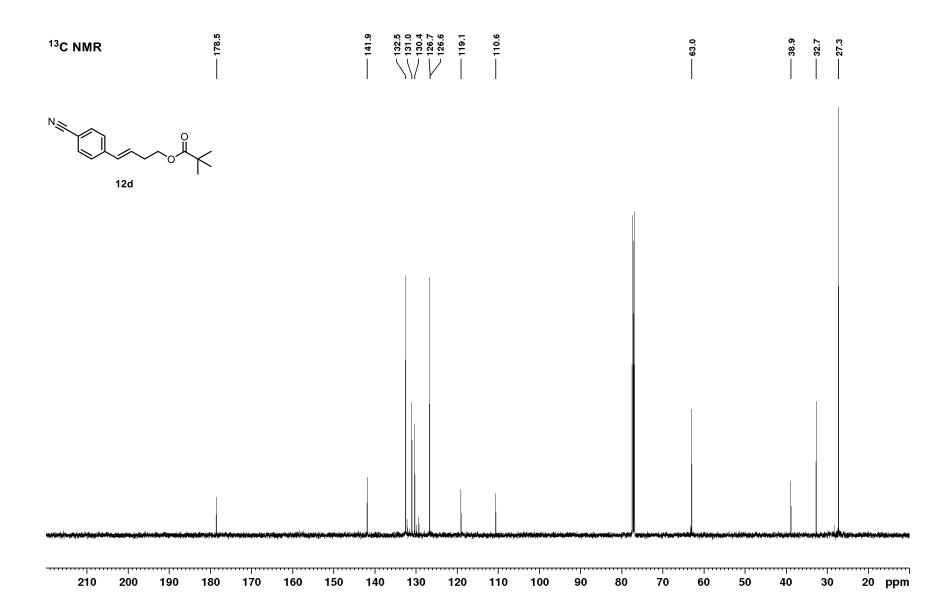


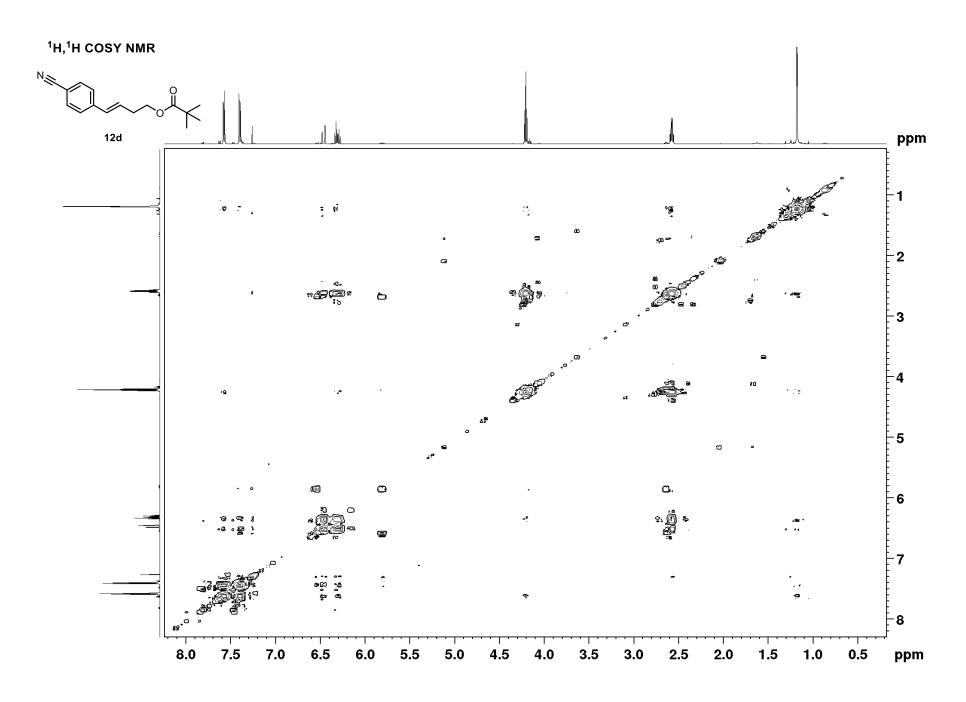




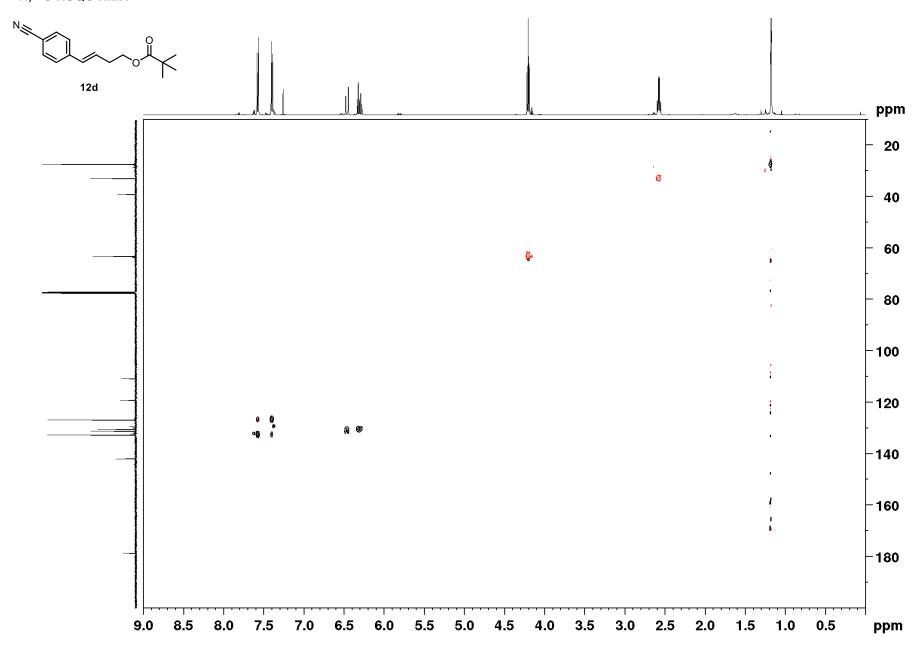


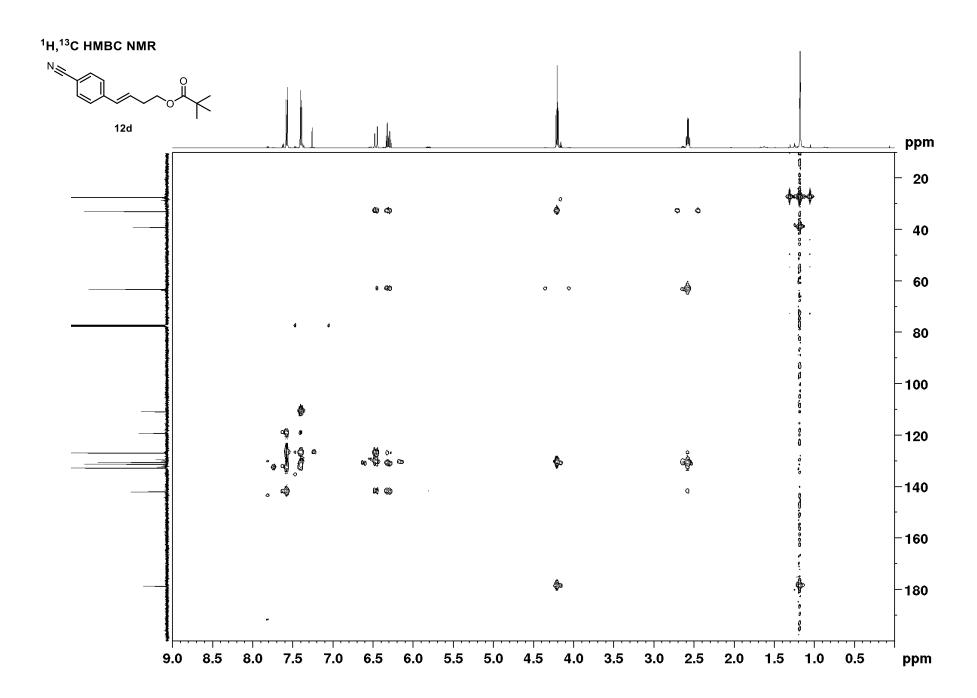


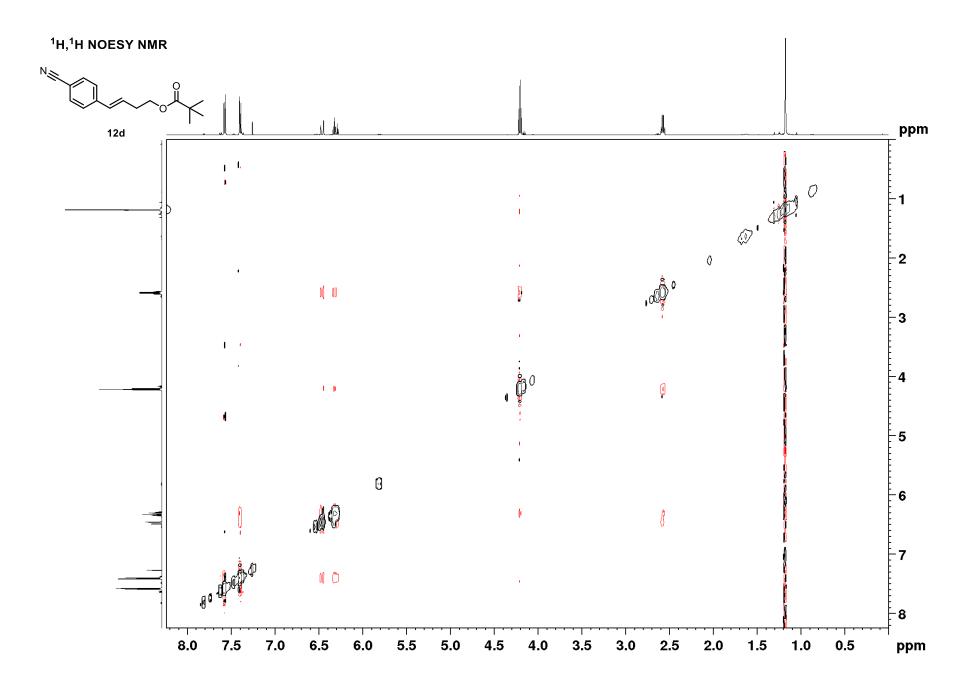


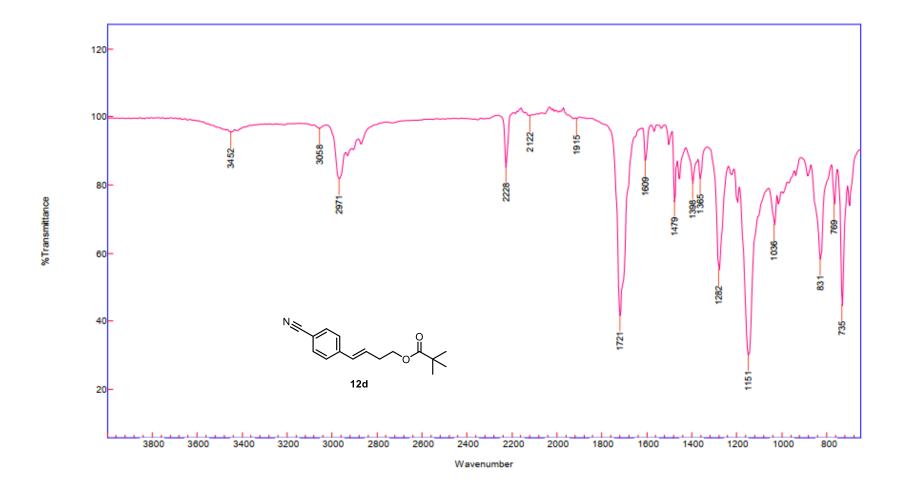


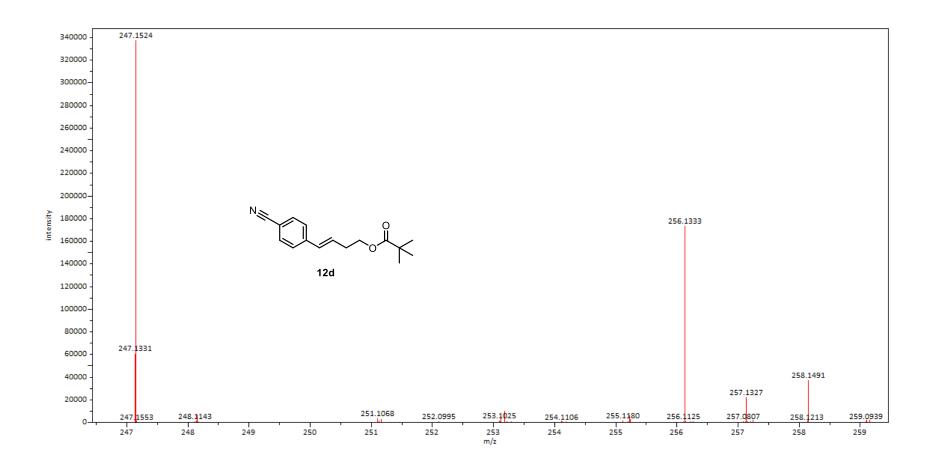
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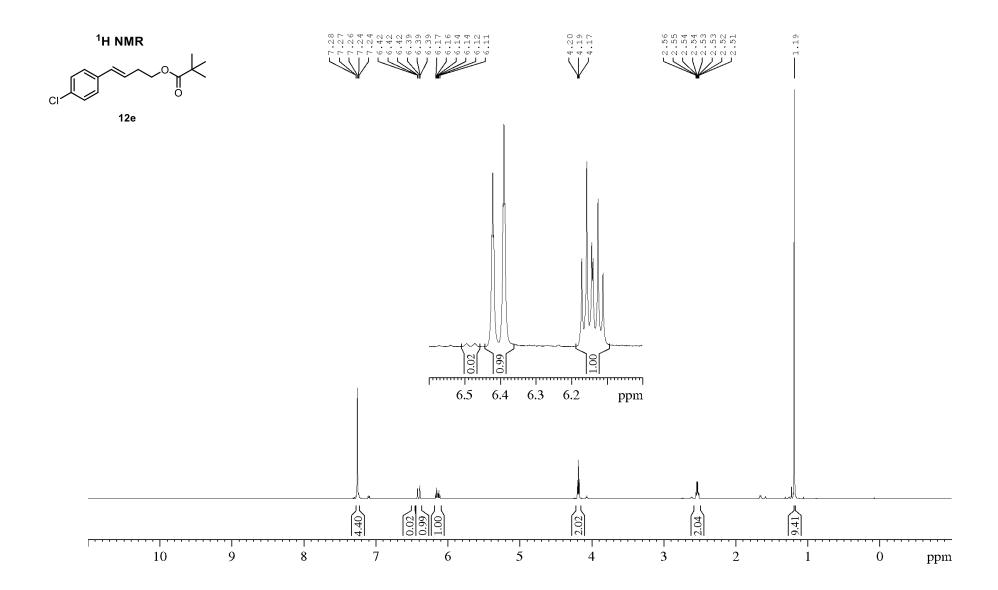


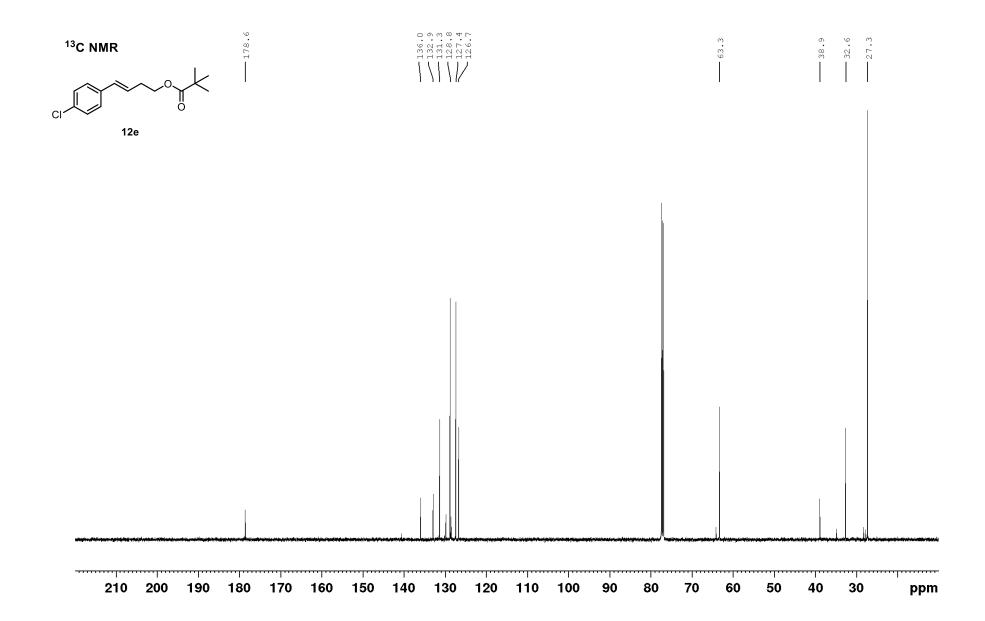


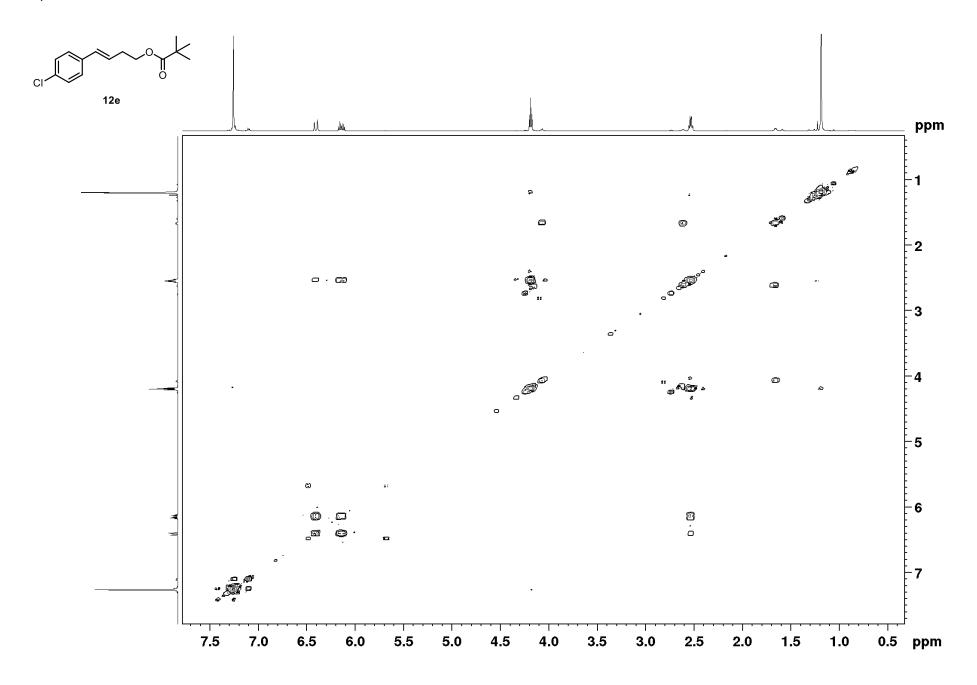


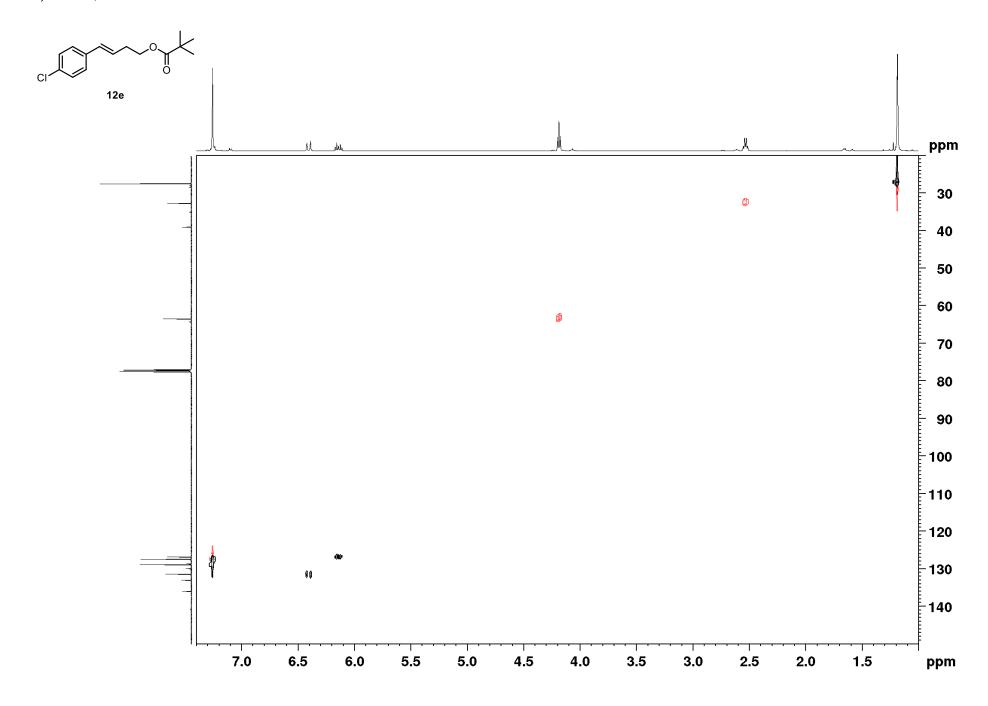


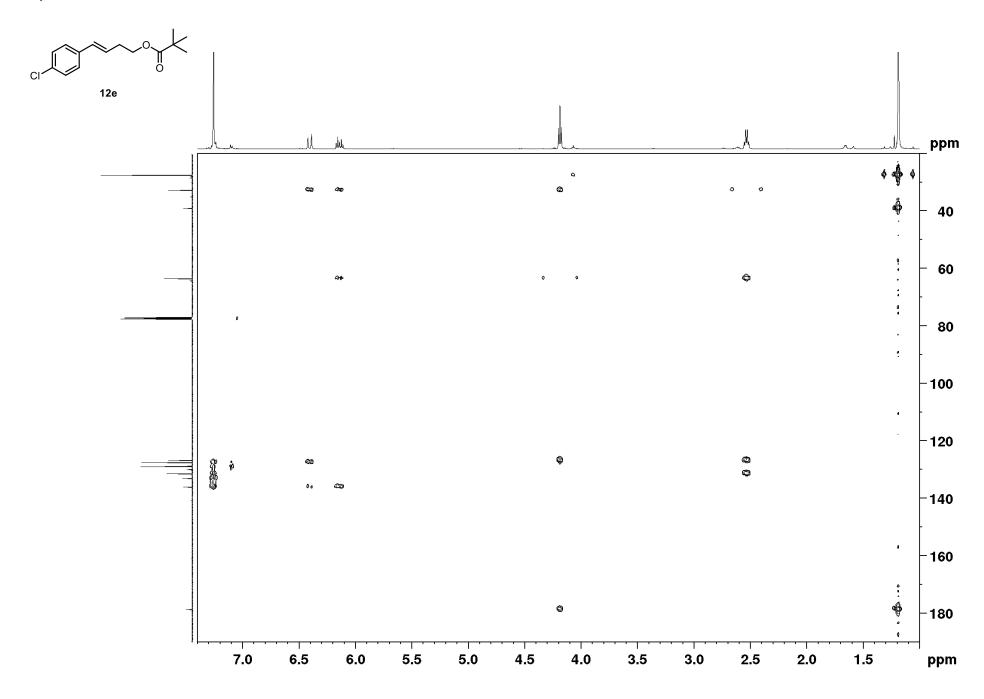




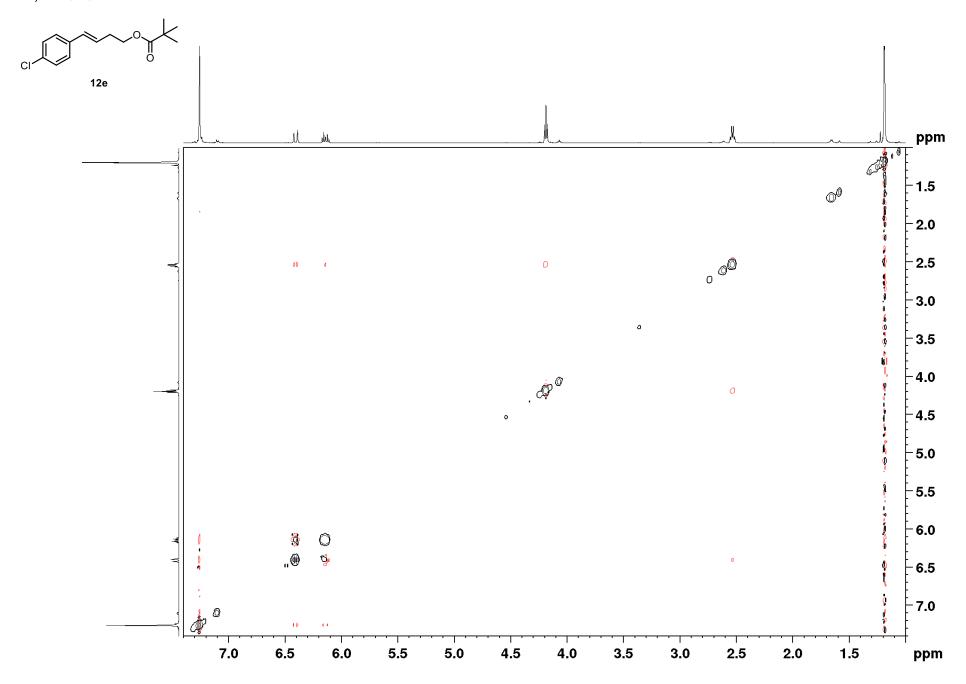


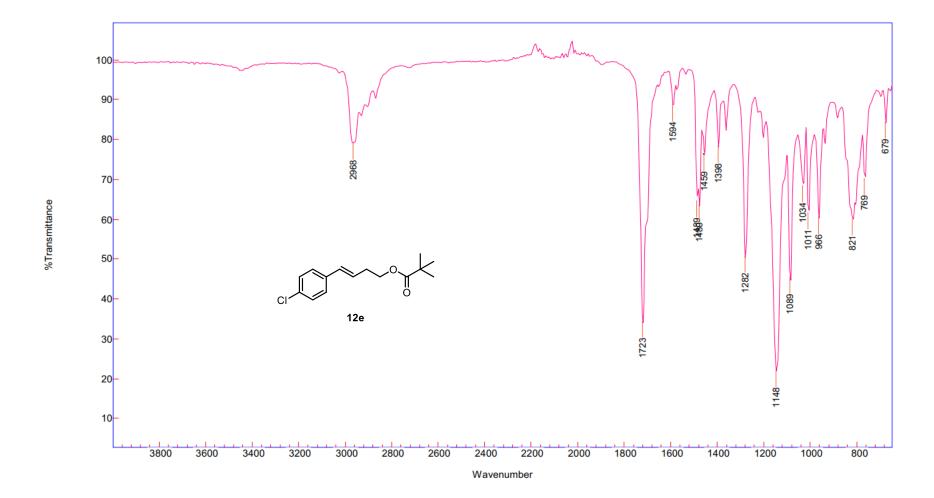


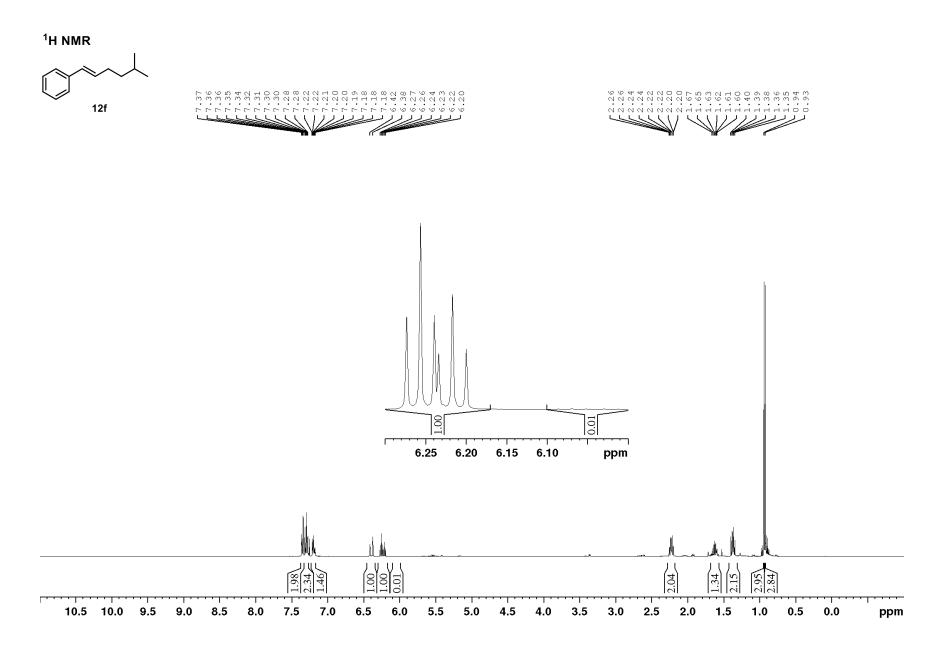




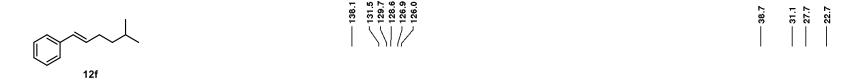


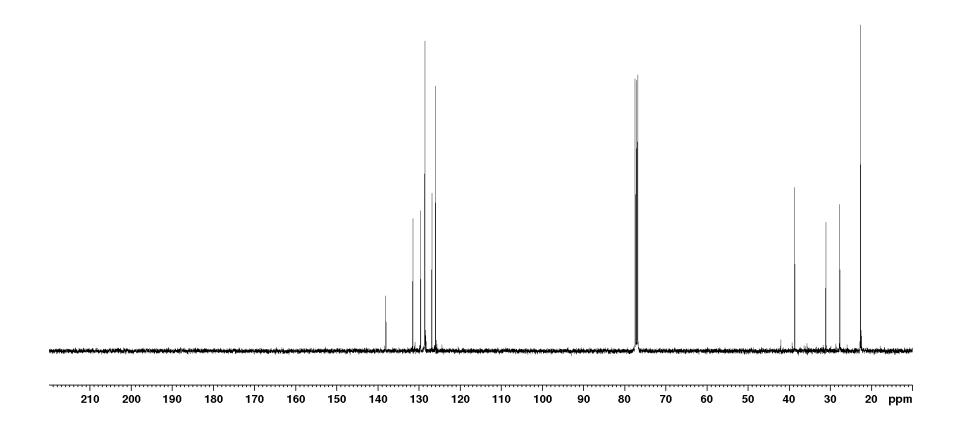


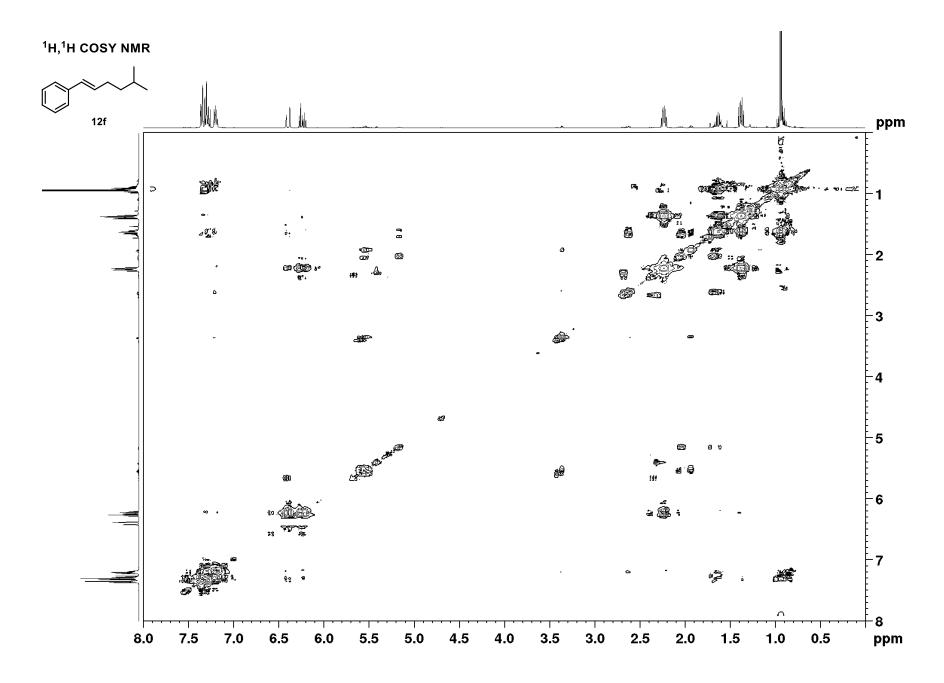




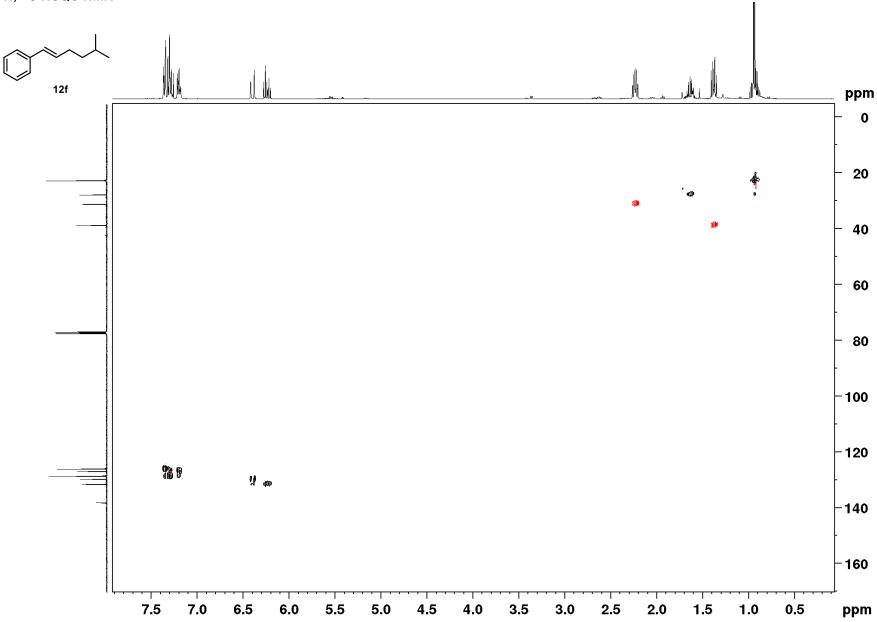


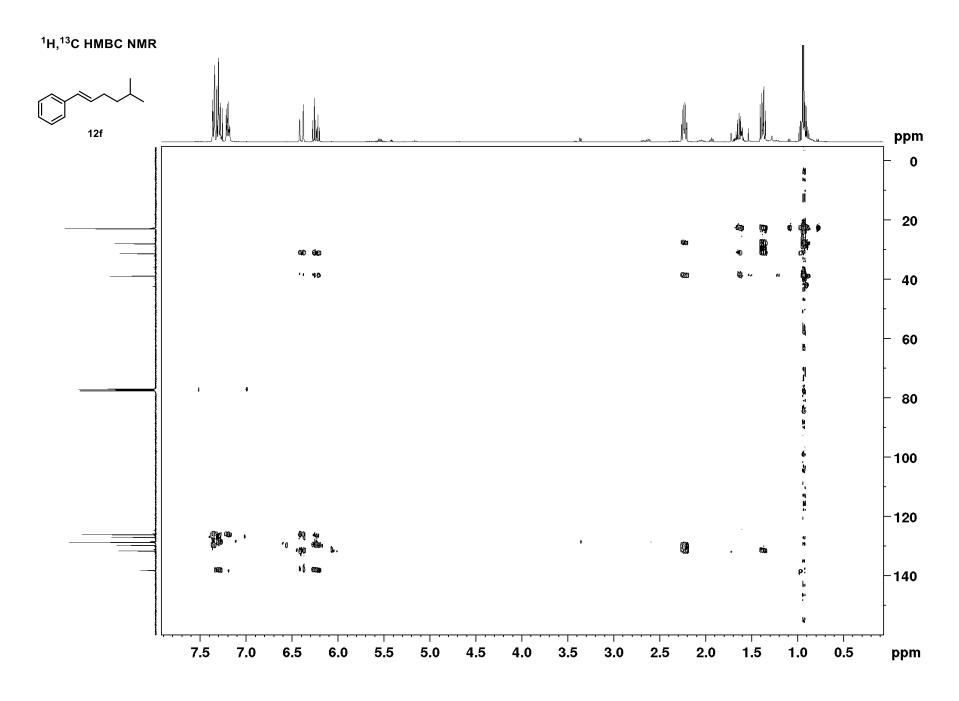


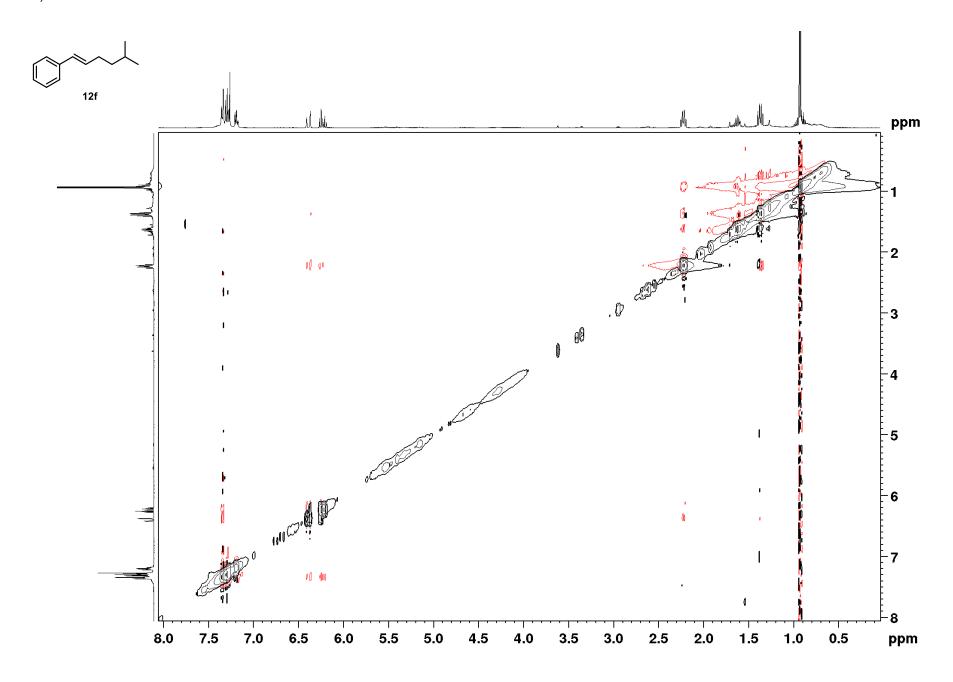


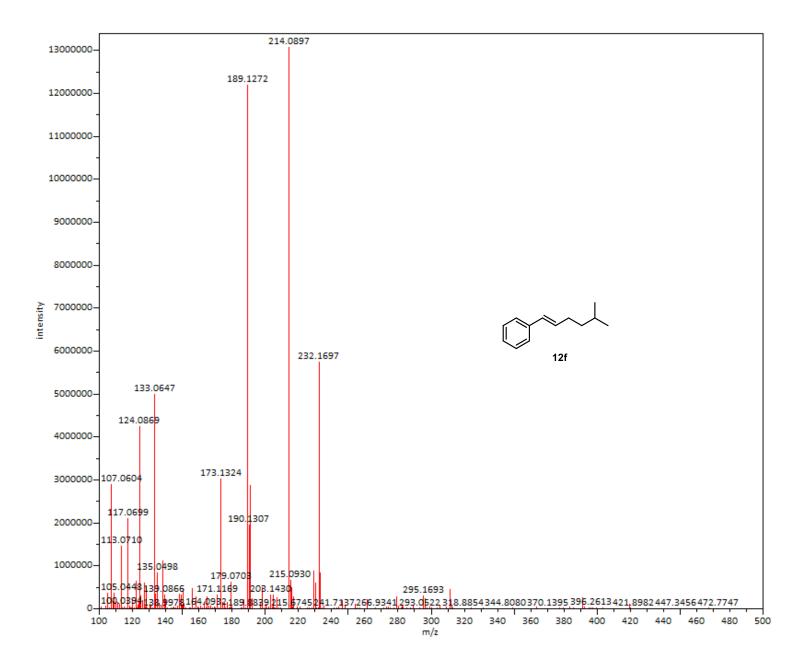


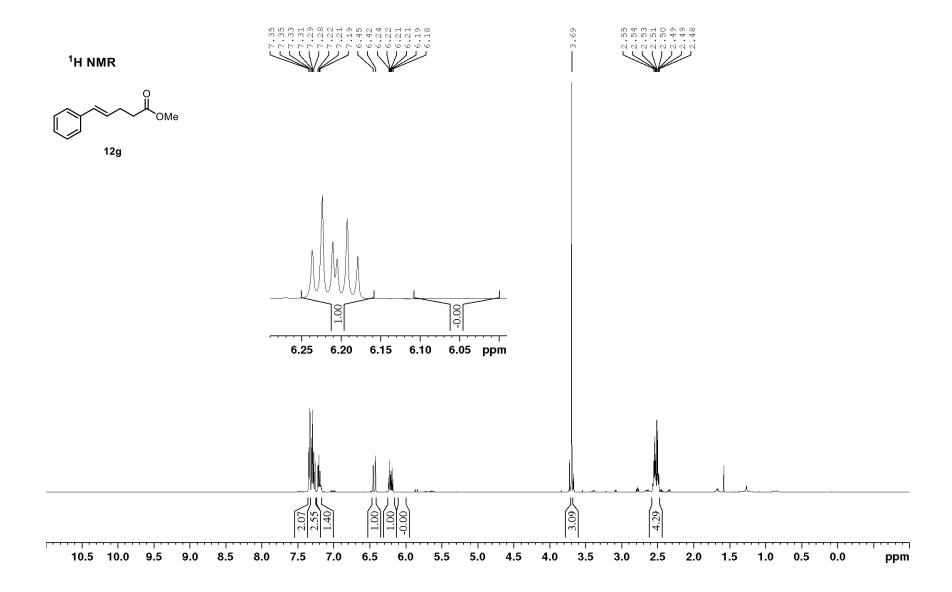


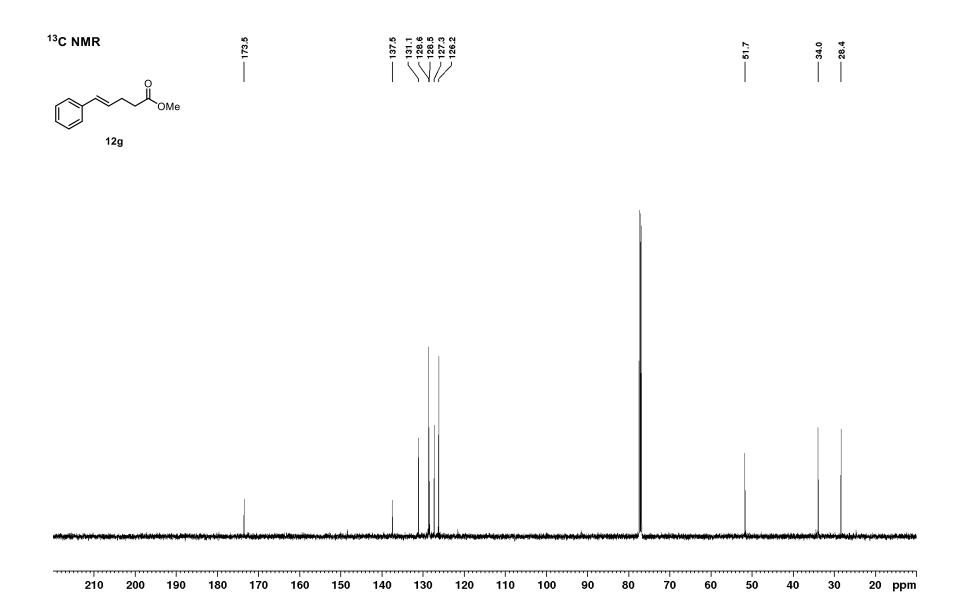




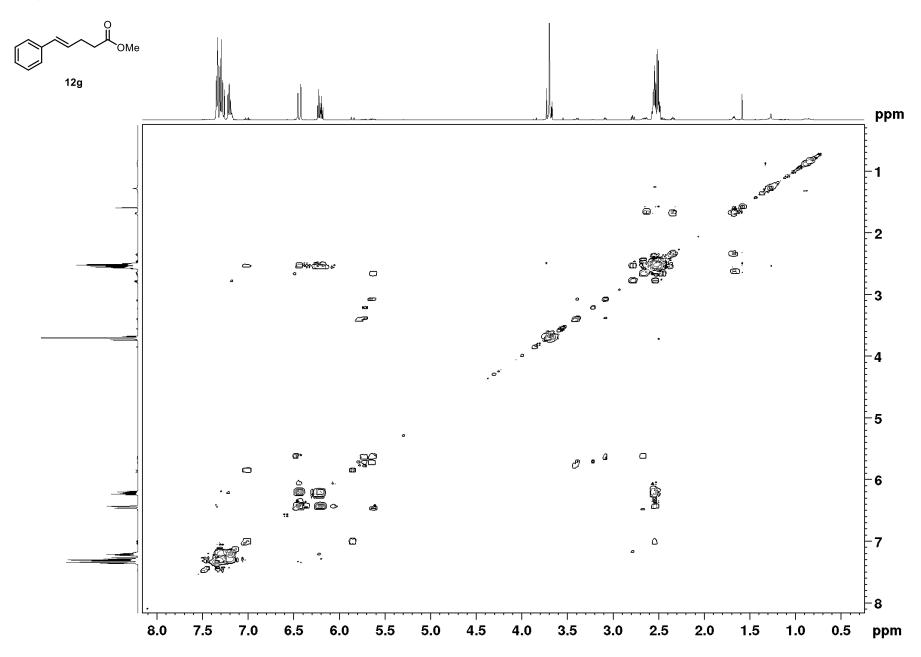




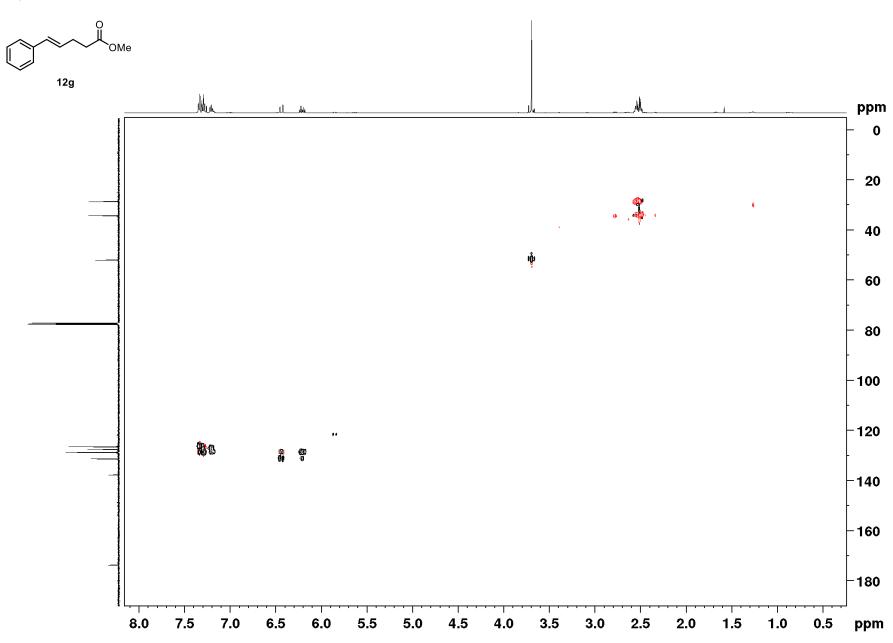




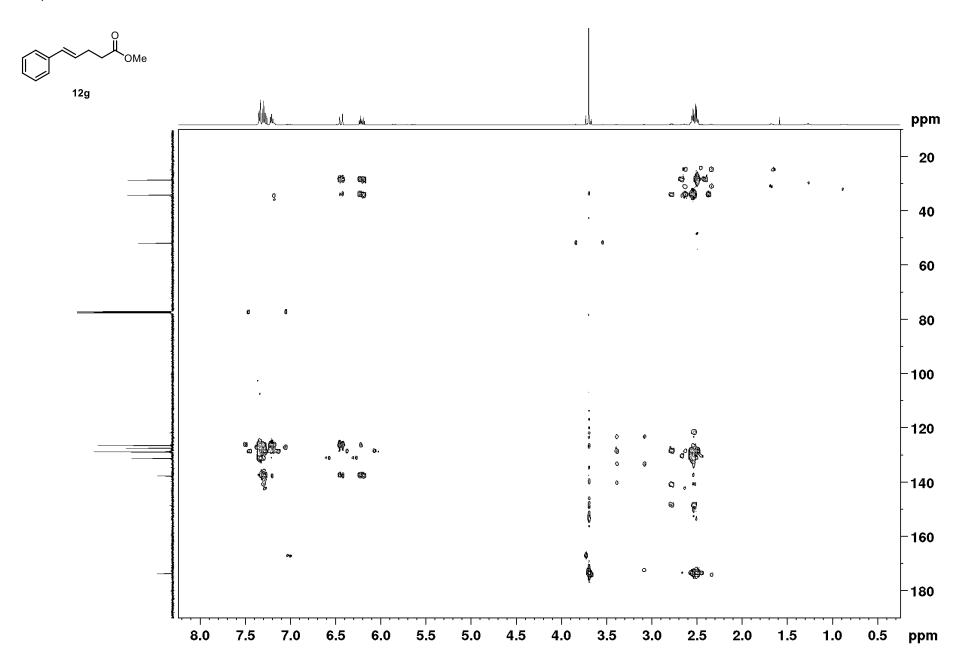


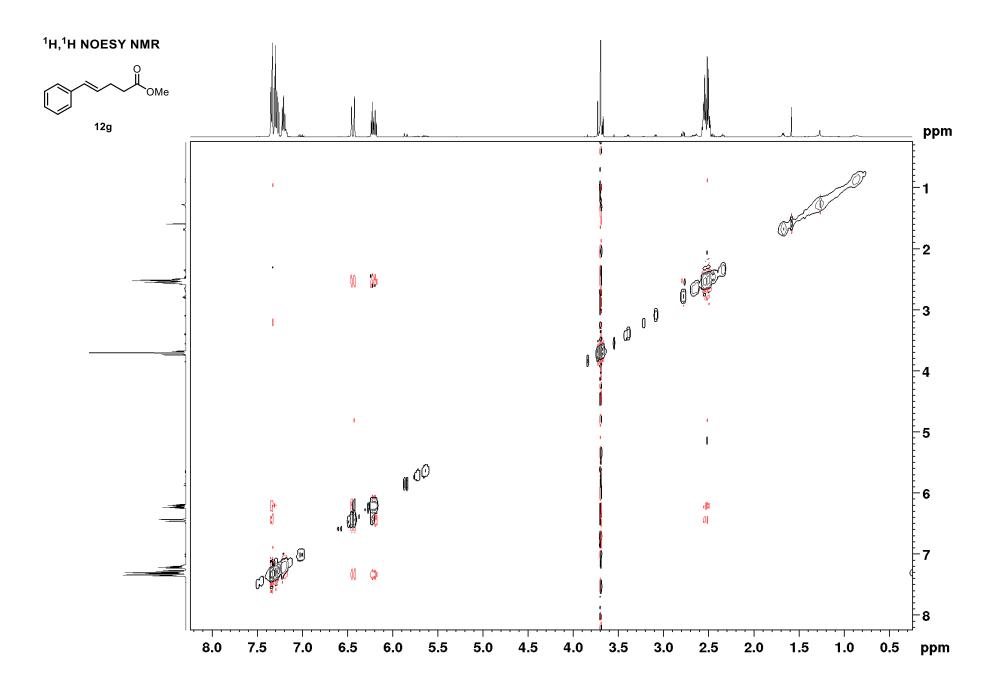


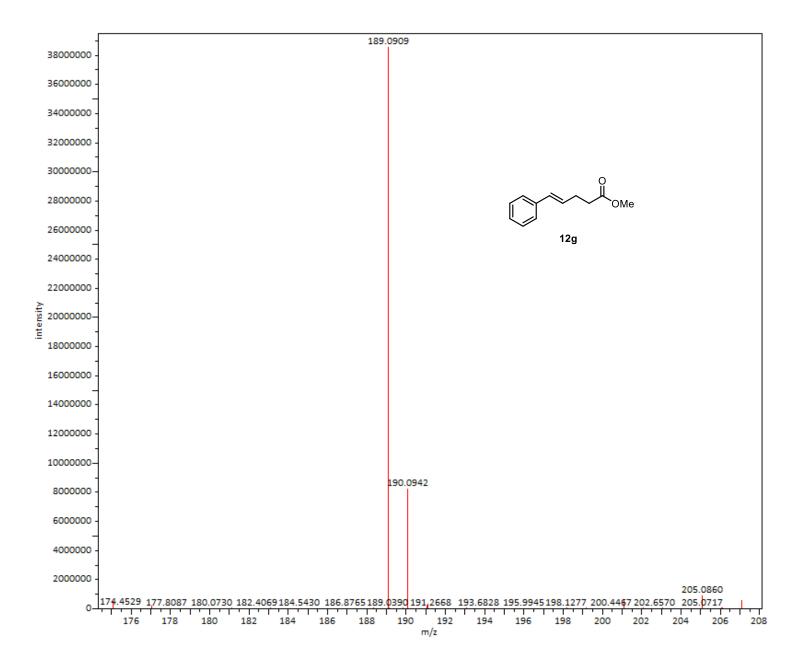




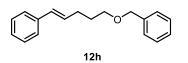
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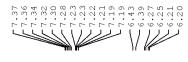


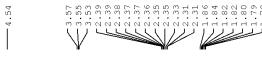


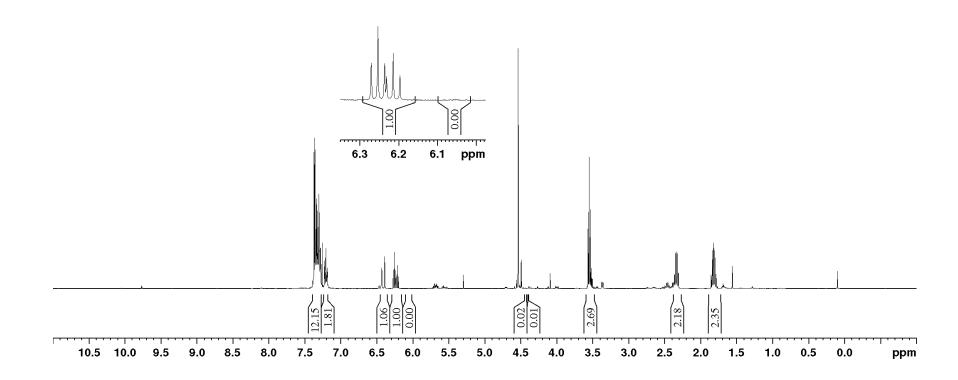


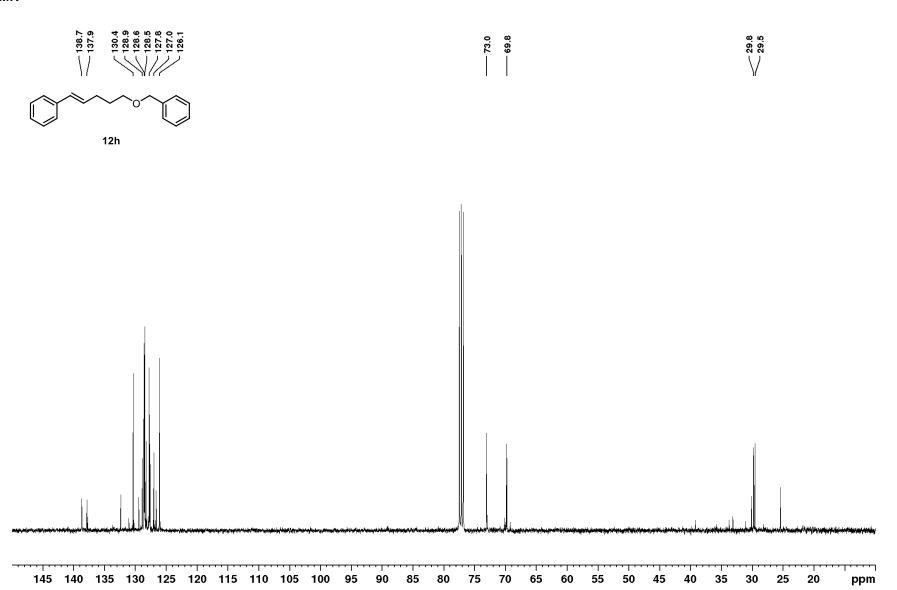




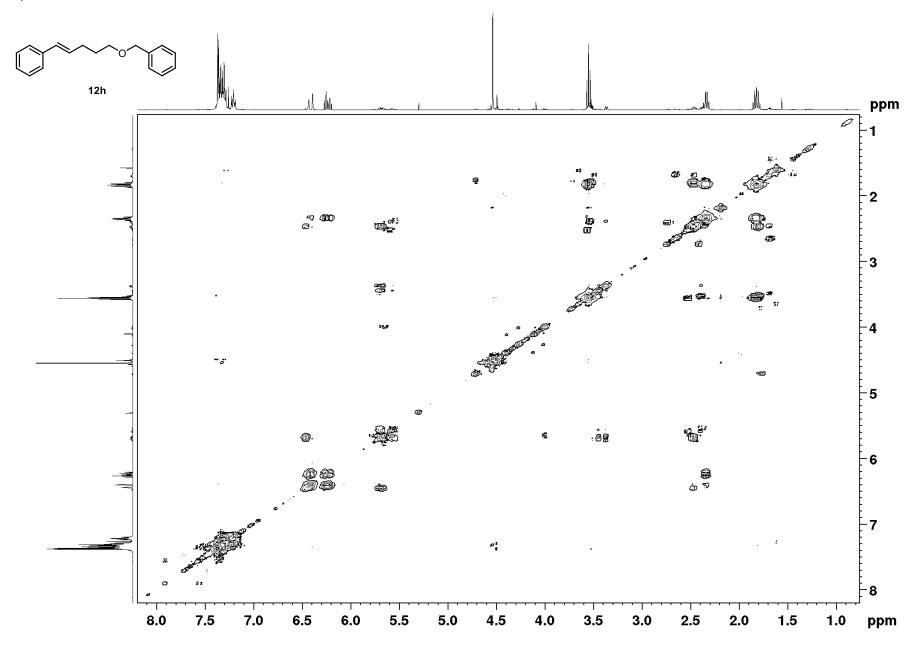




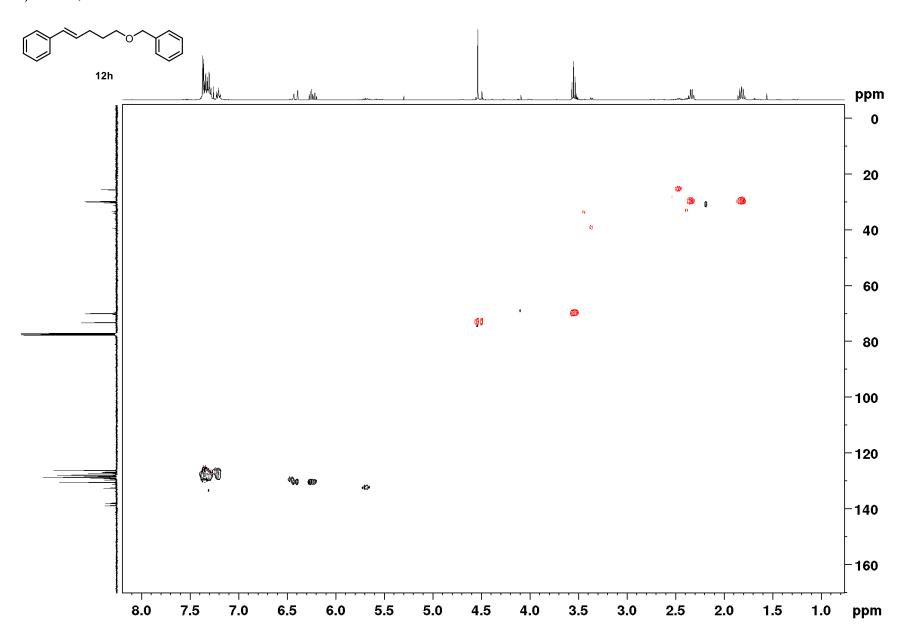


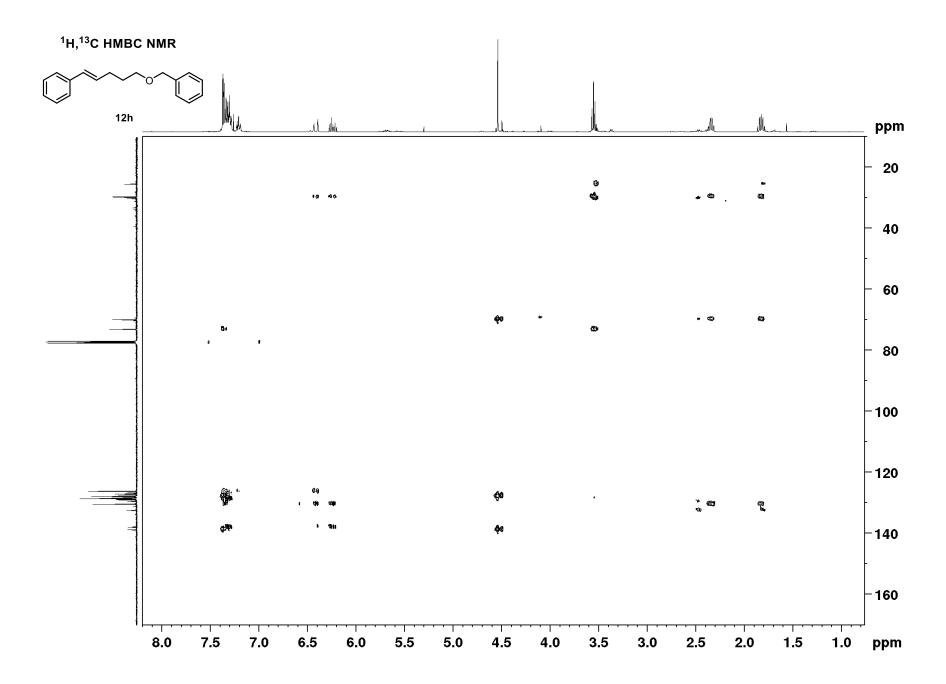


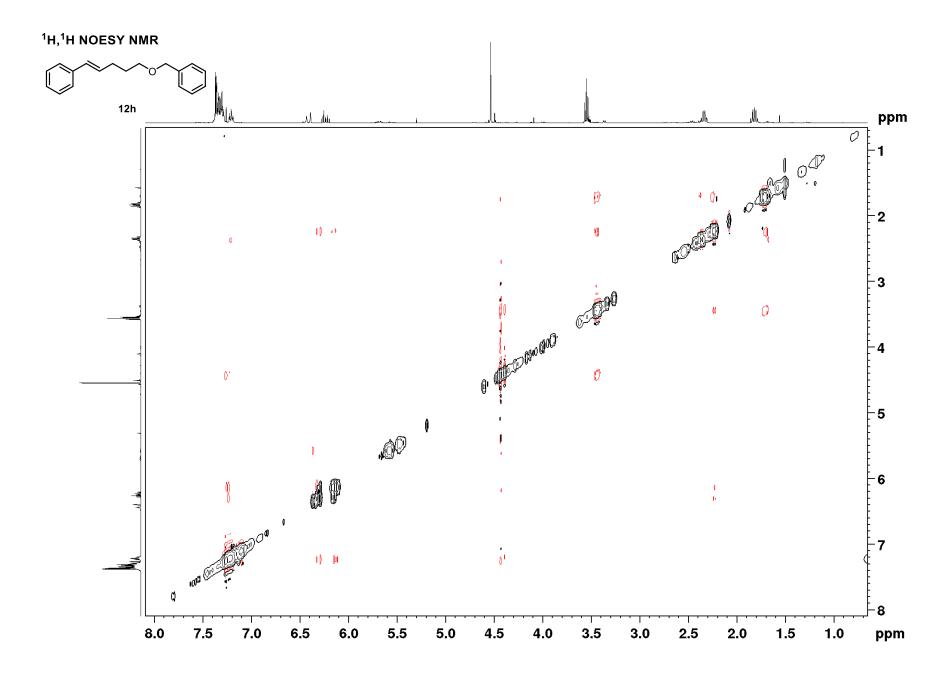
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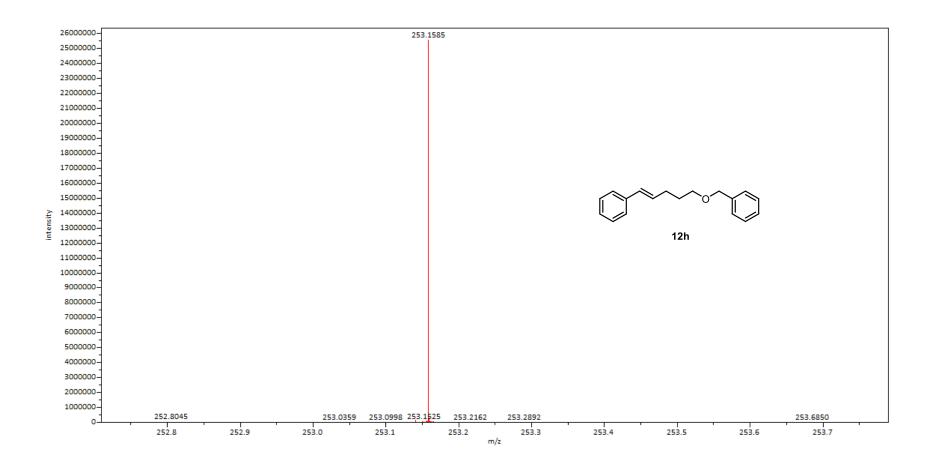


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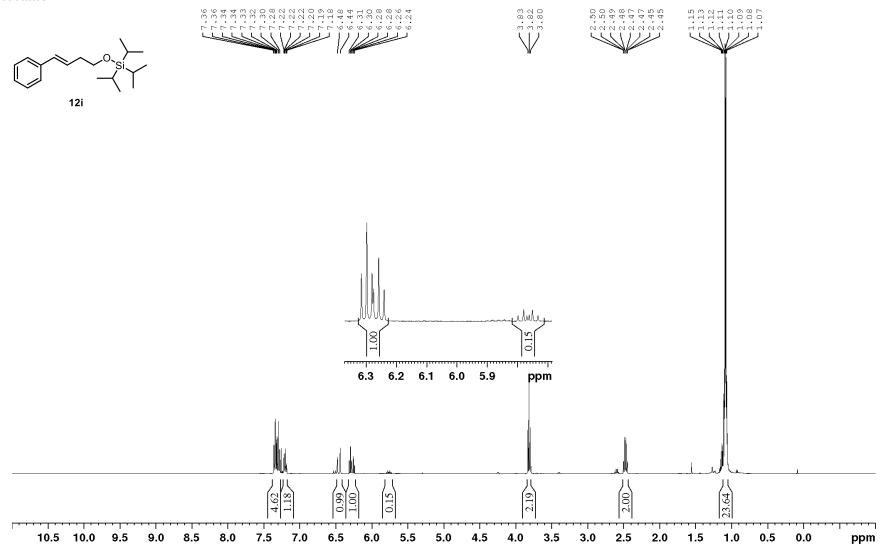




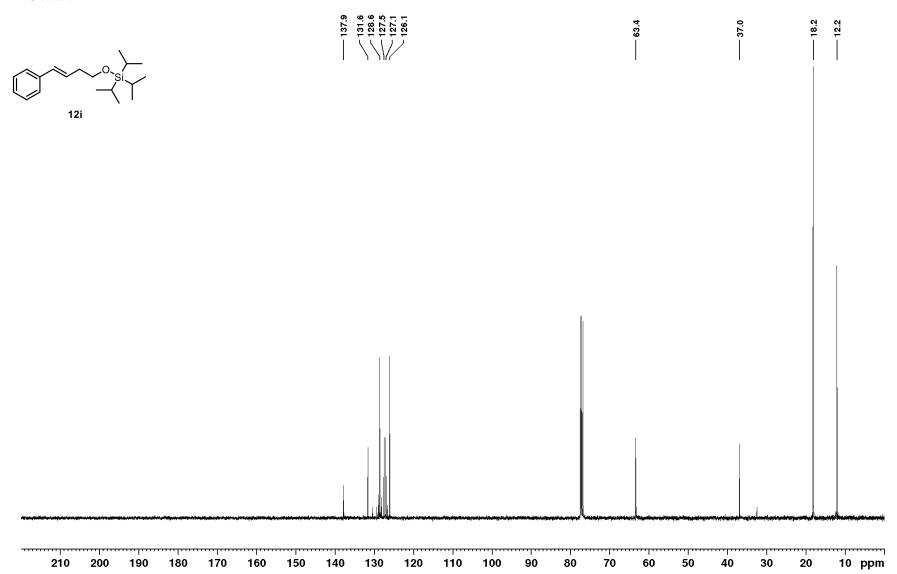




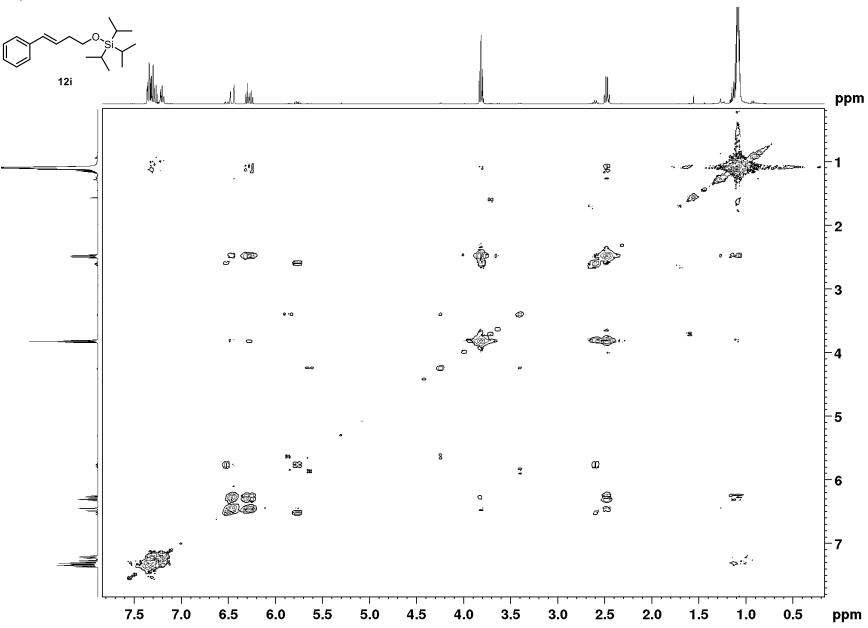


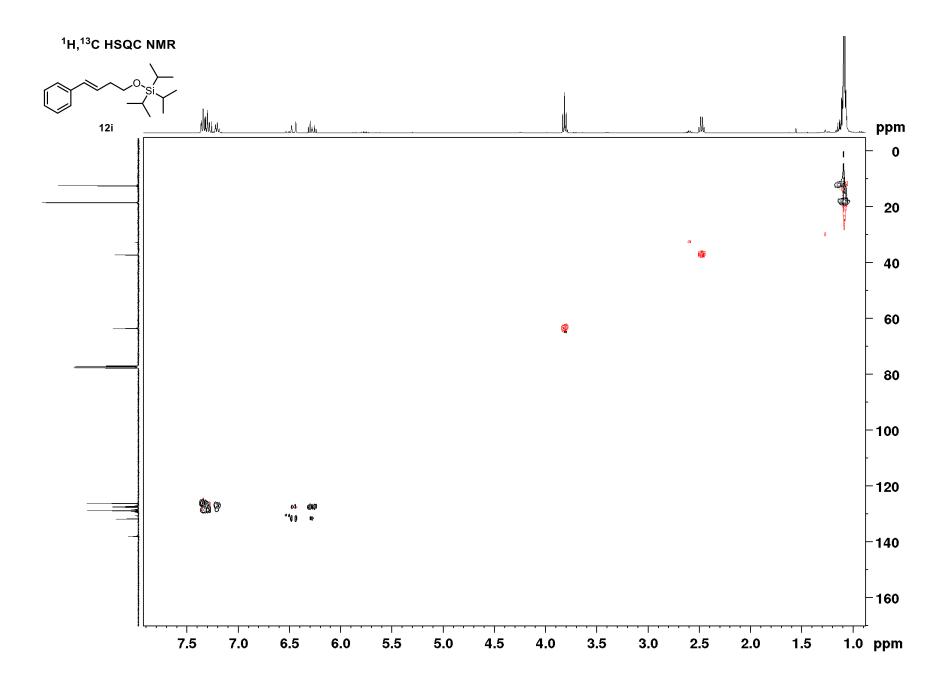




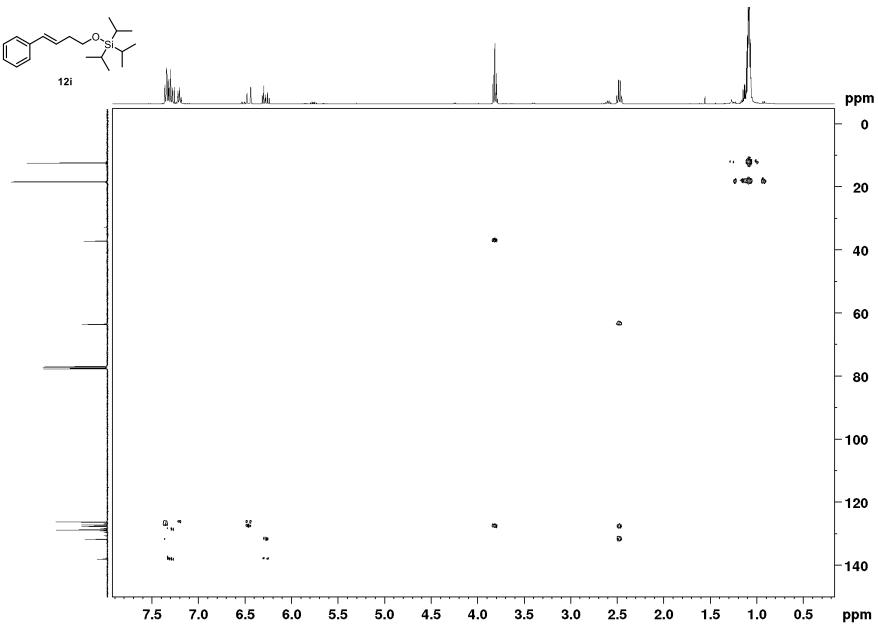




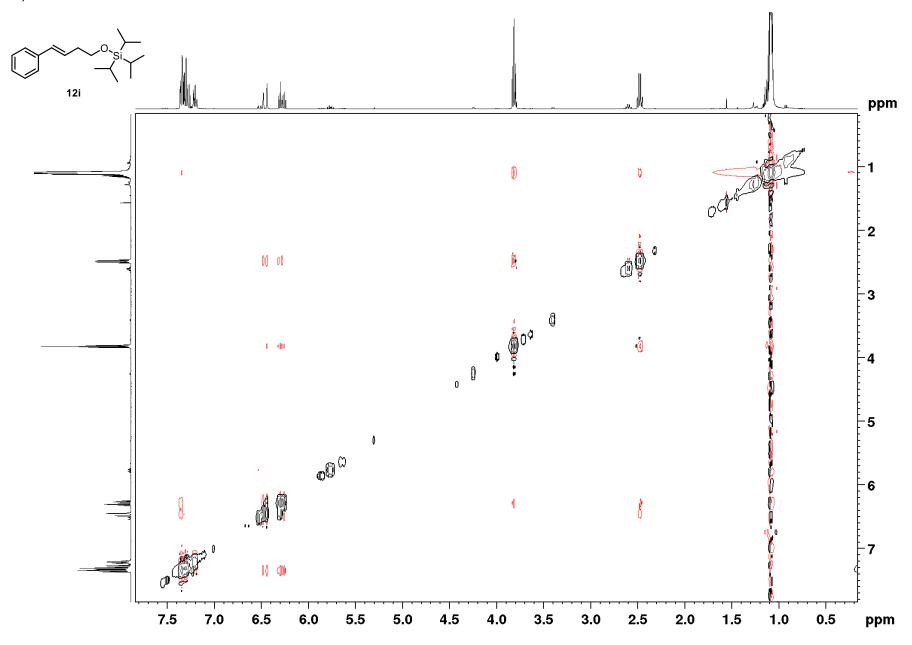




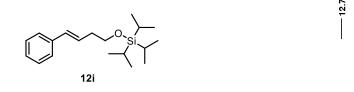


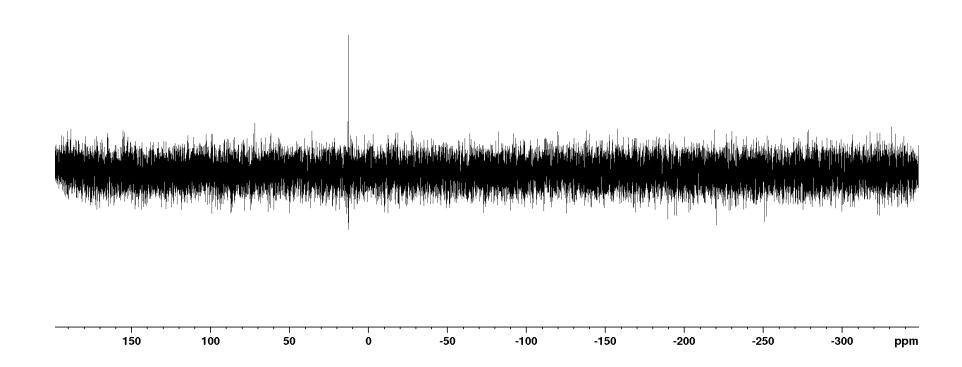


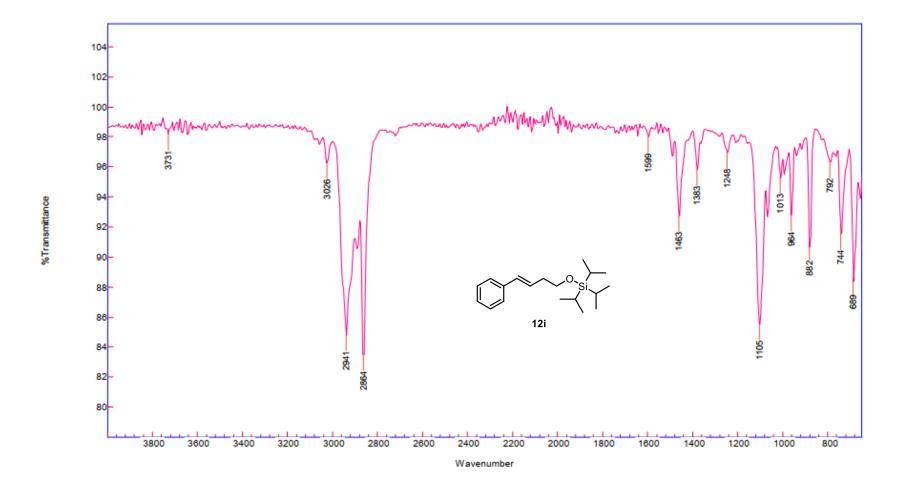
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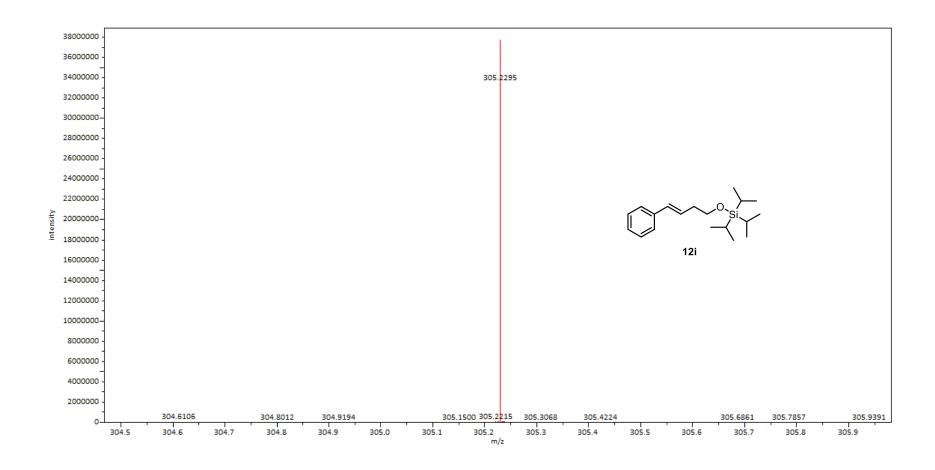


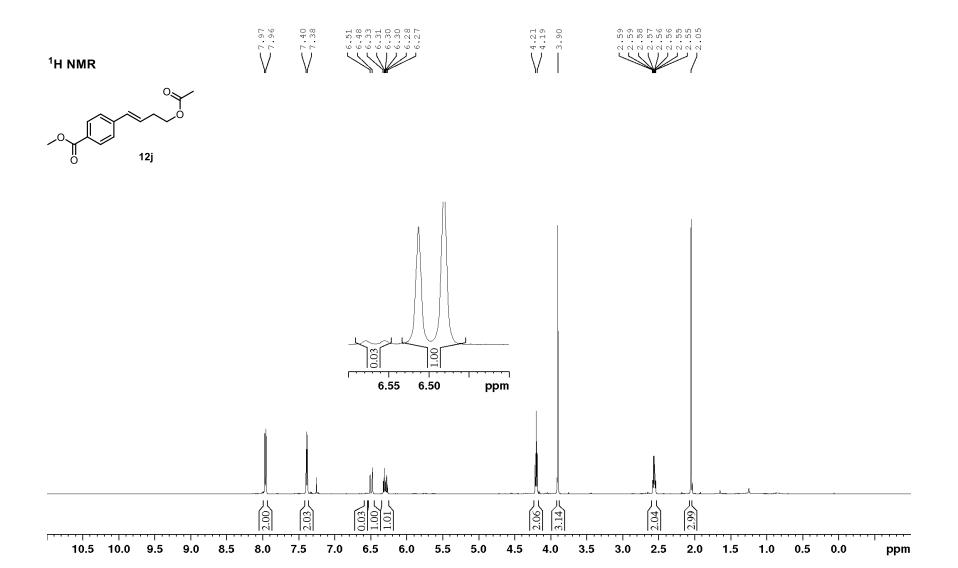


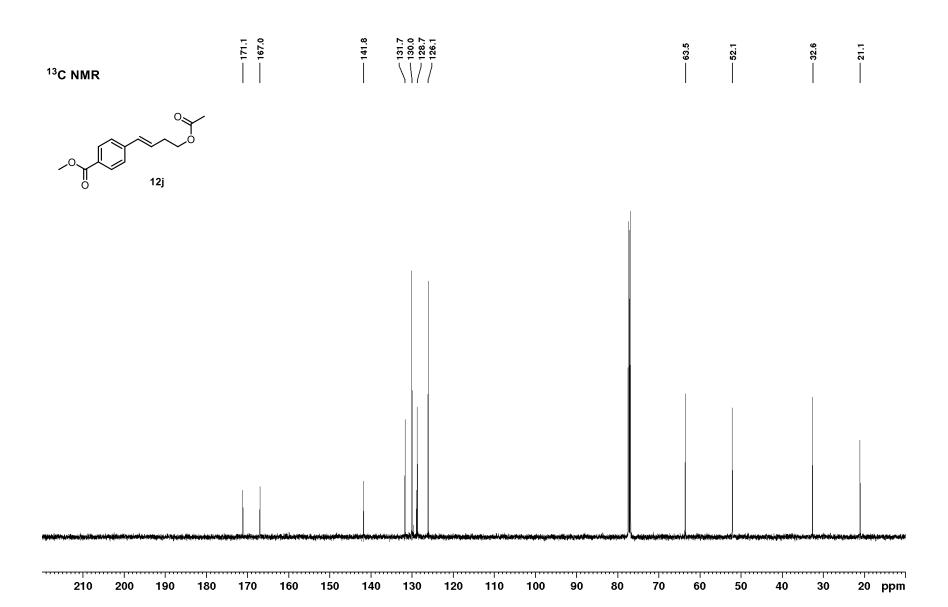


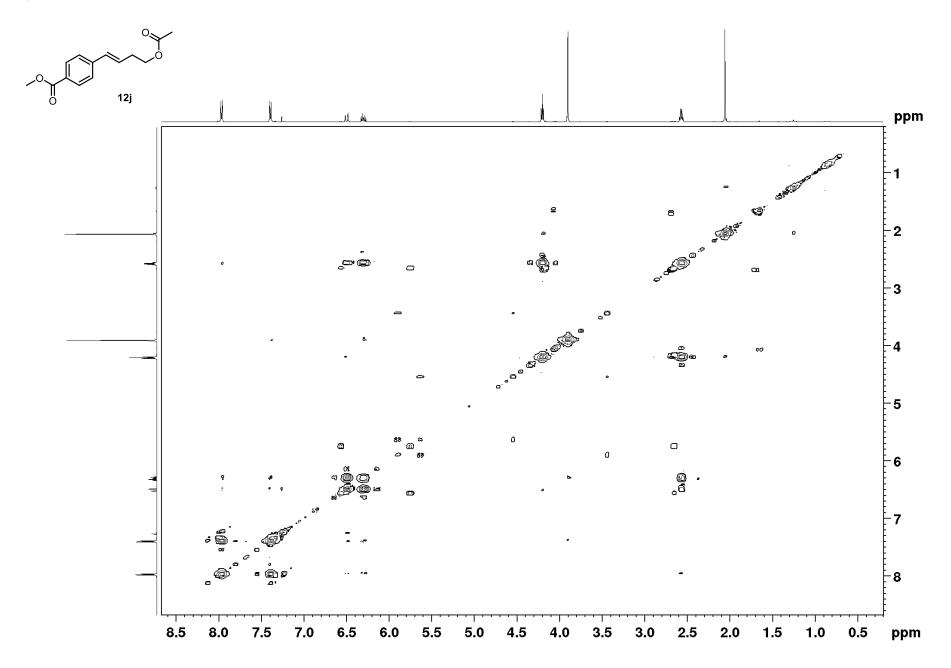




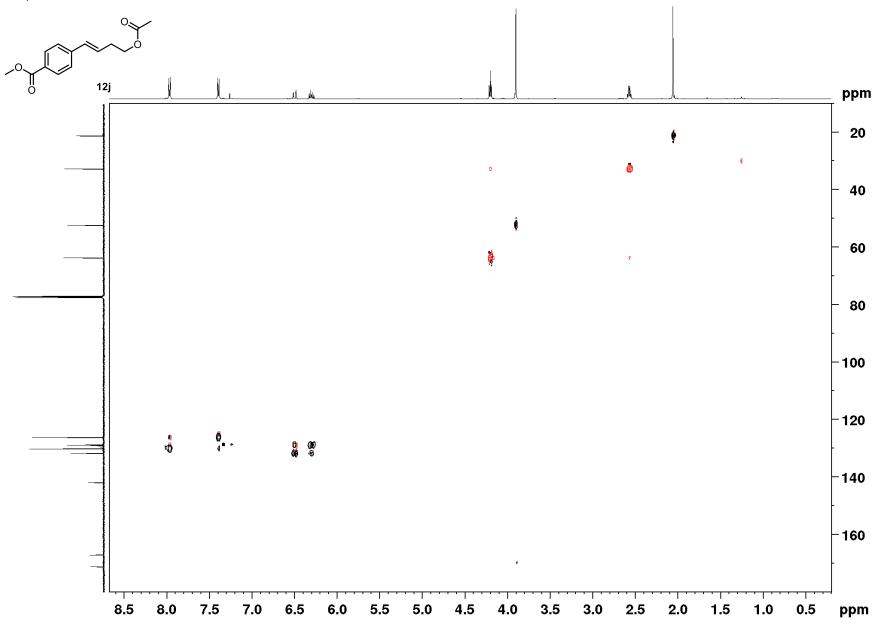


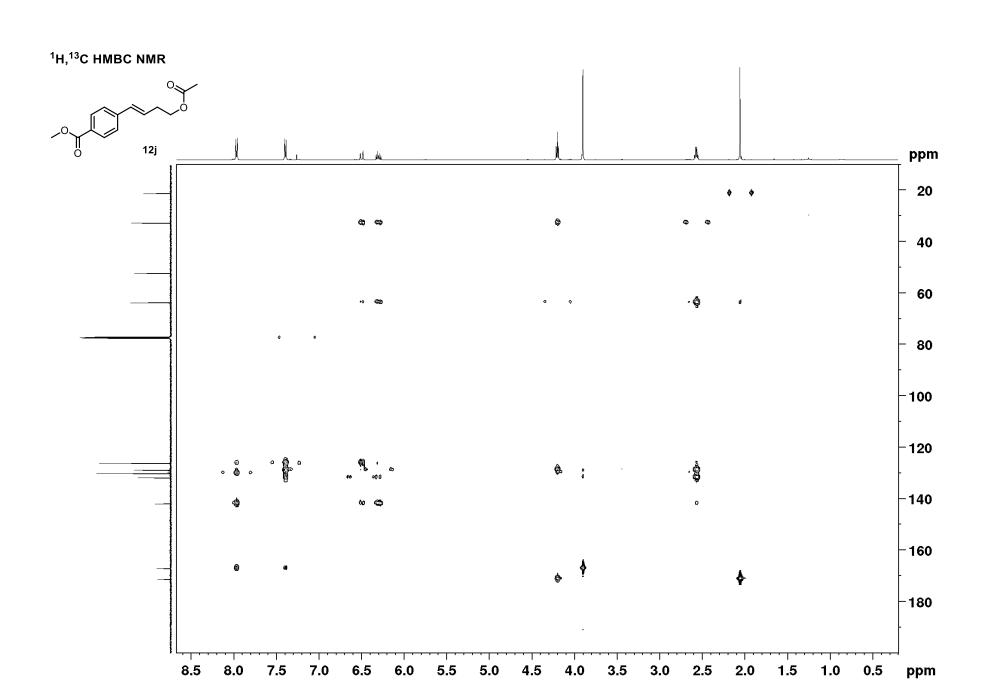


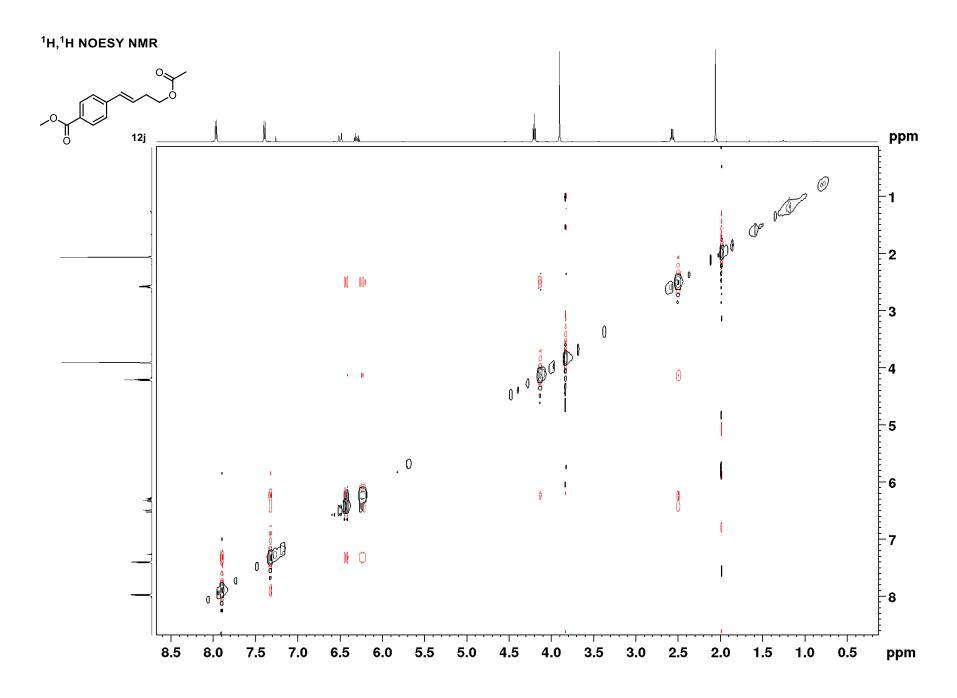


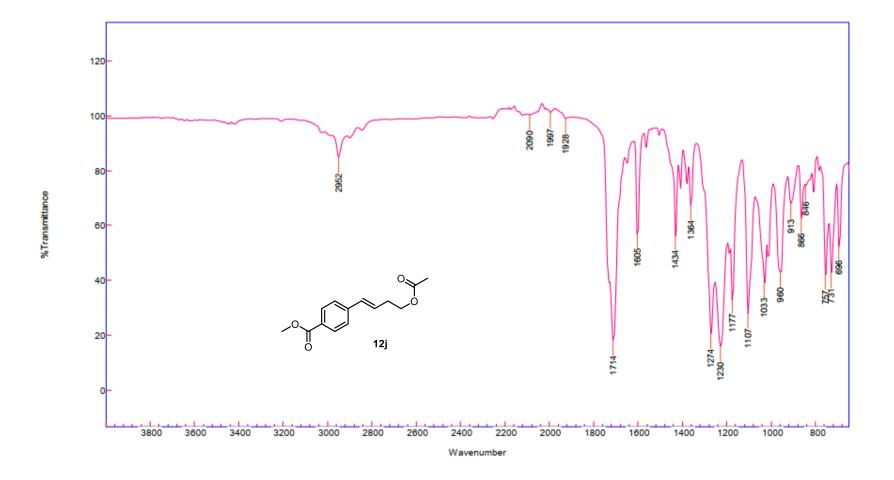


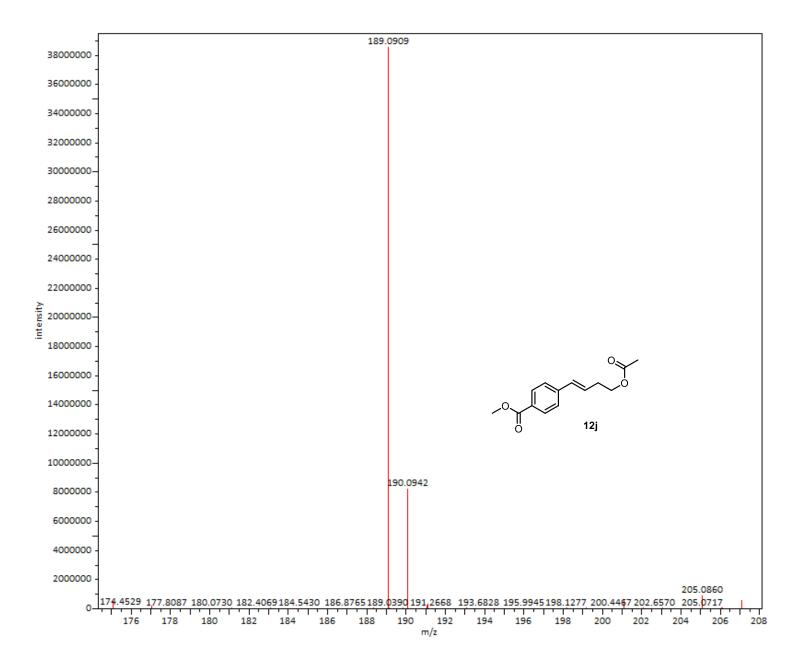


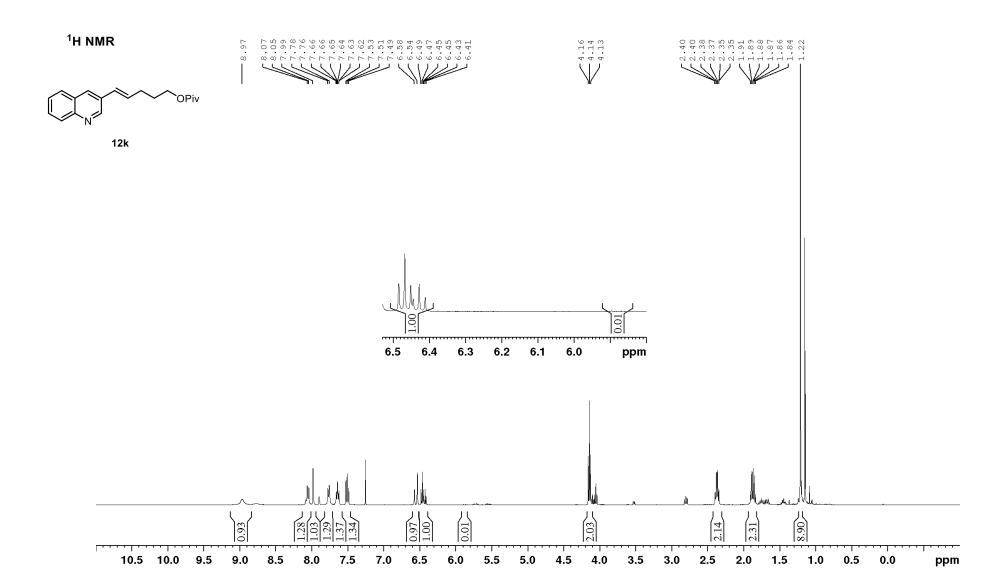




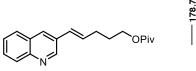




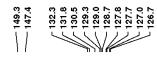




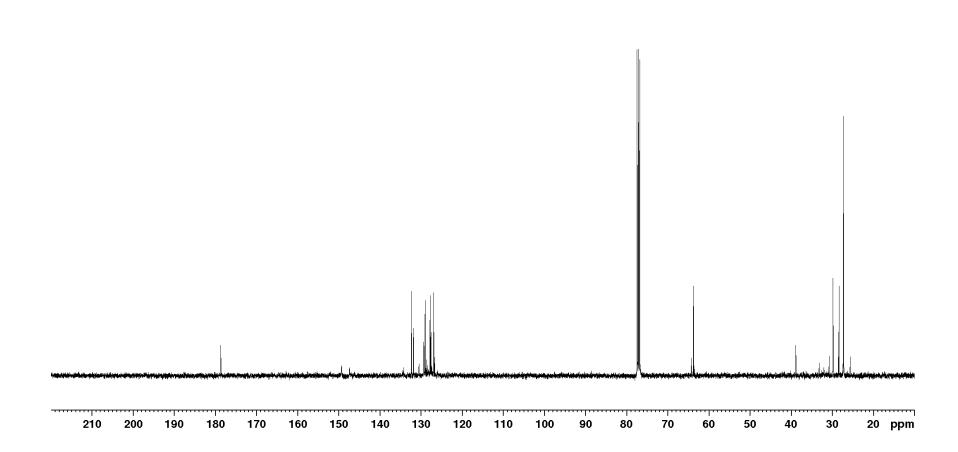


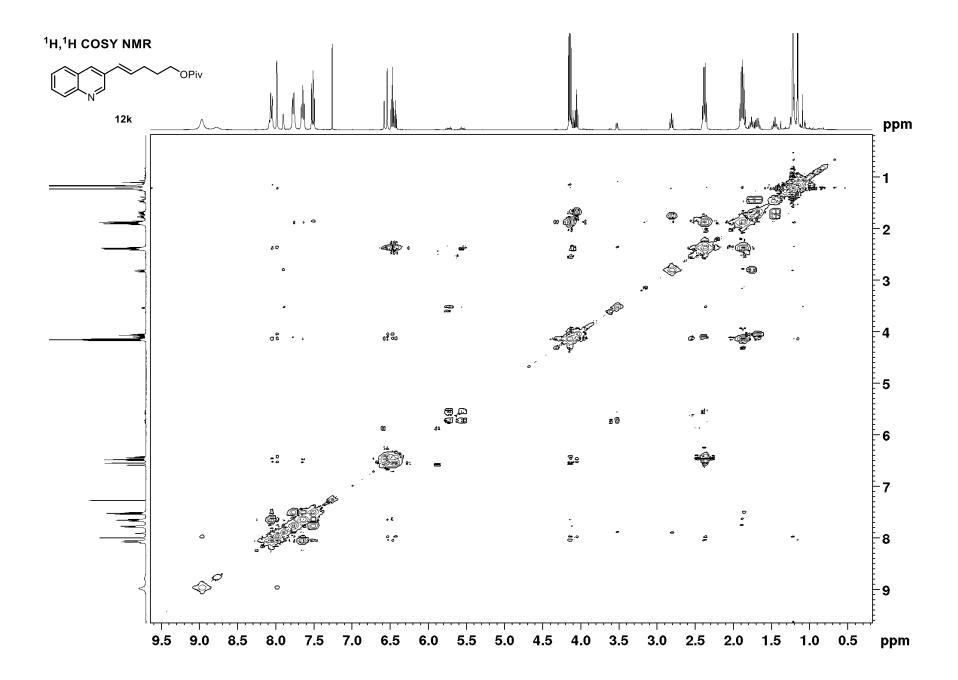


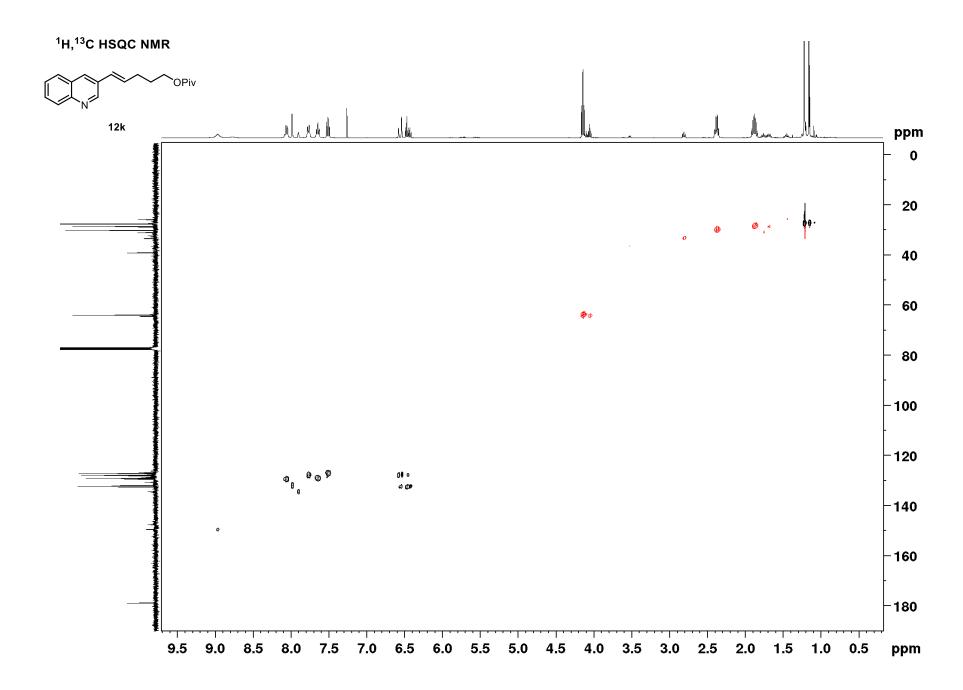
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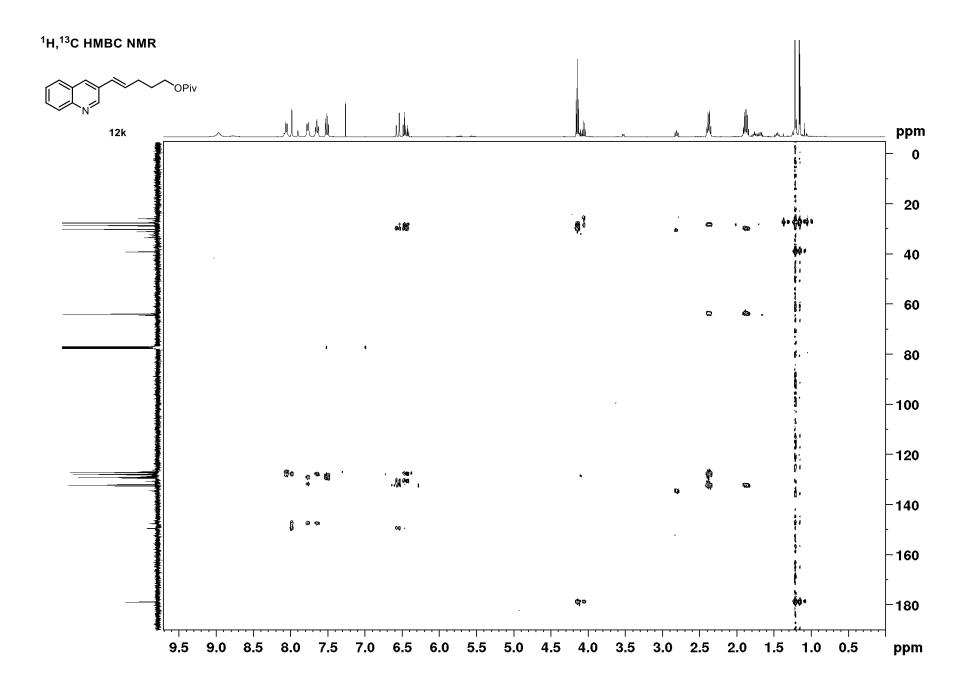


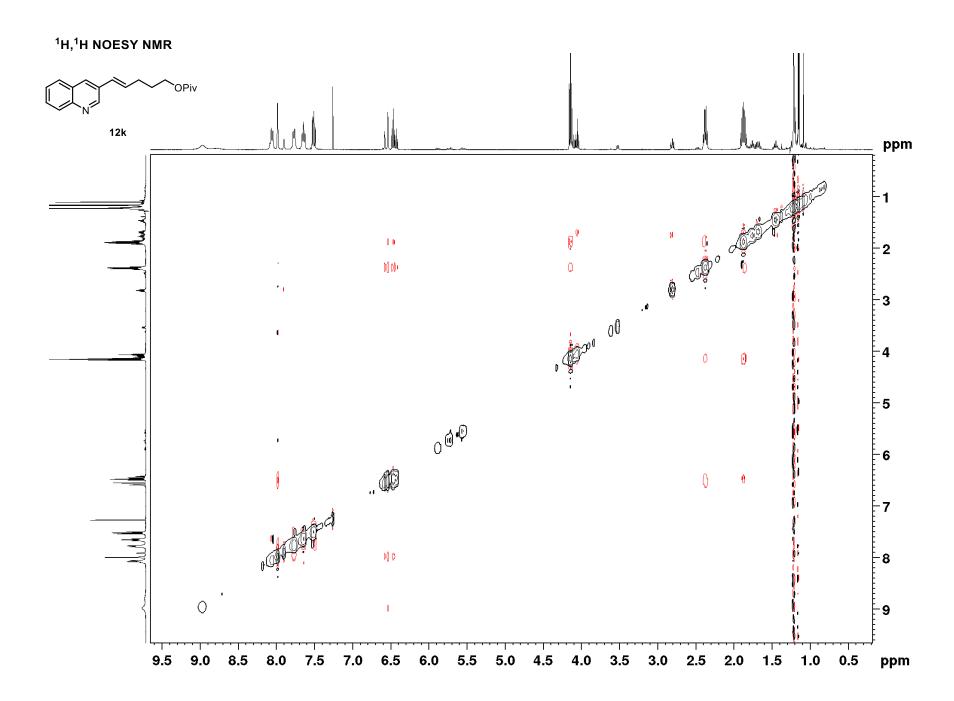


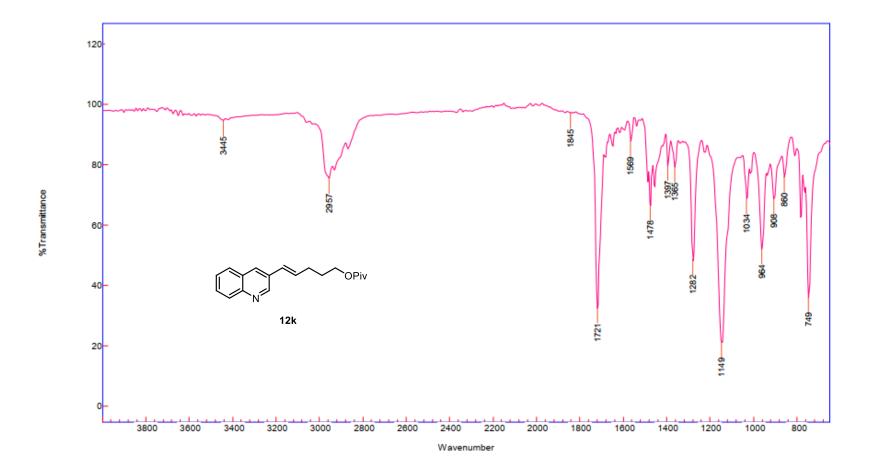


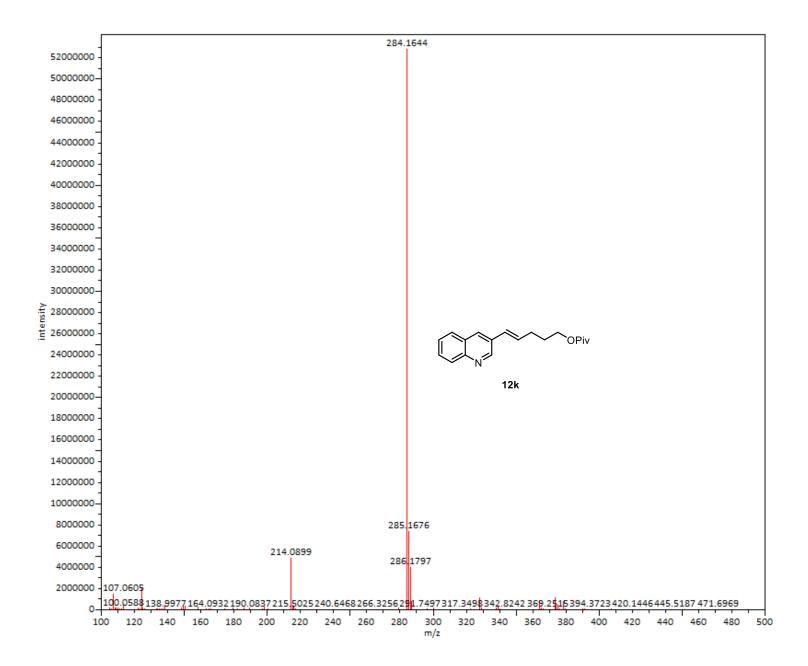


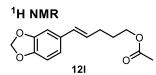


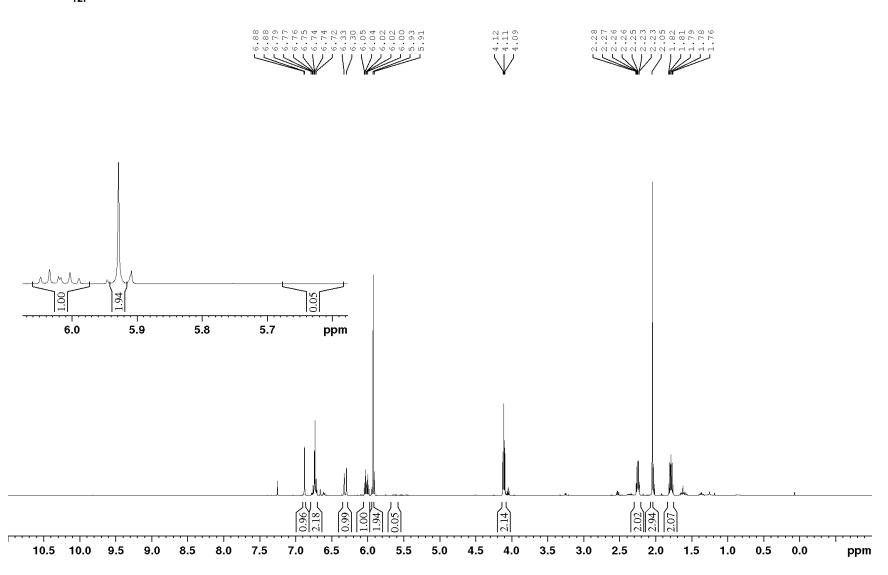




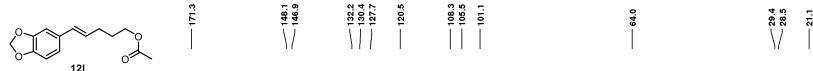


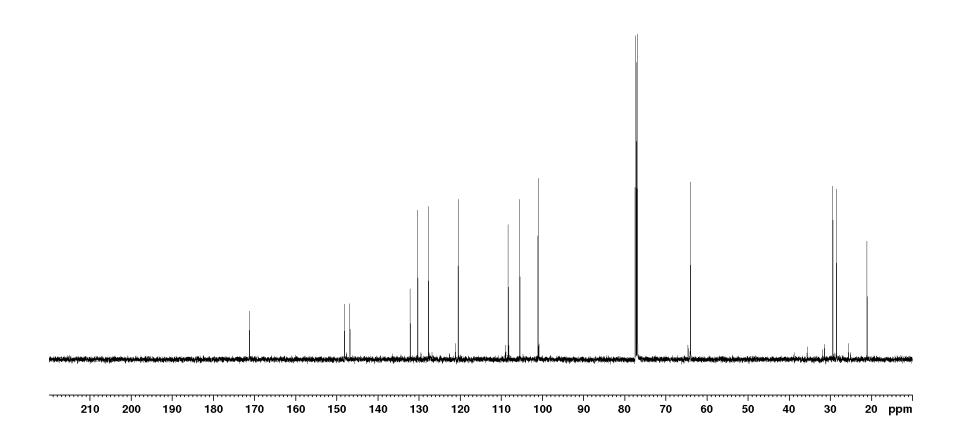


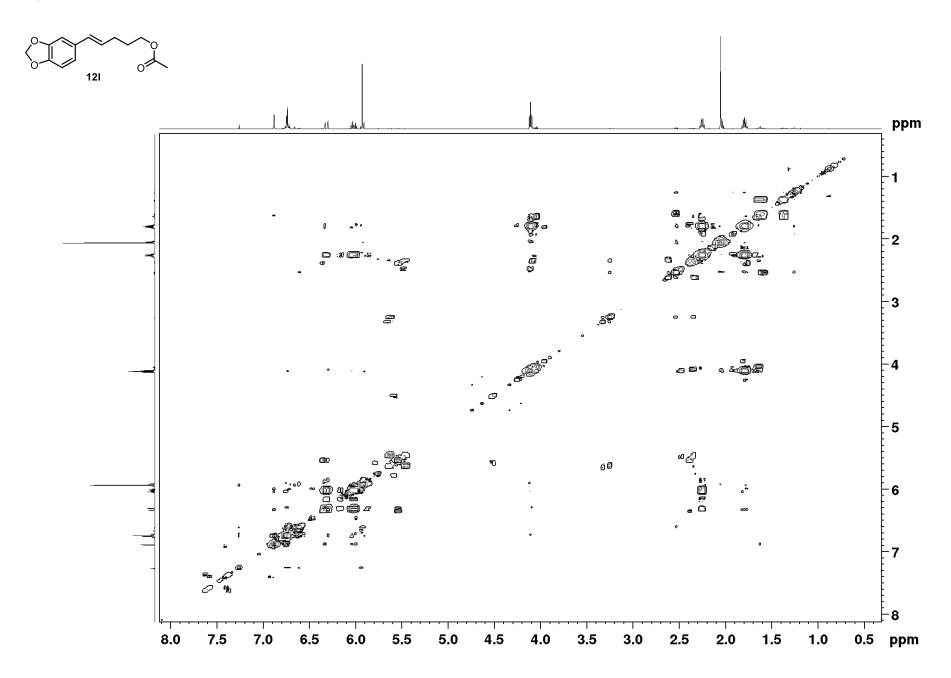




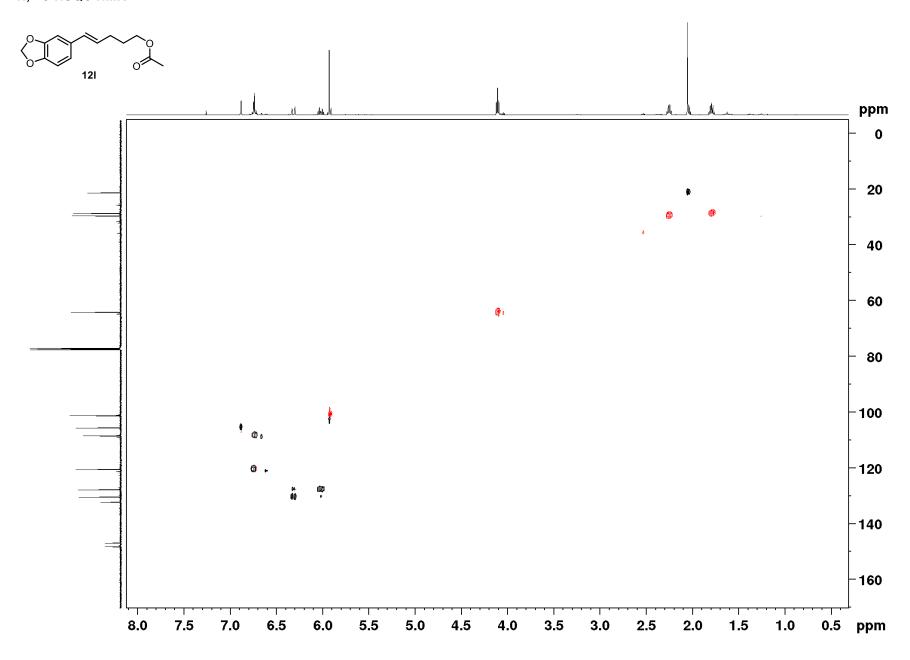




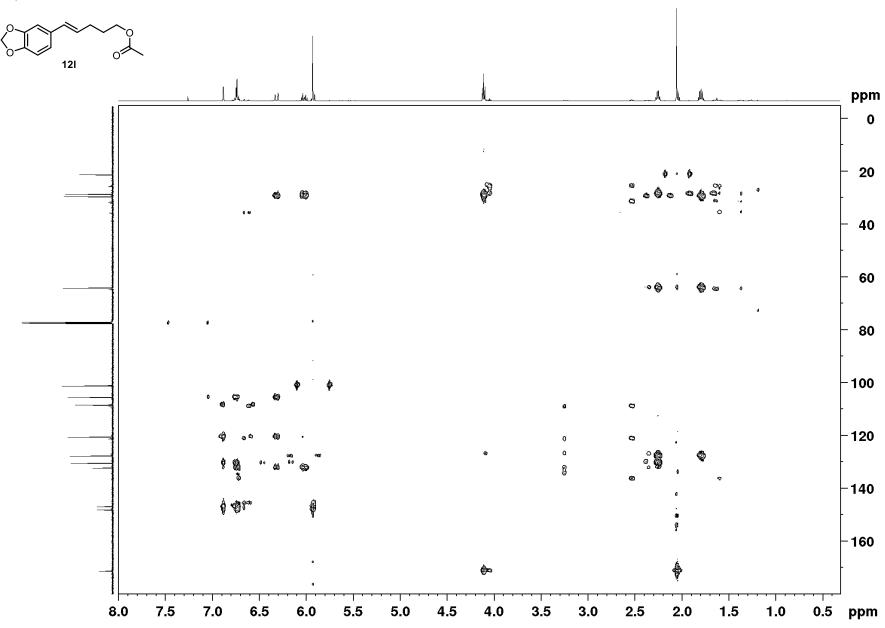


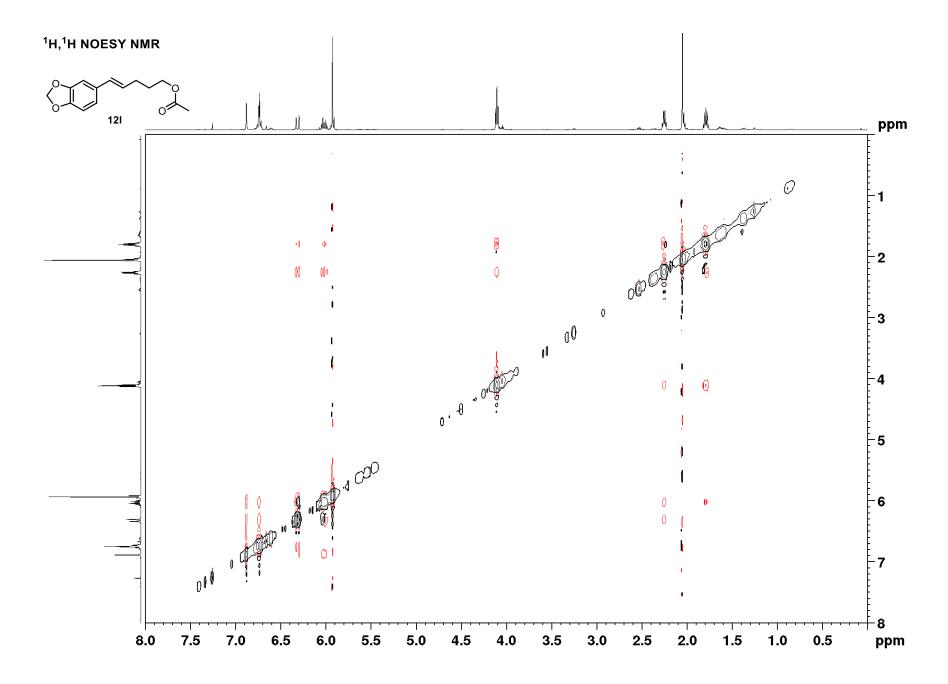


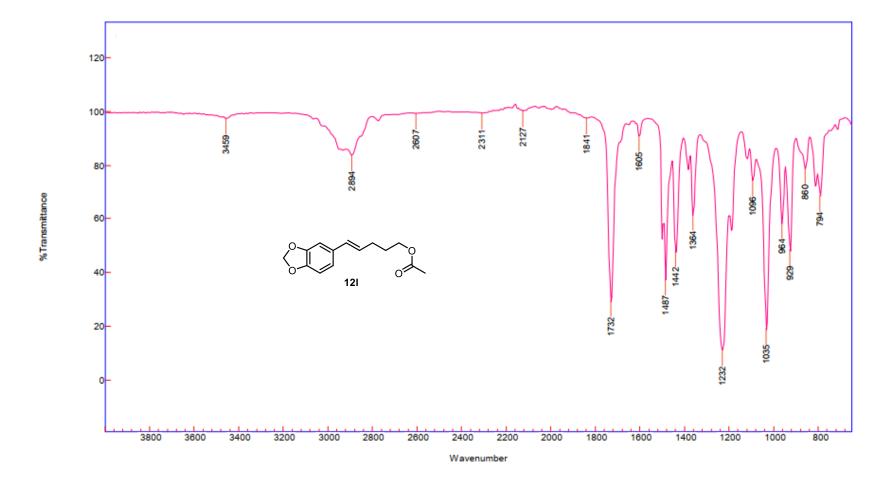
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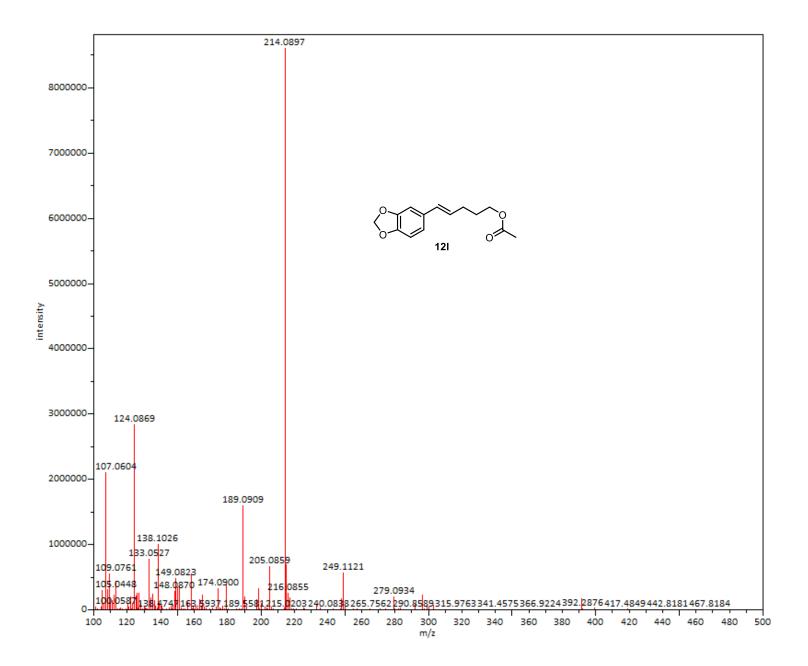


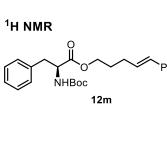


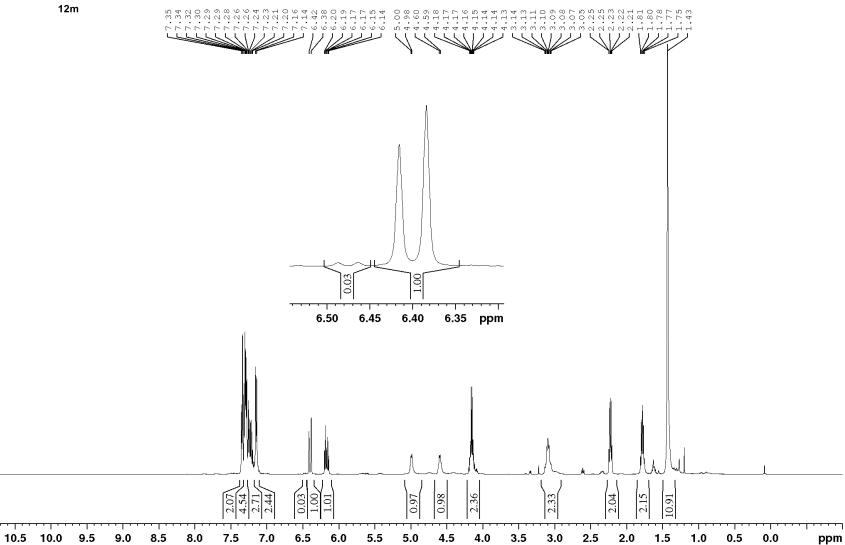


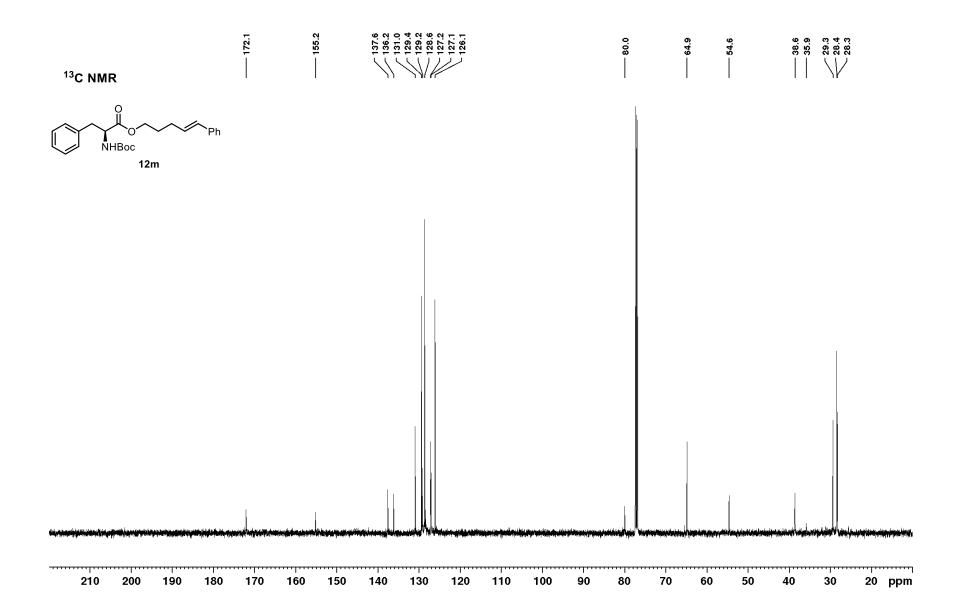


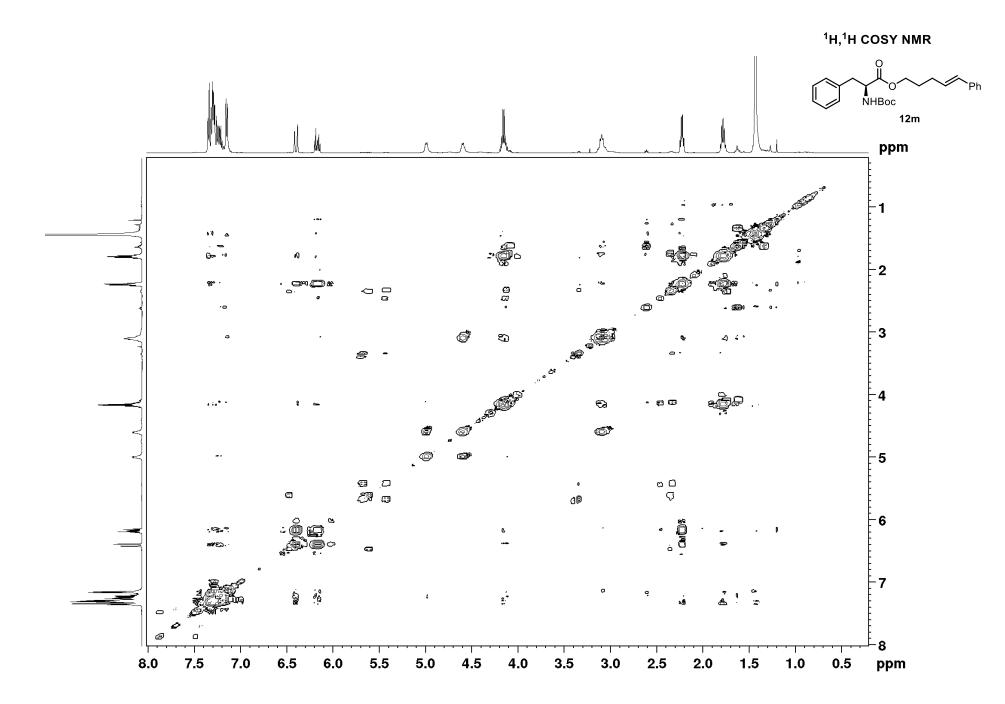


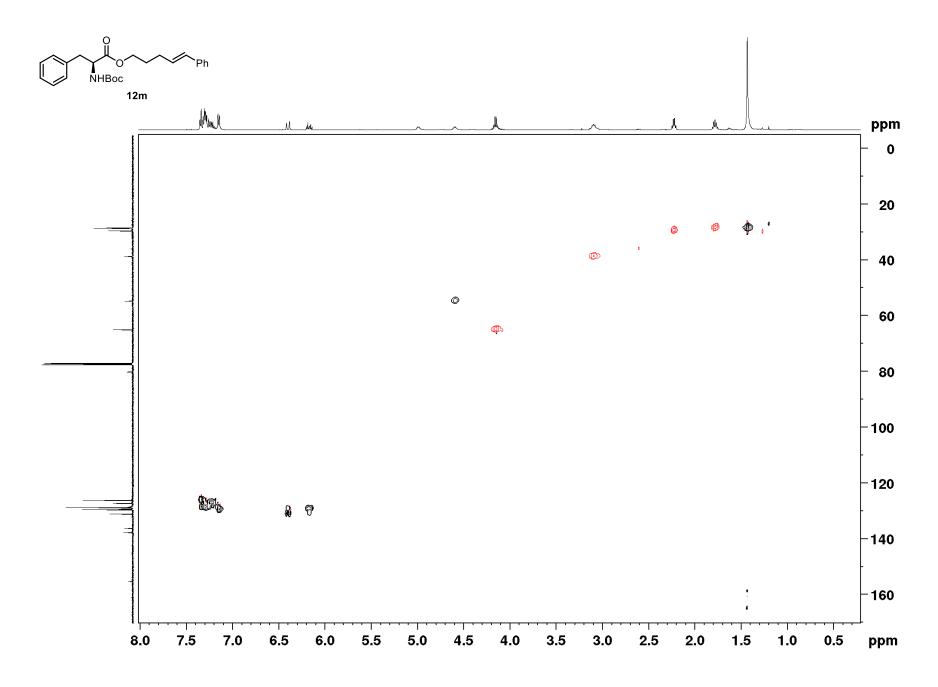




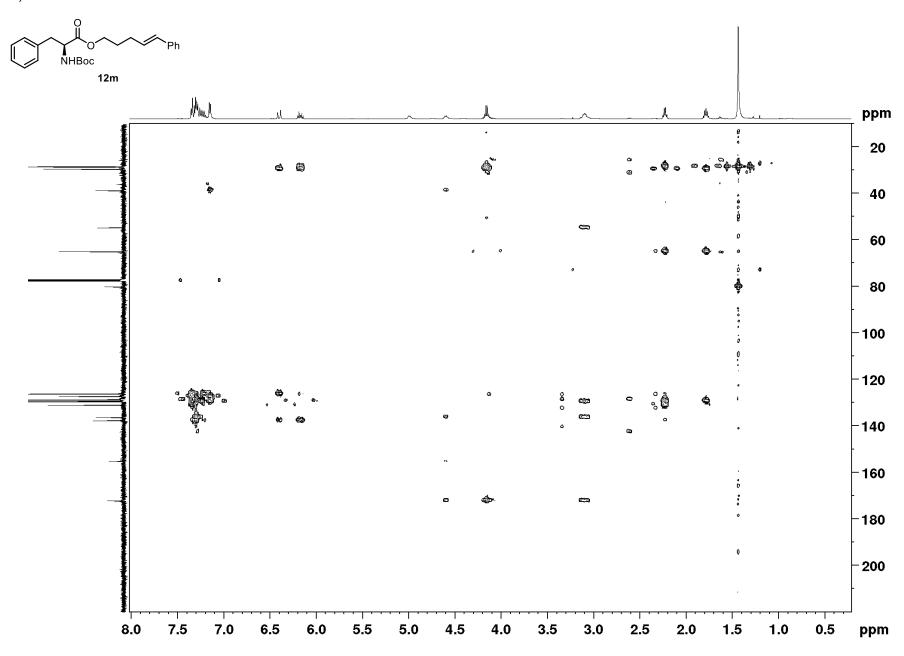




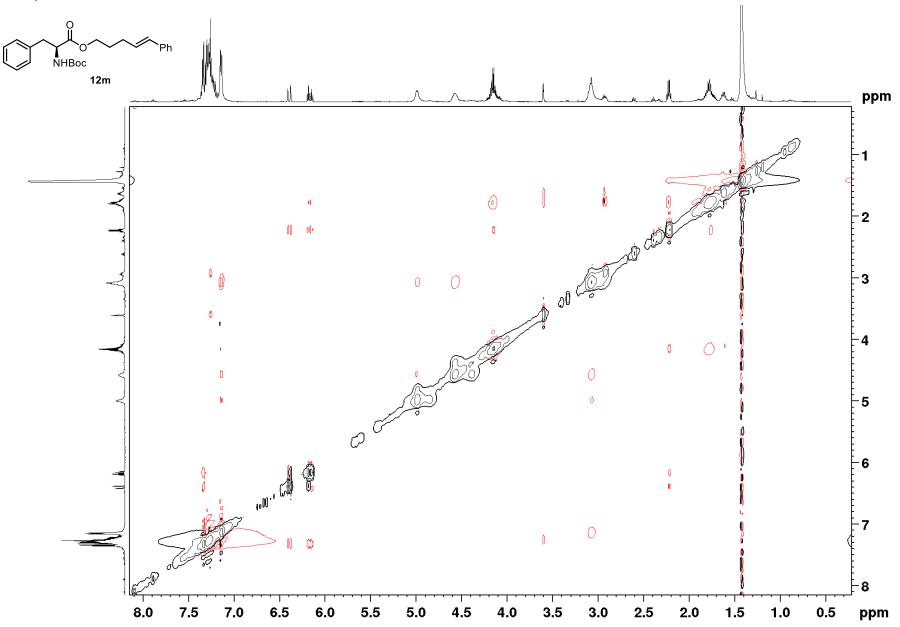


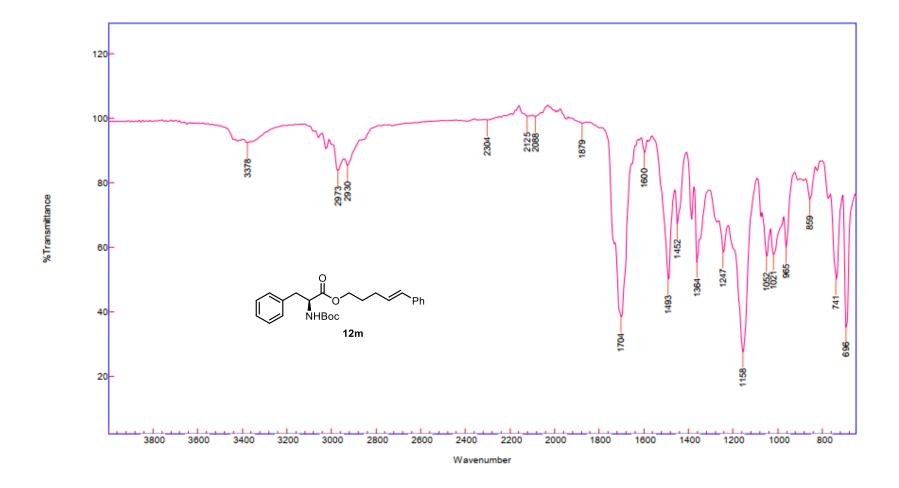


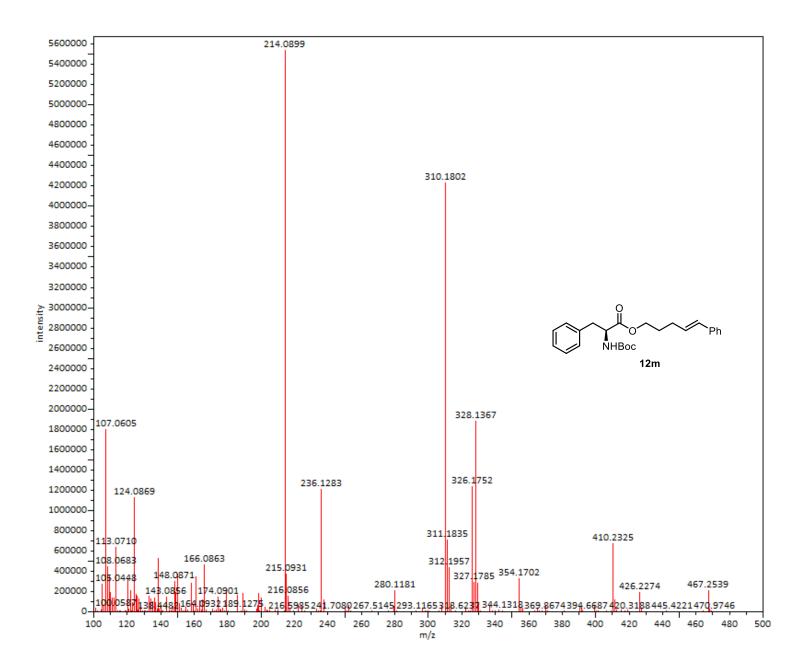
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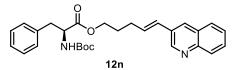


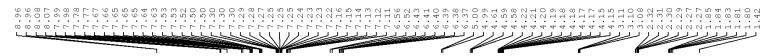


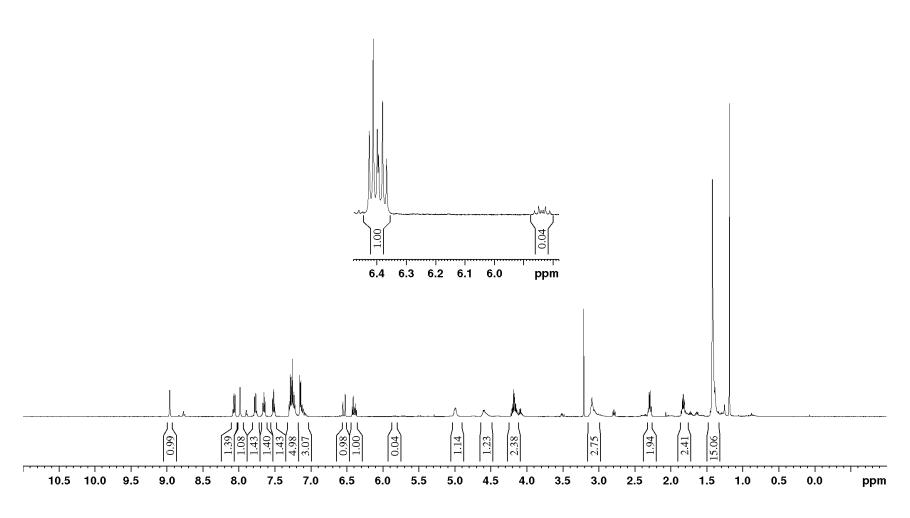


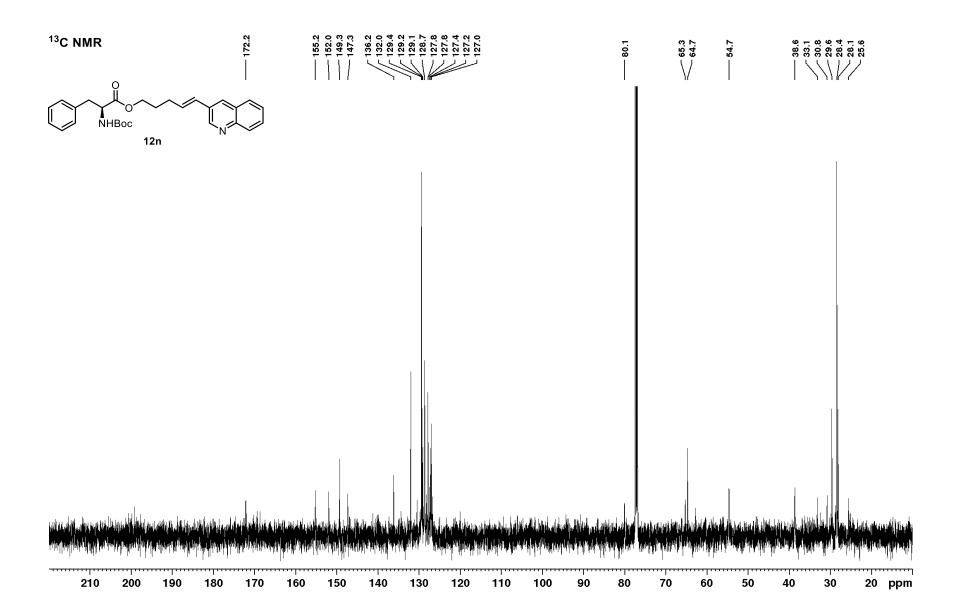


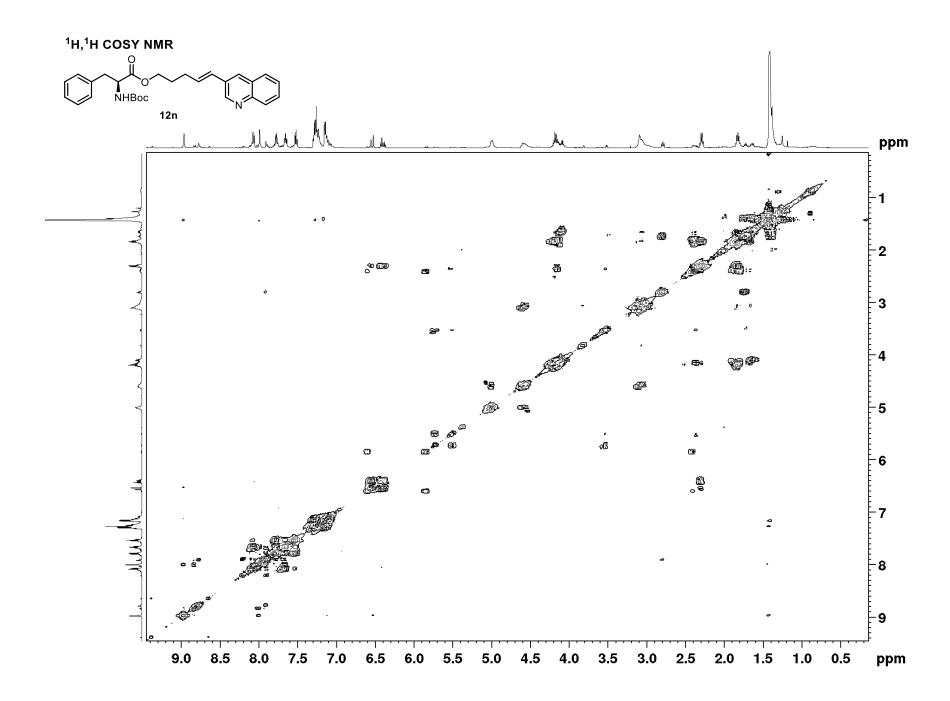




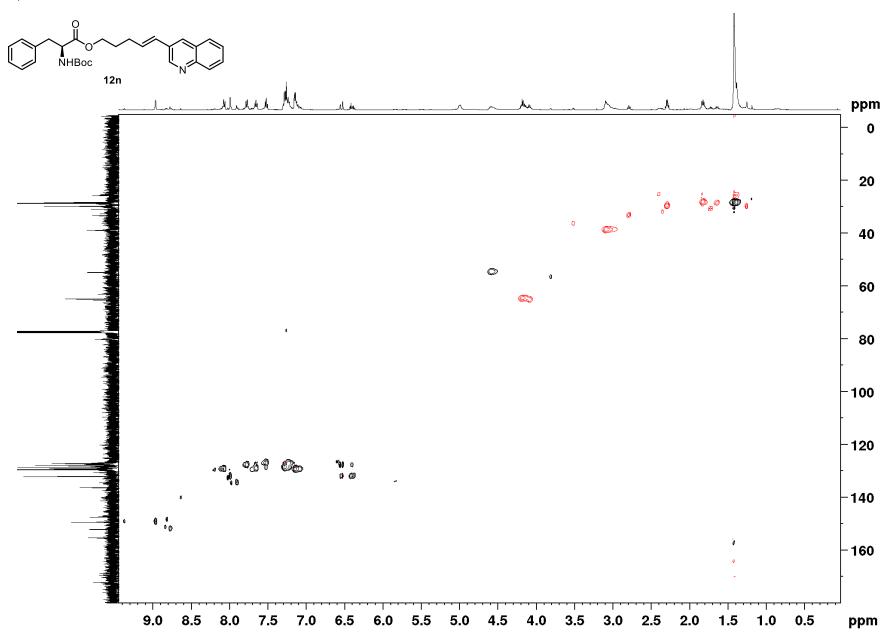


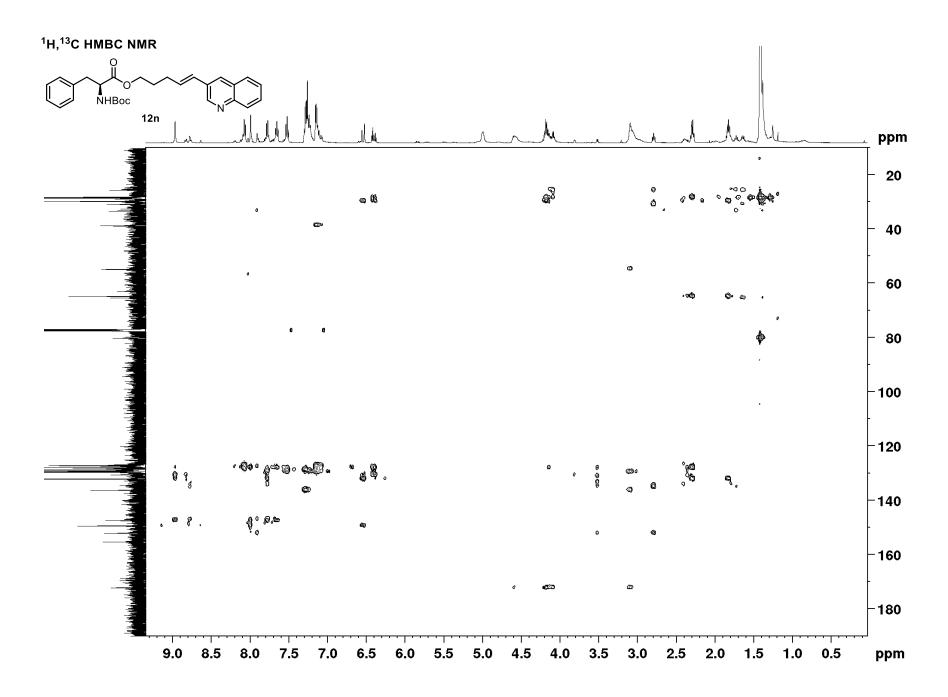


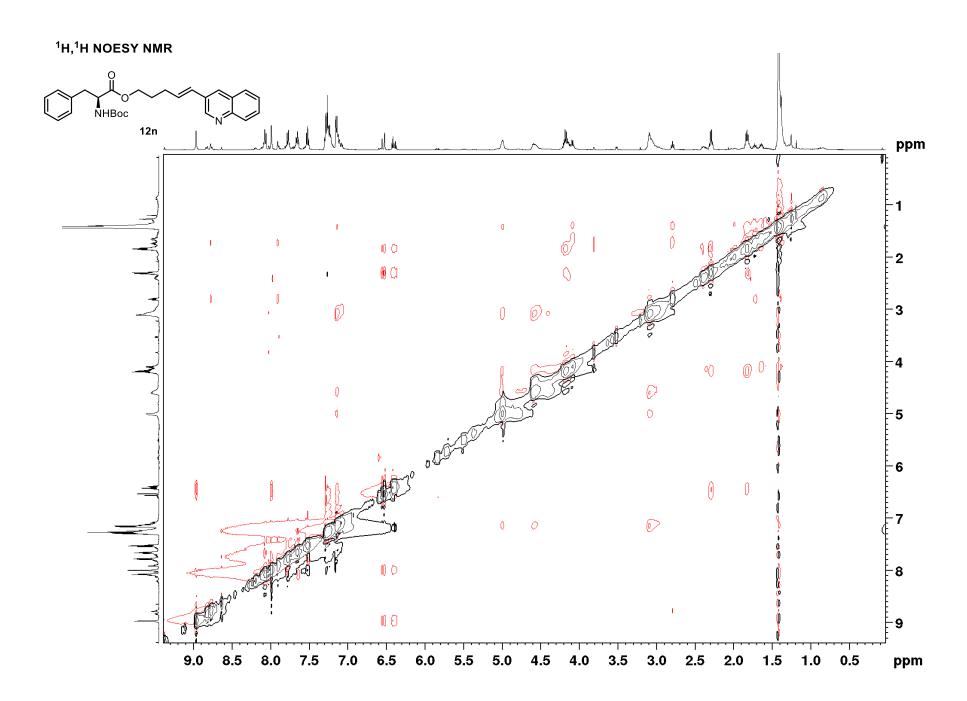


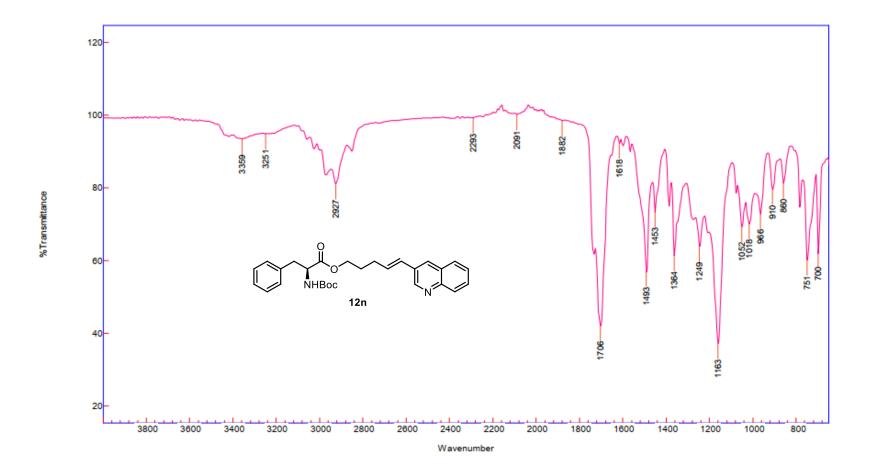


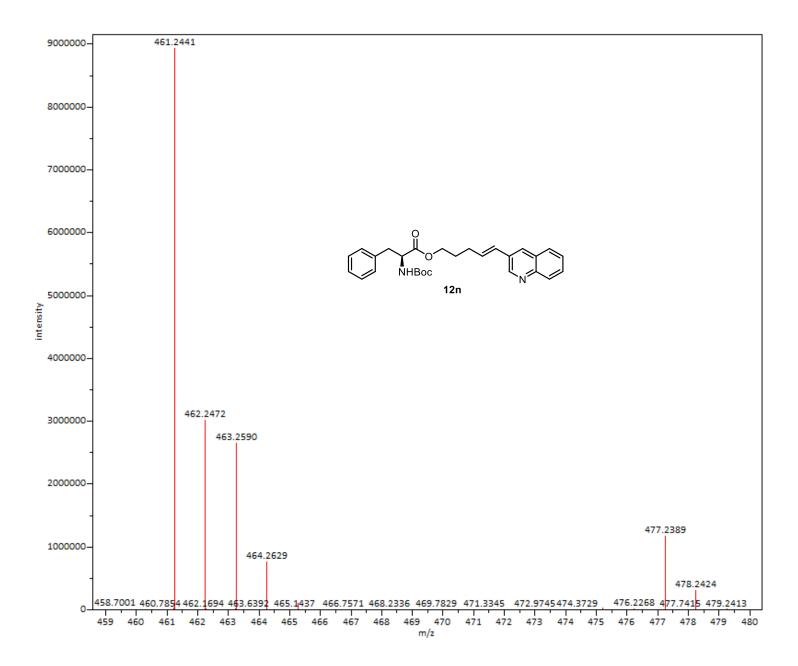


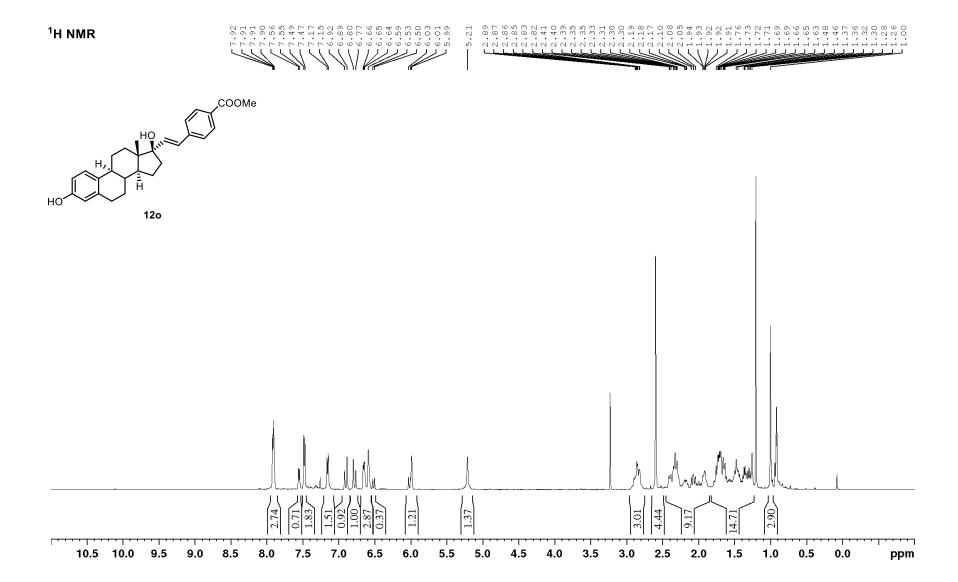


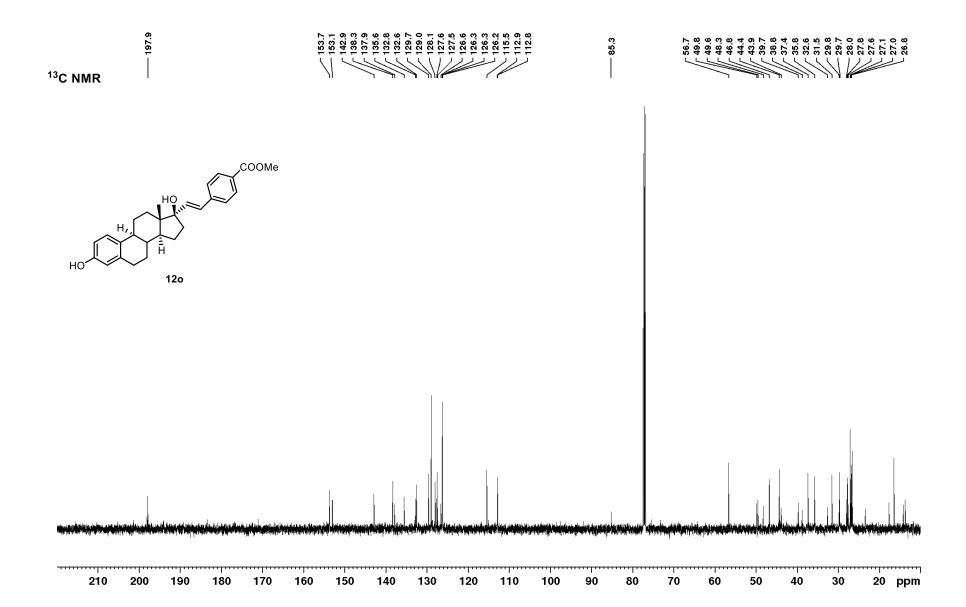




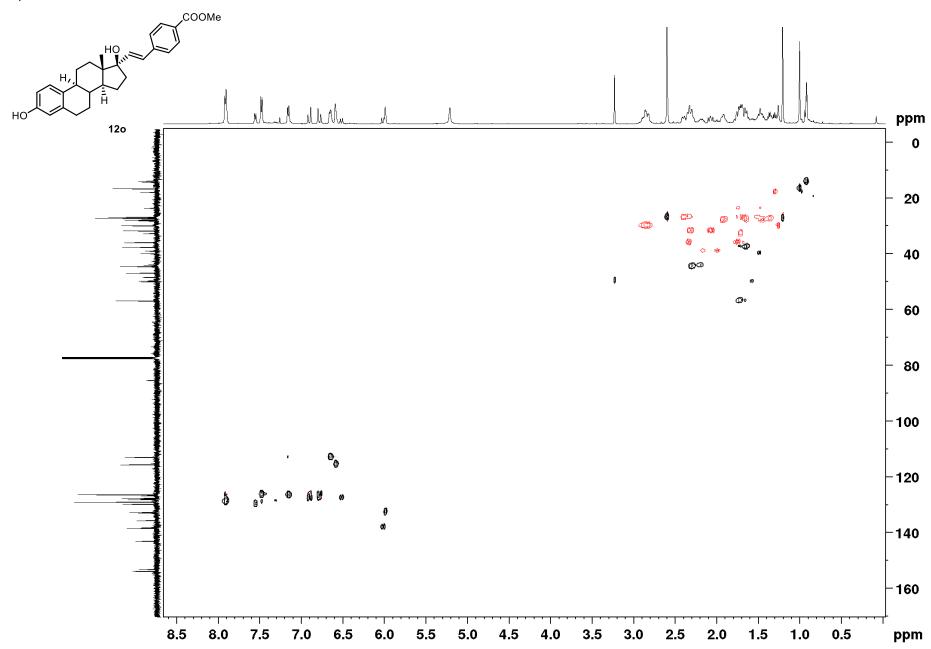


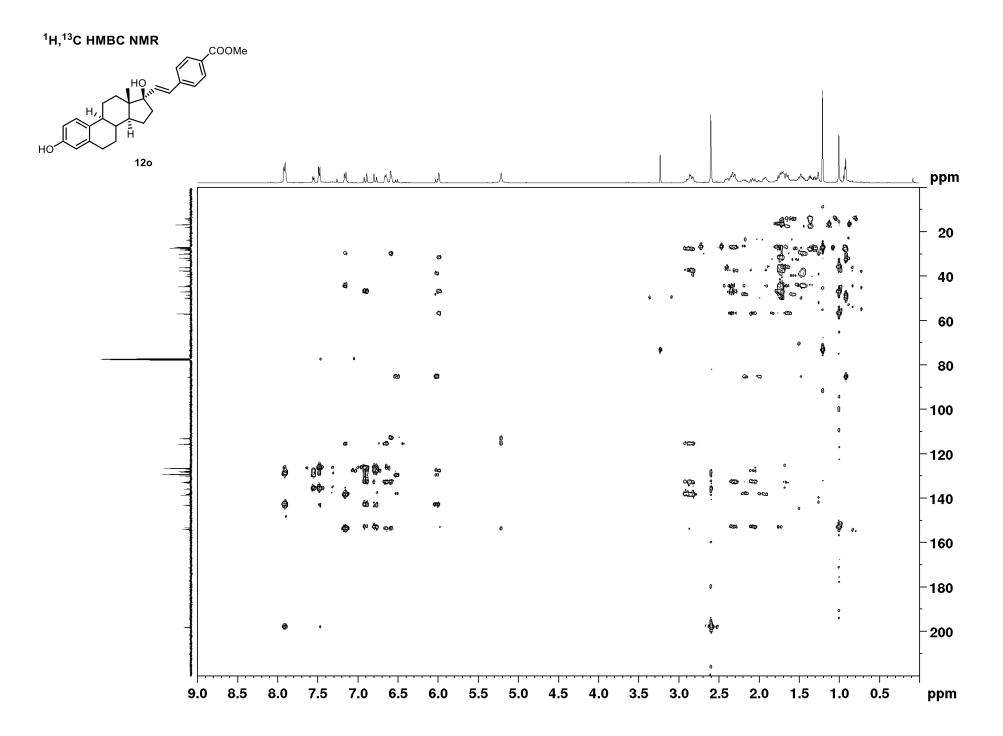


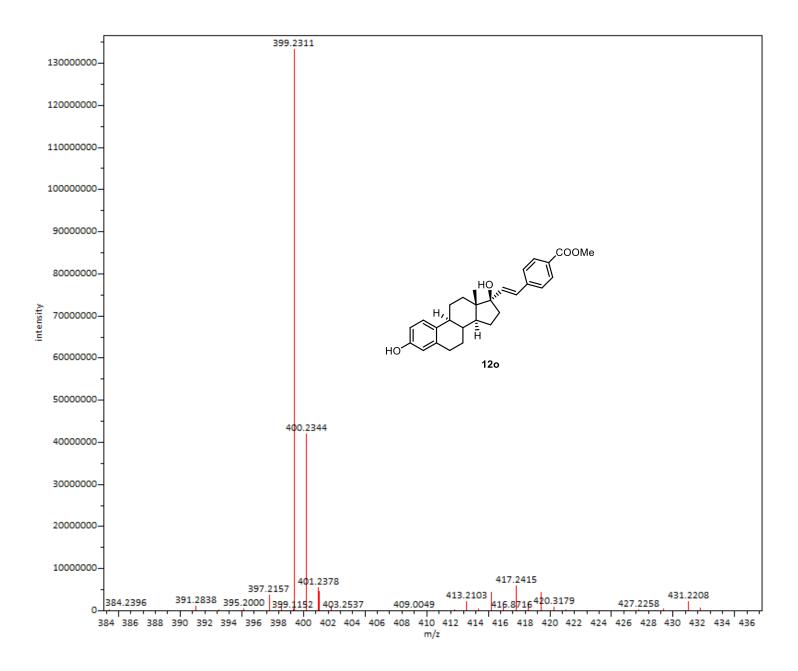


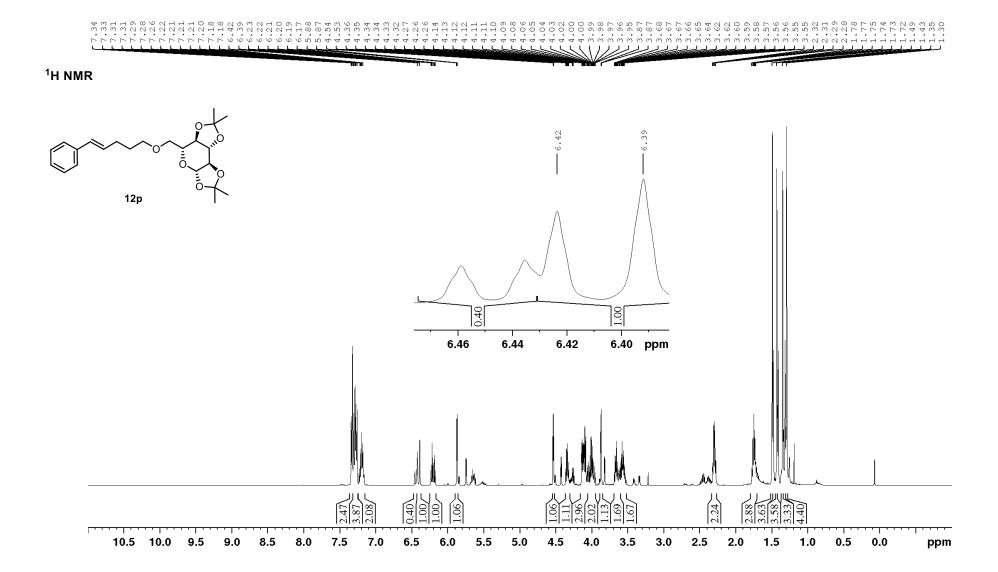


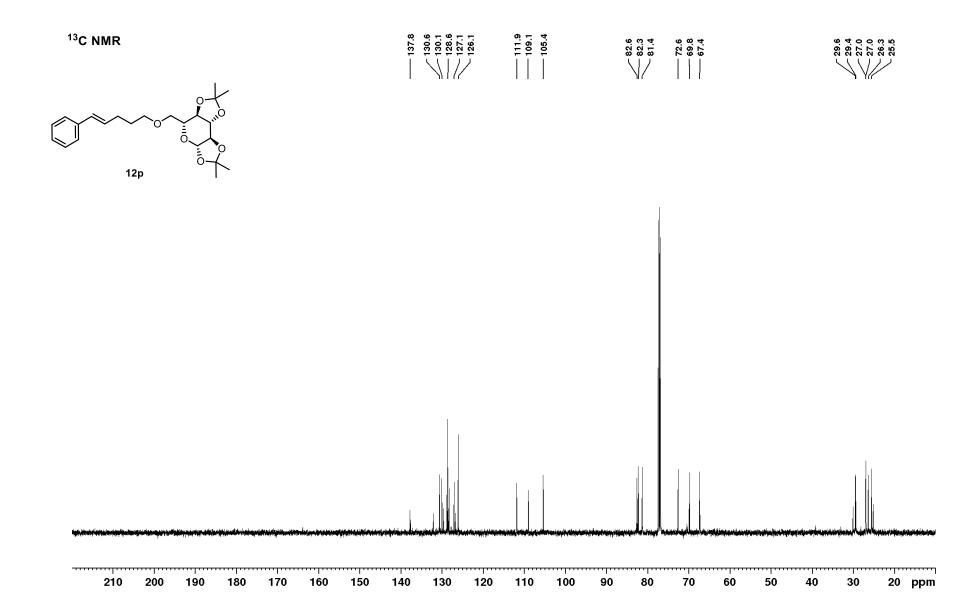


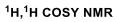


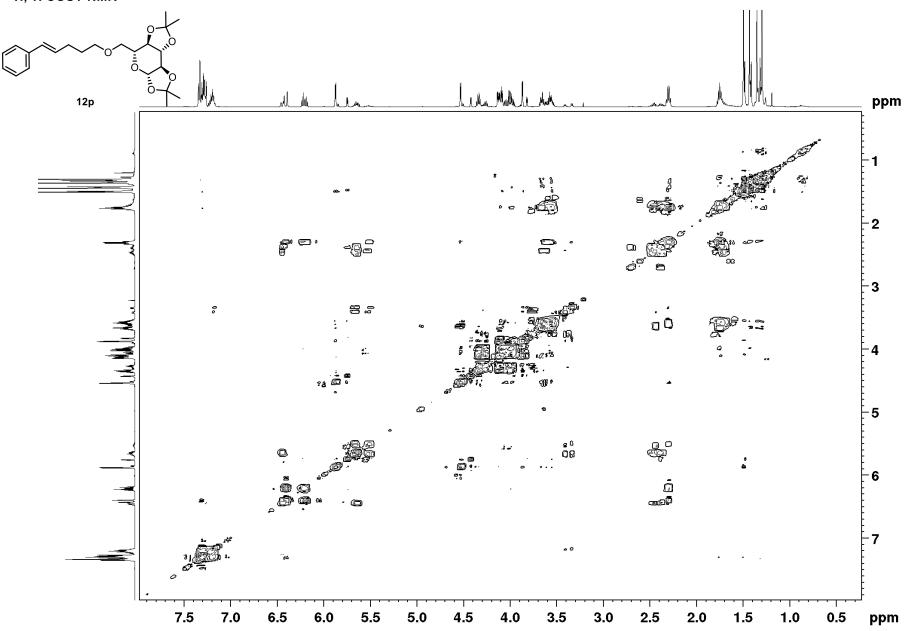


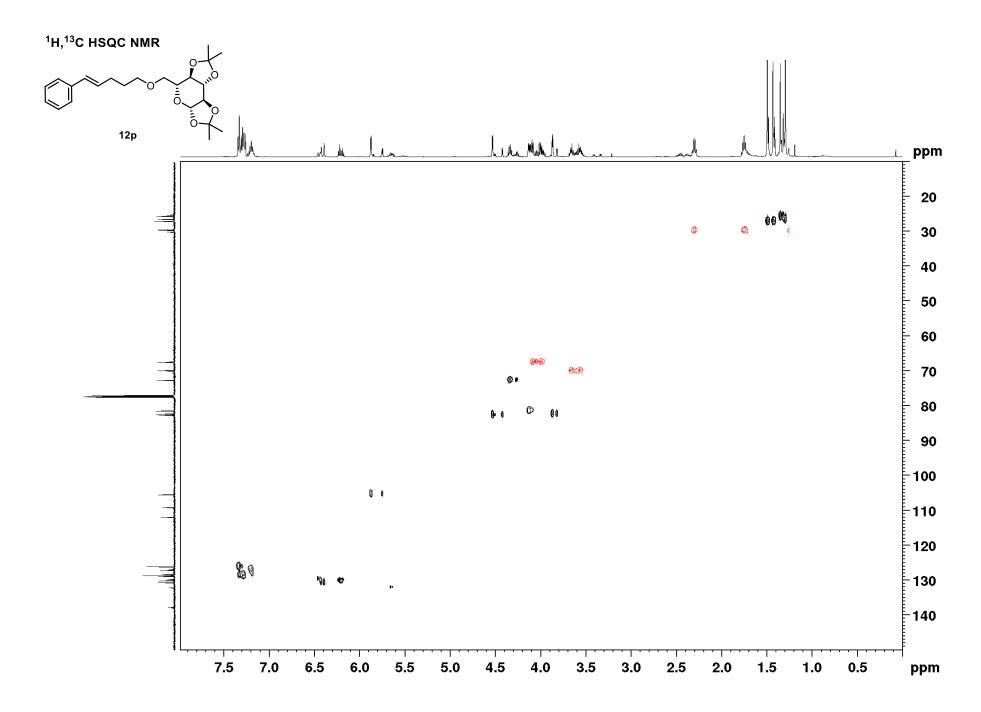




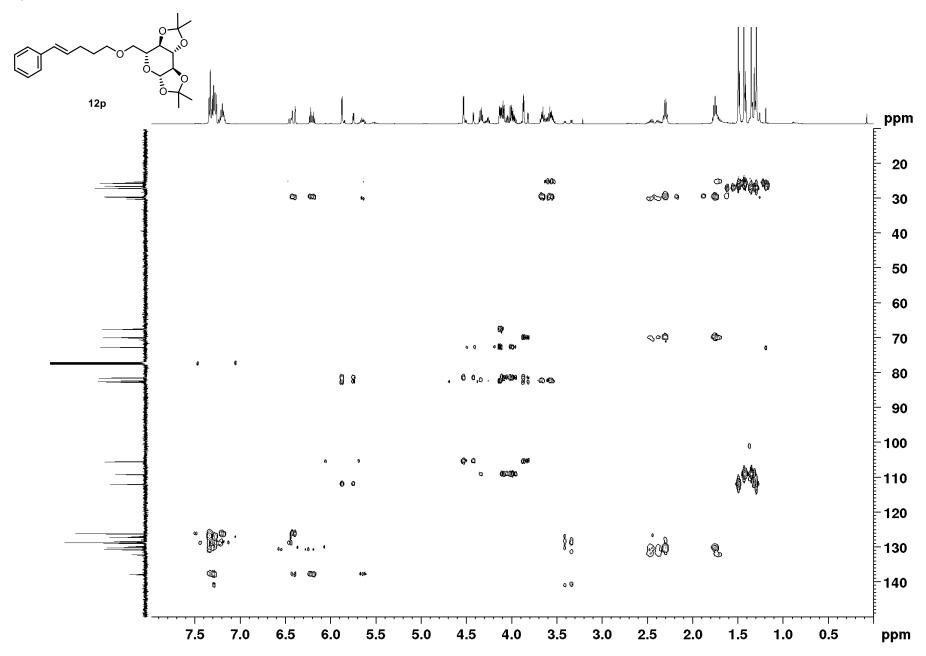


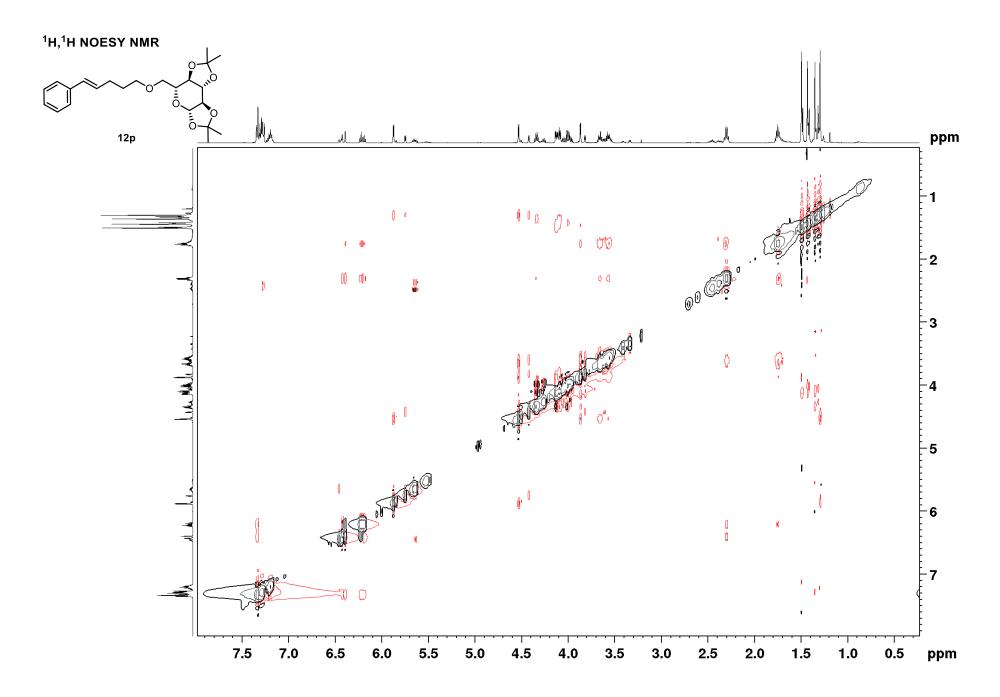


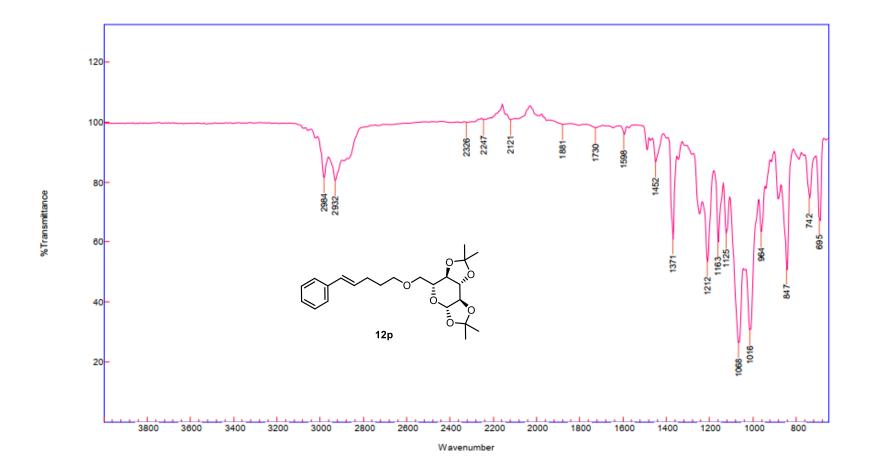


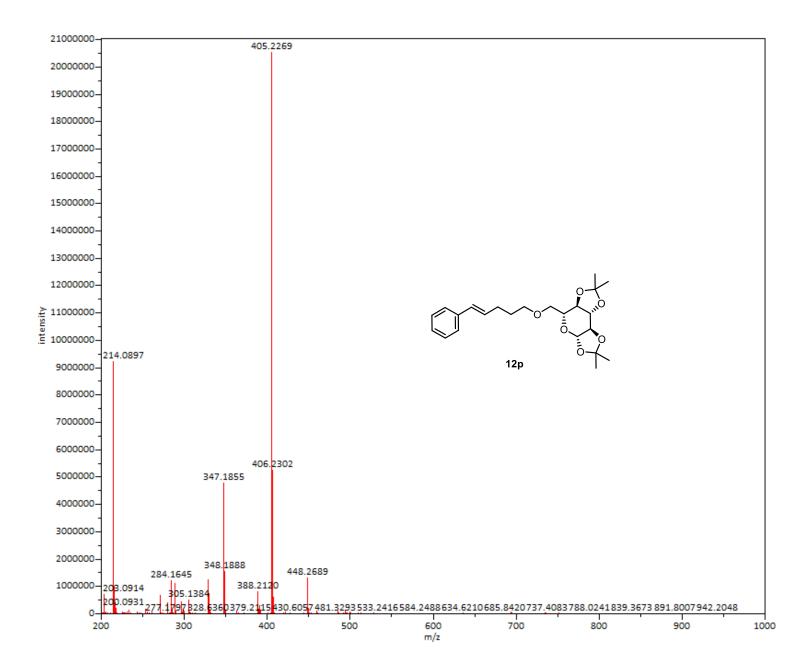


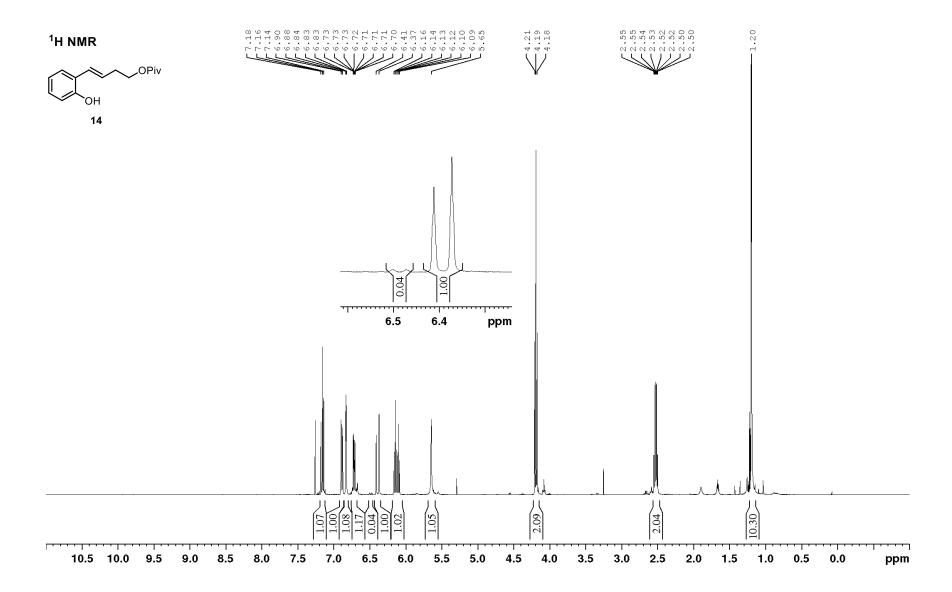


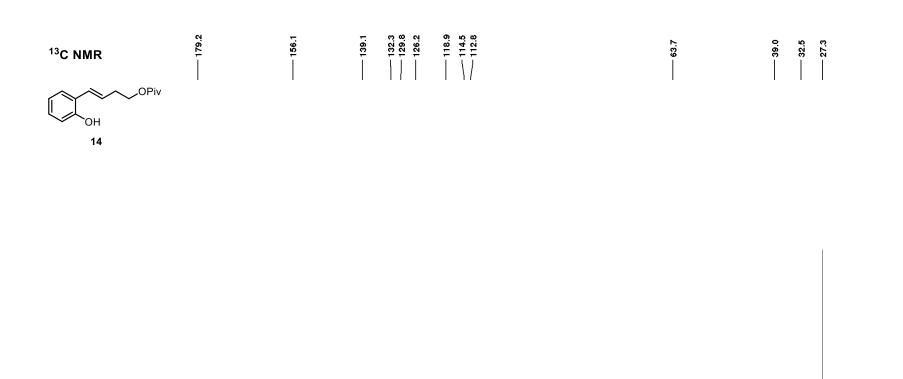










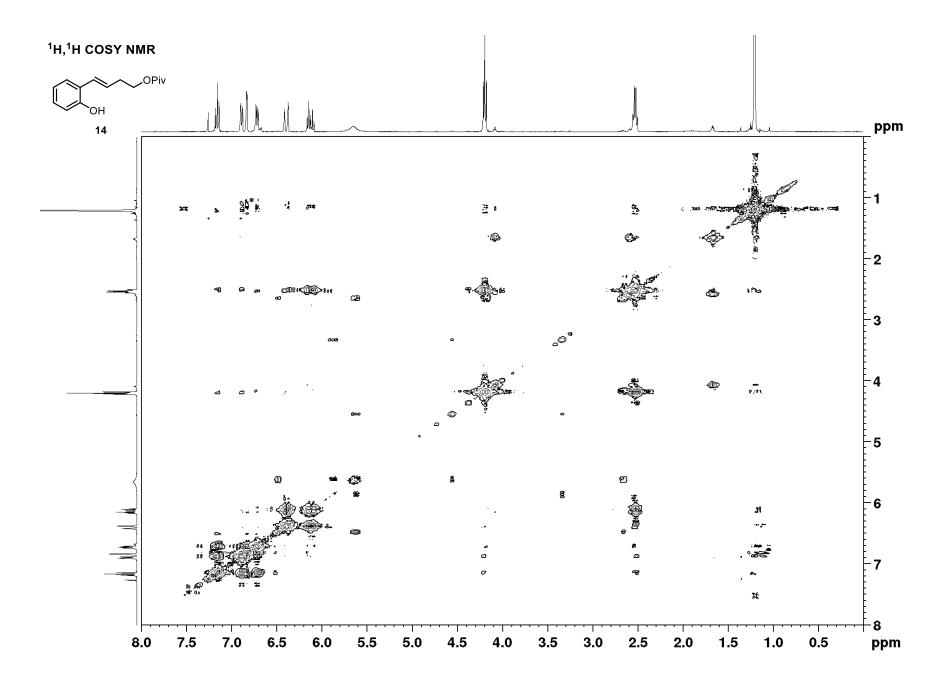


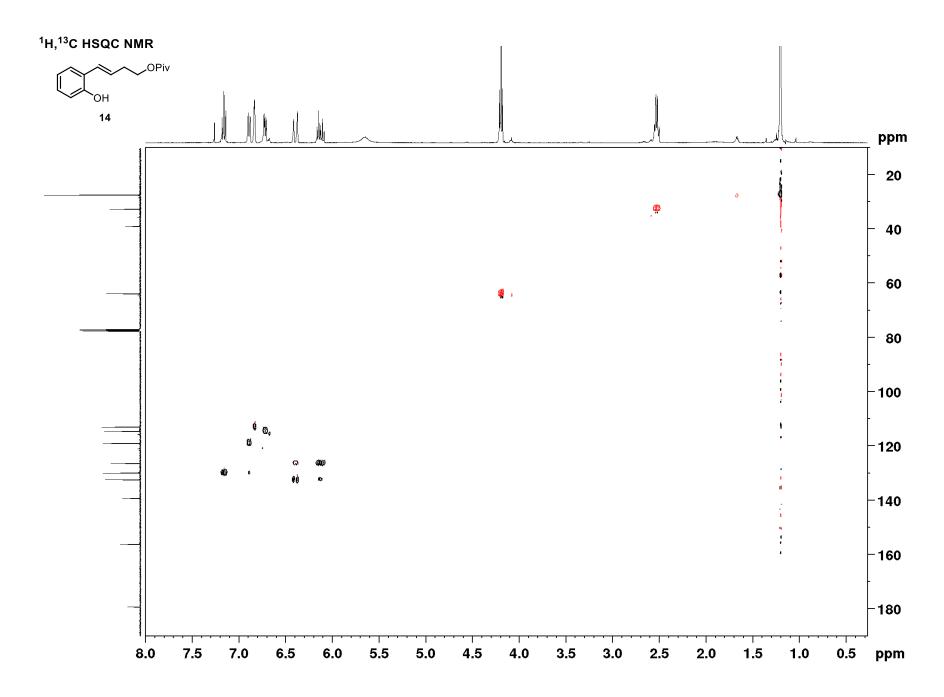
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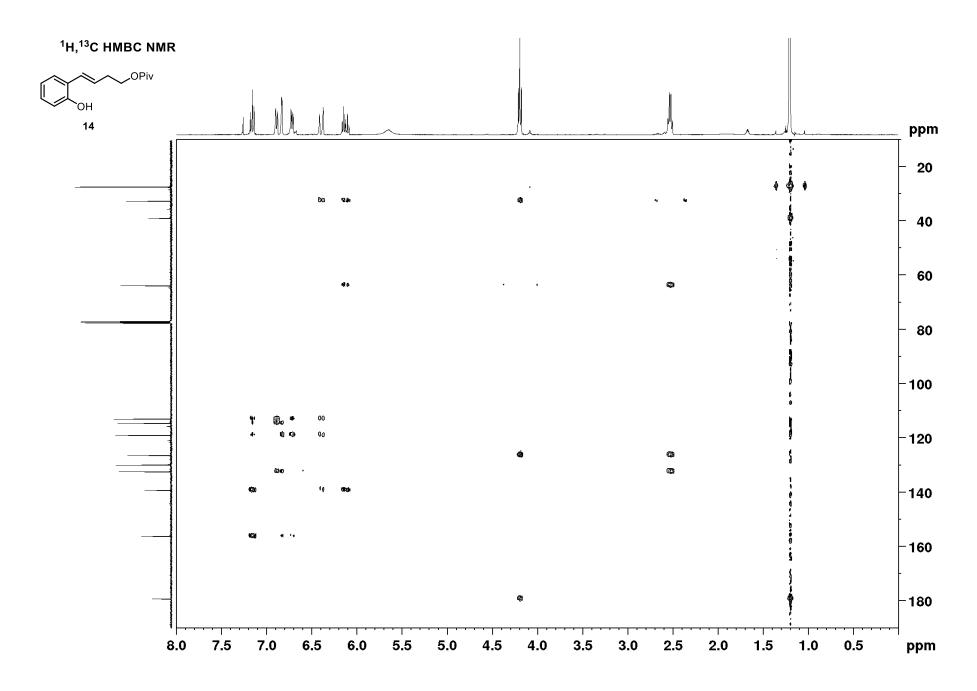
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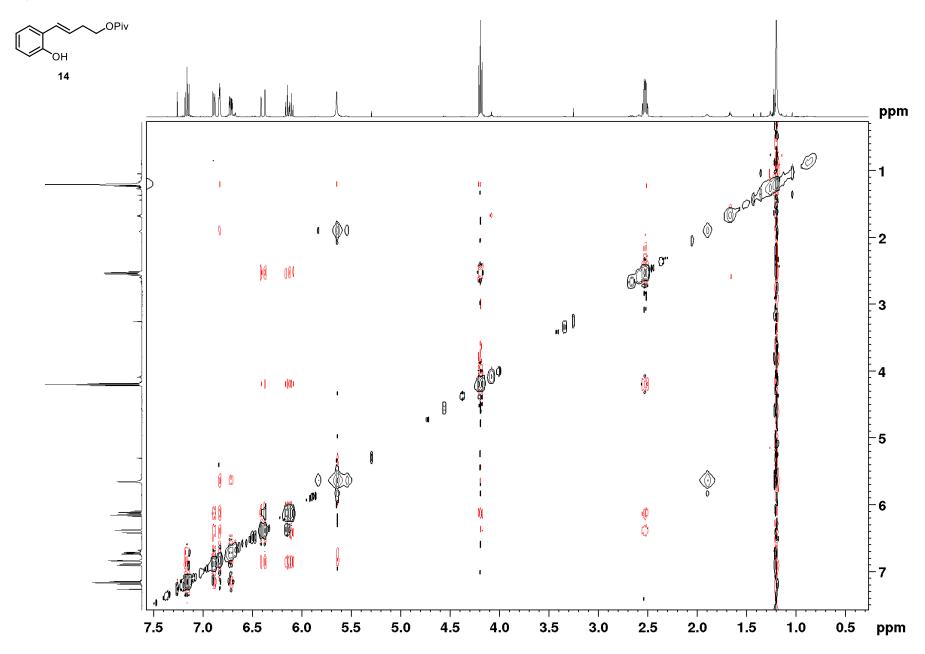
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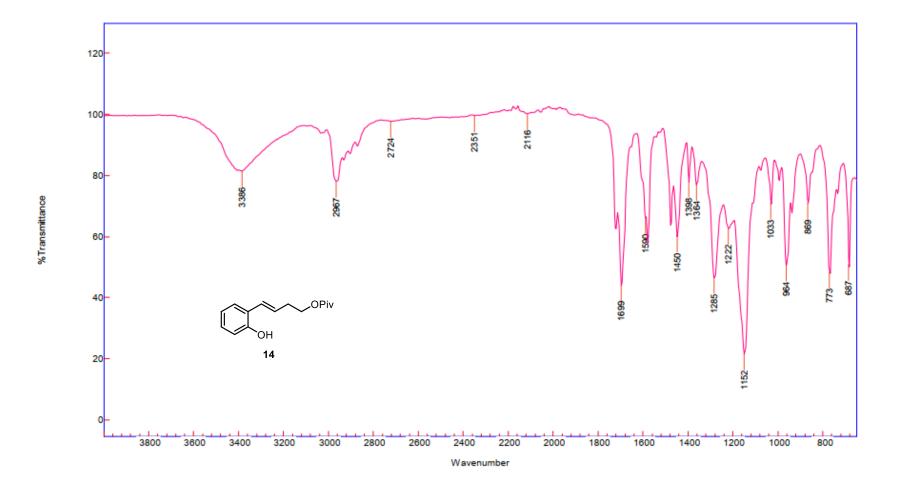


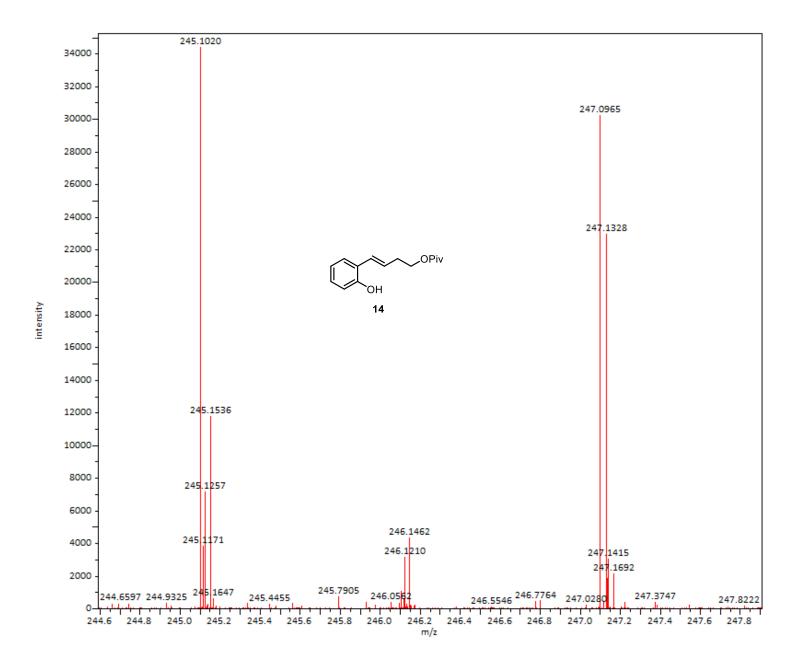


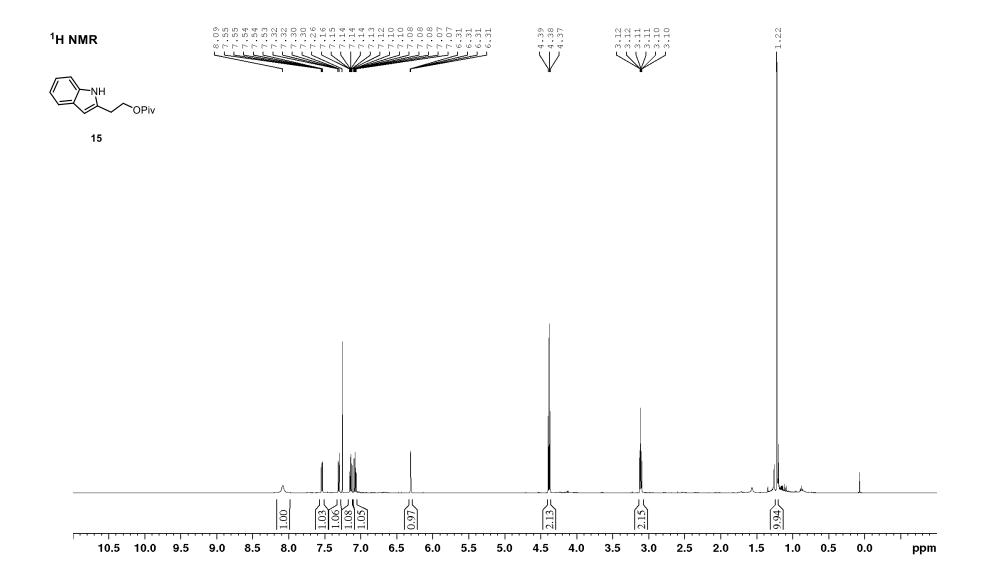


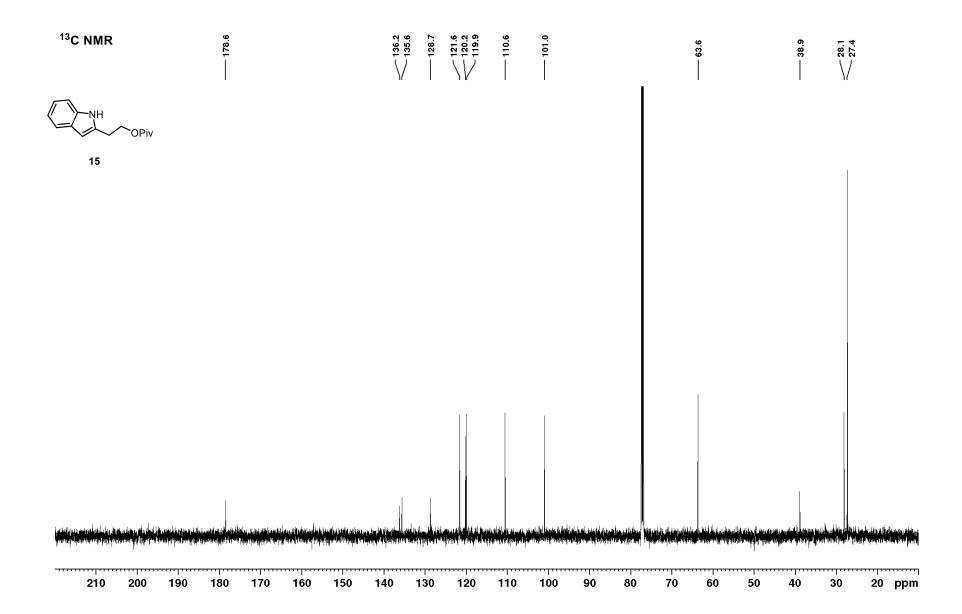




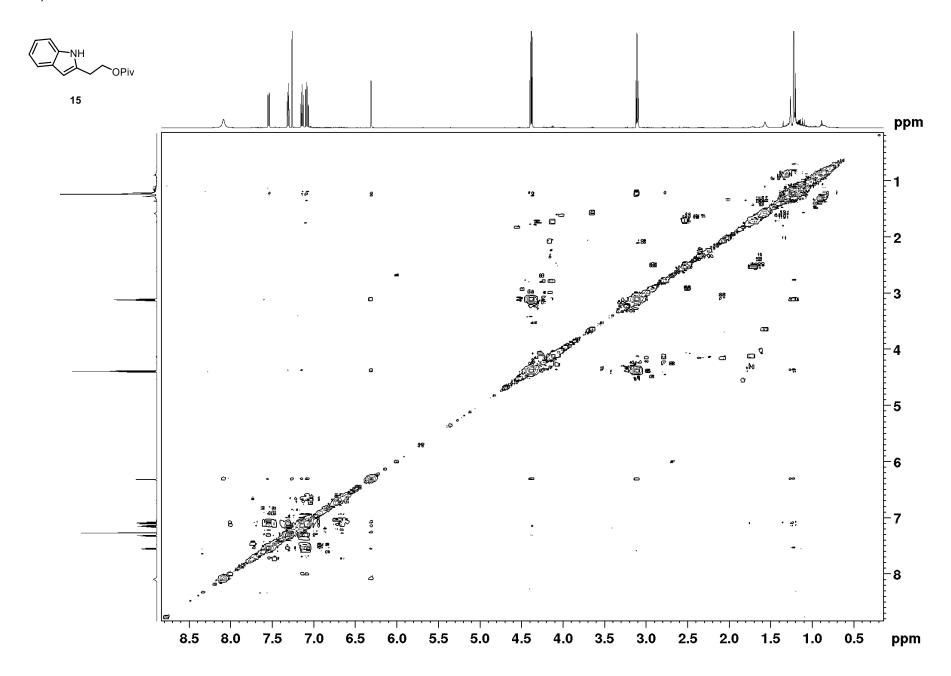


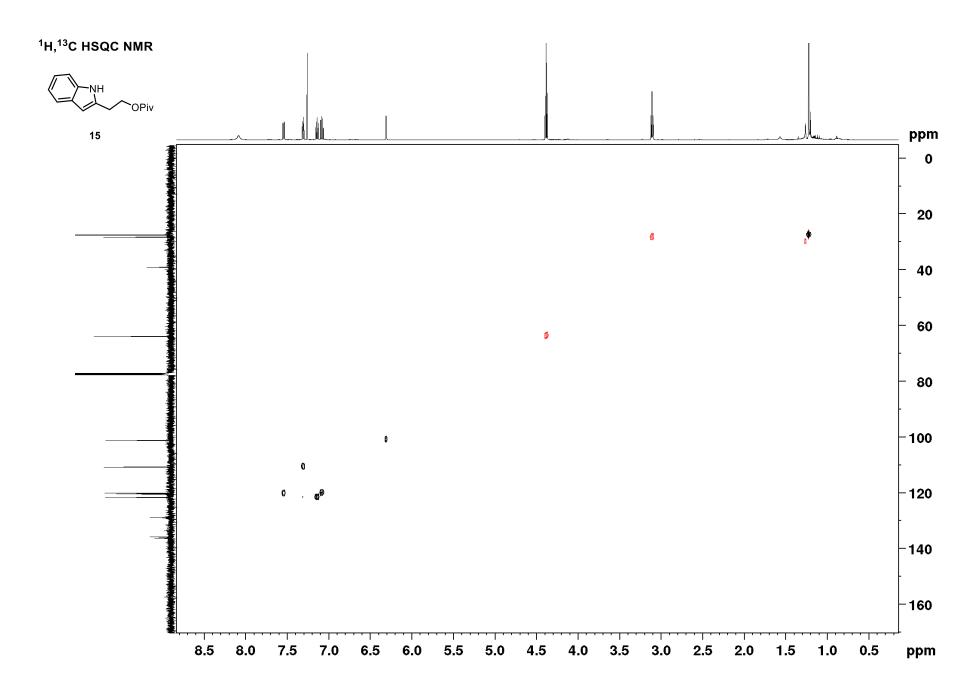




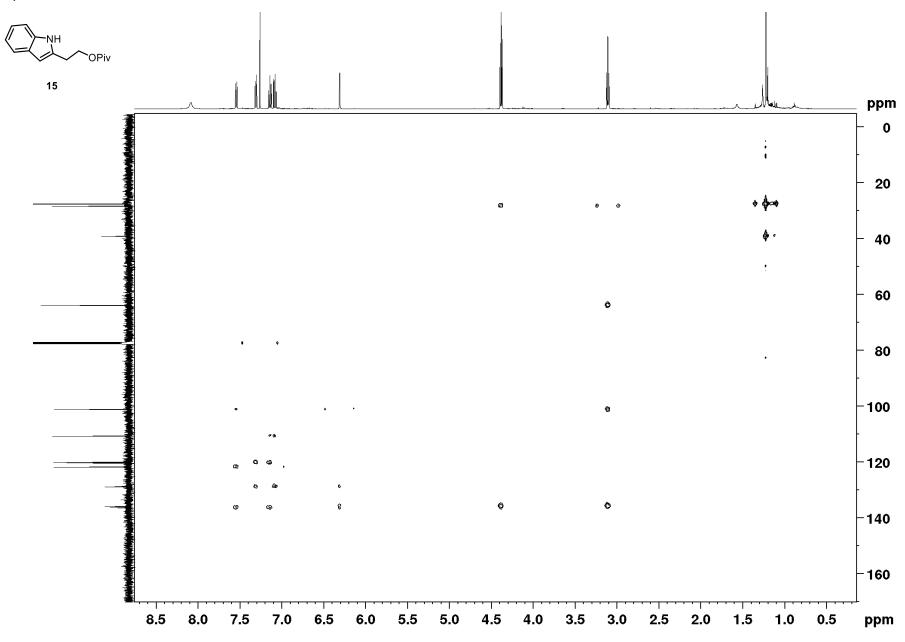


<sup>1</sup>H, <sup>1</sup>H COSY NMR

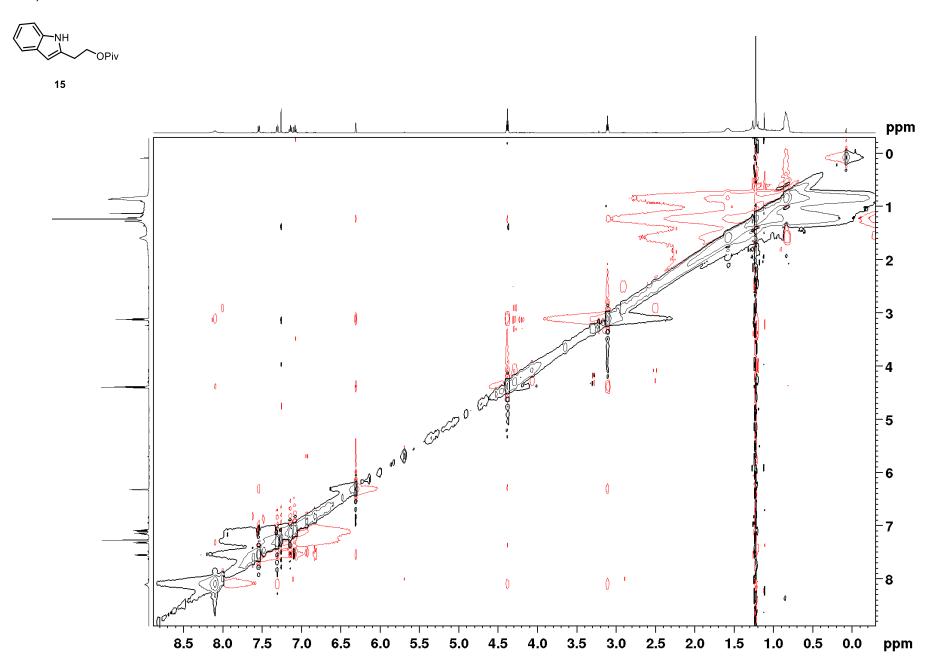


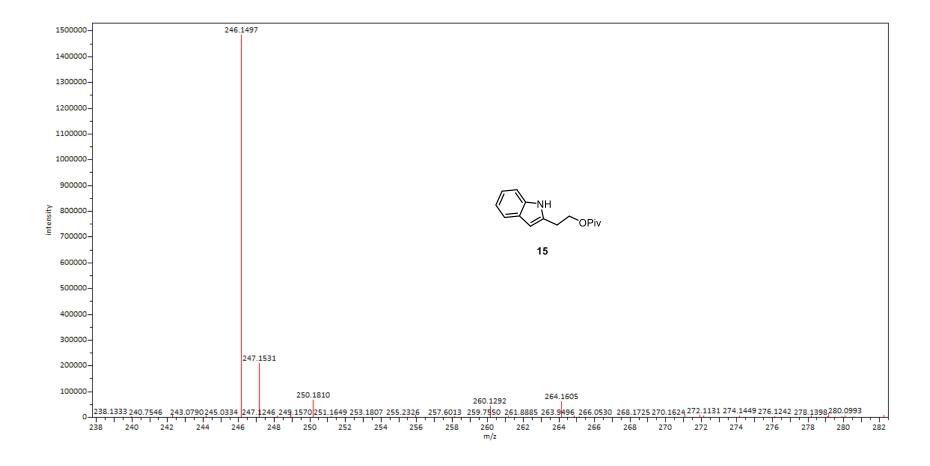


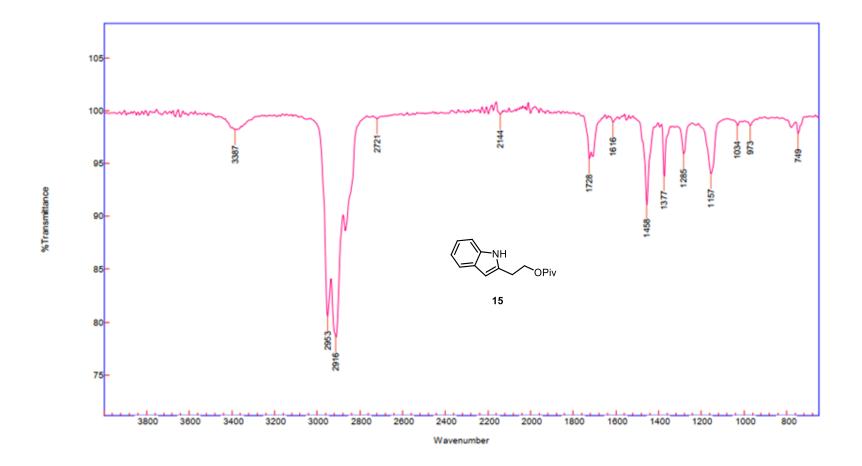


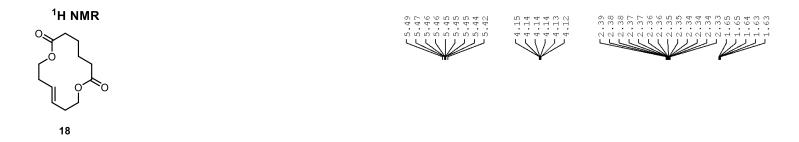


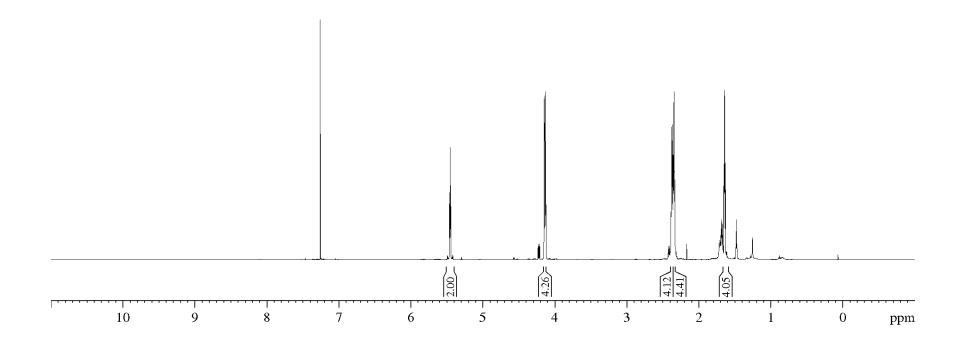


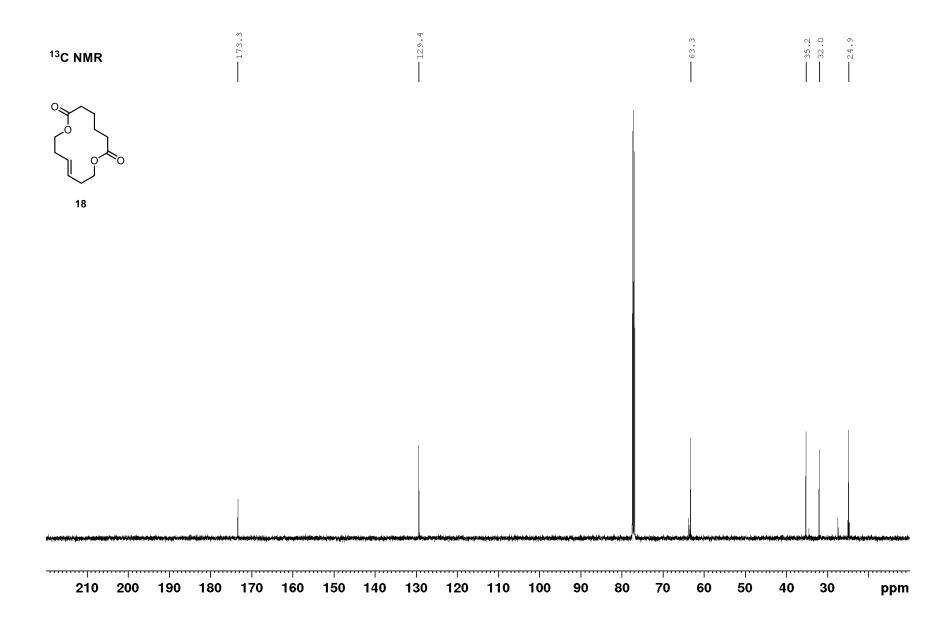


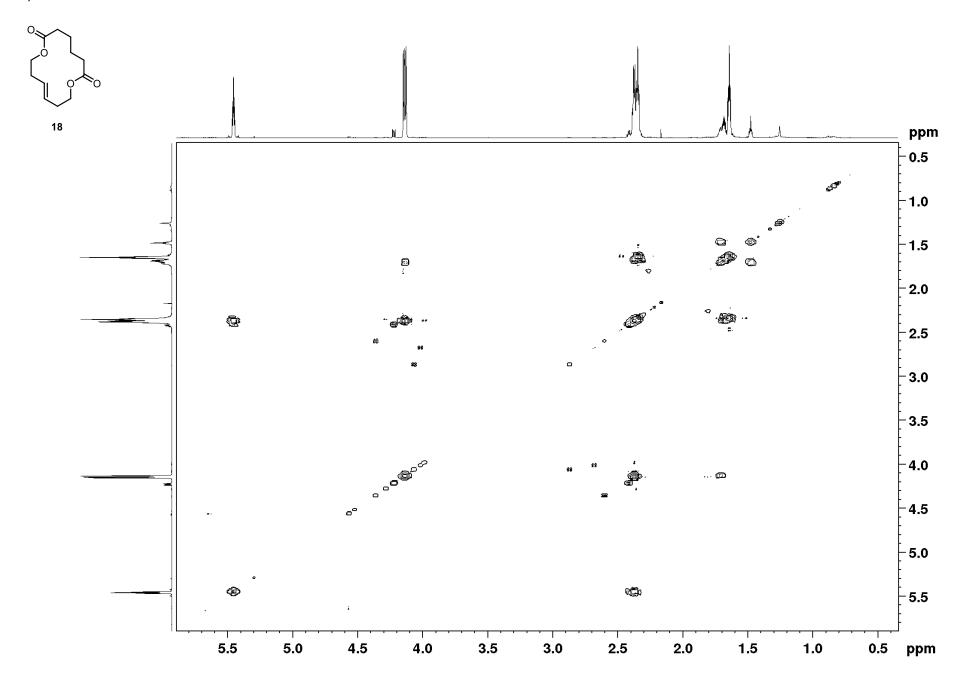


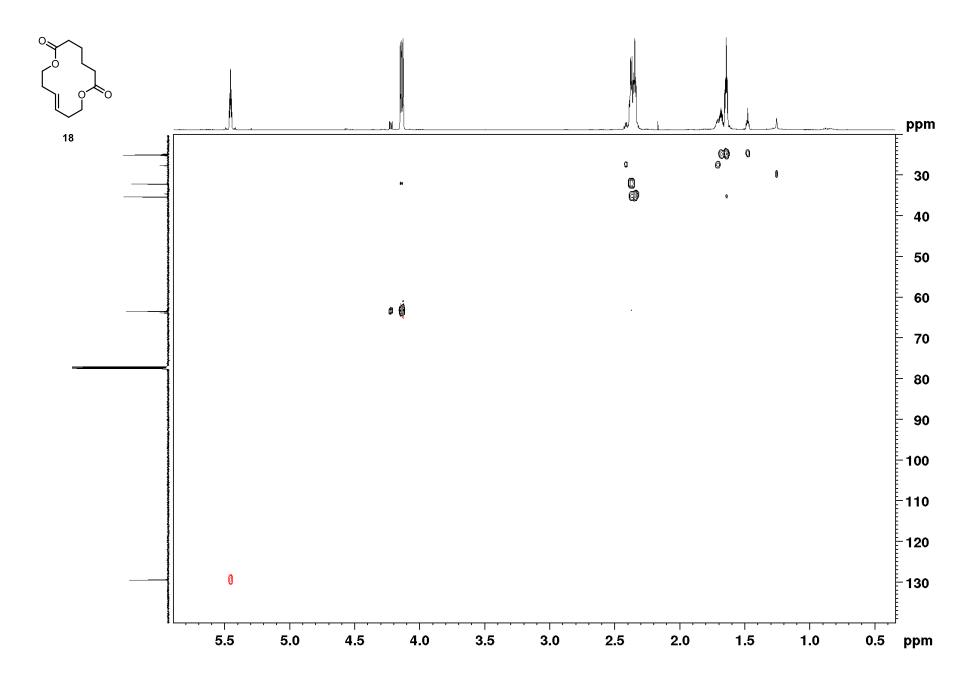


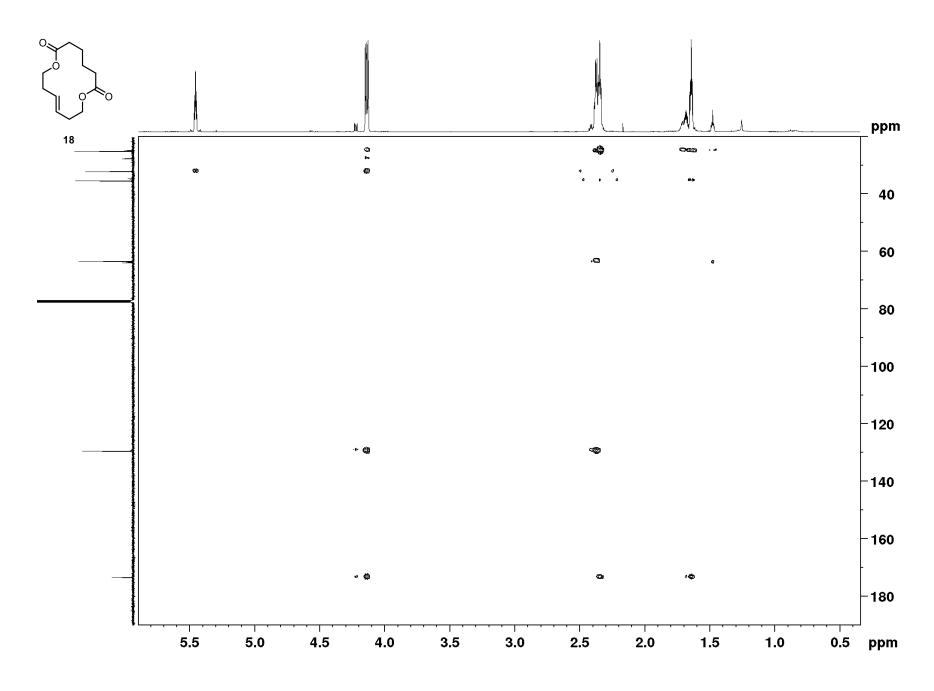


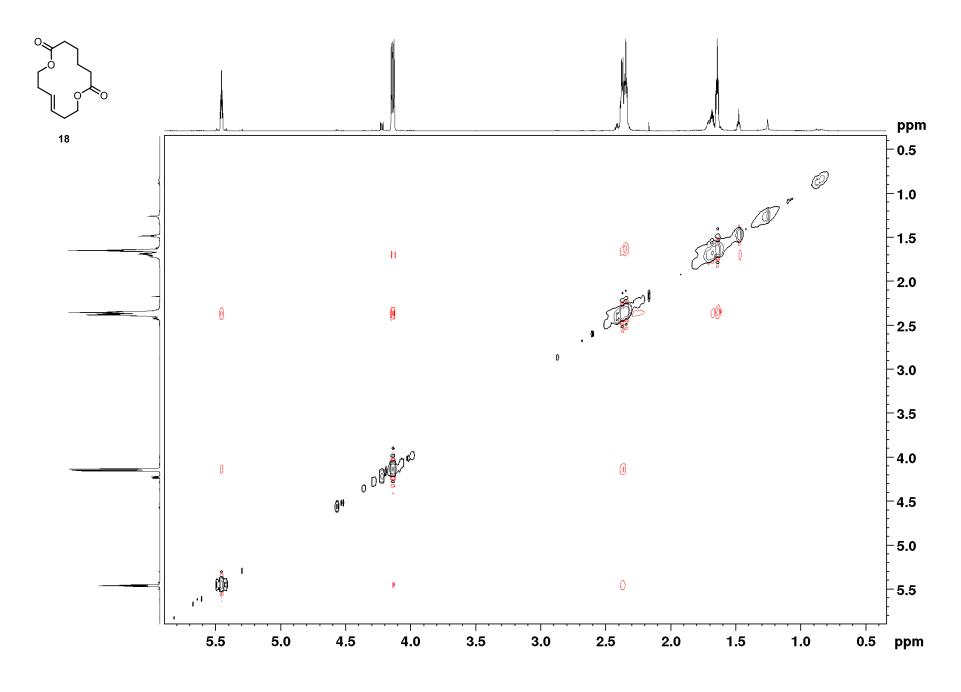


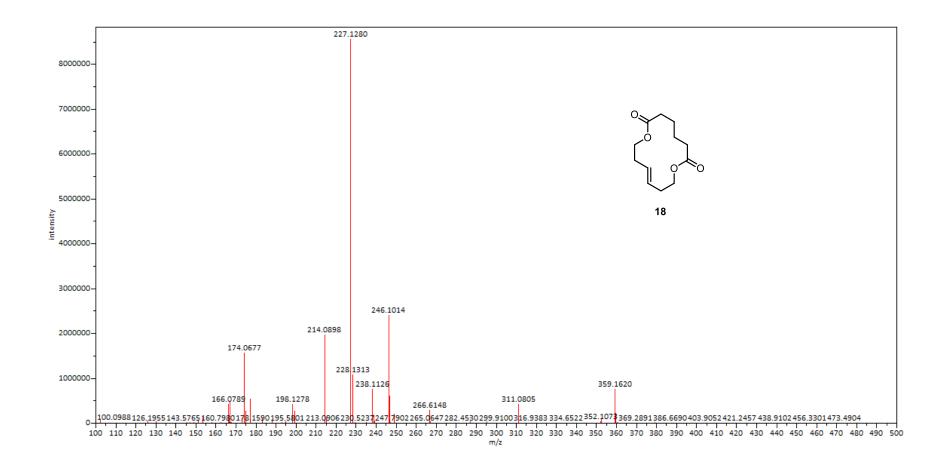


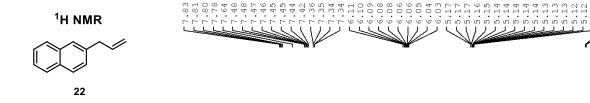


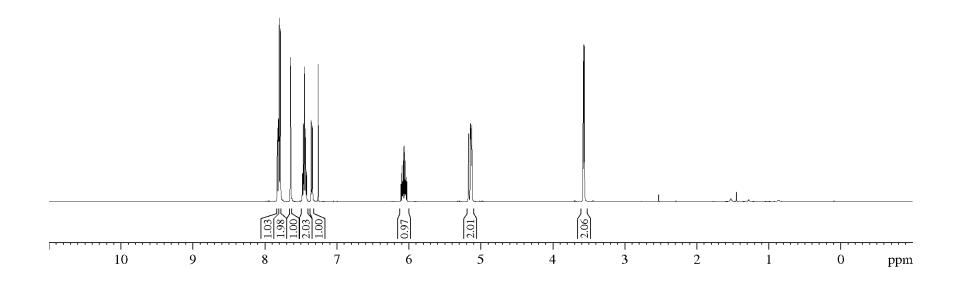


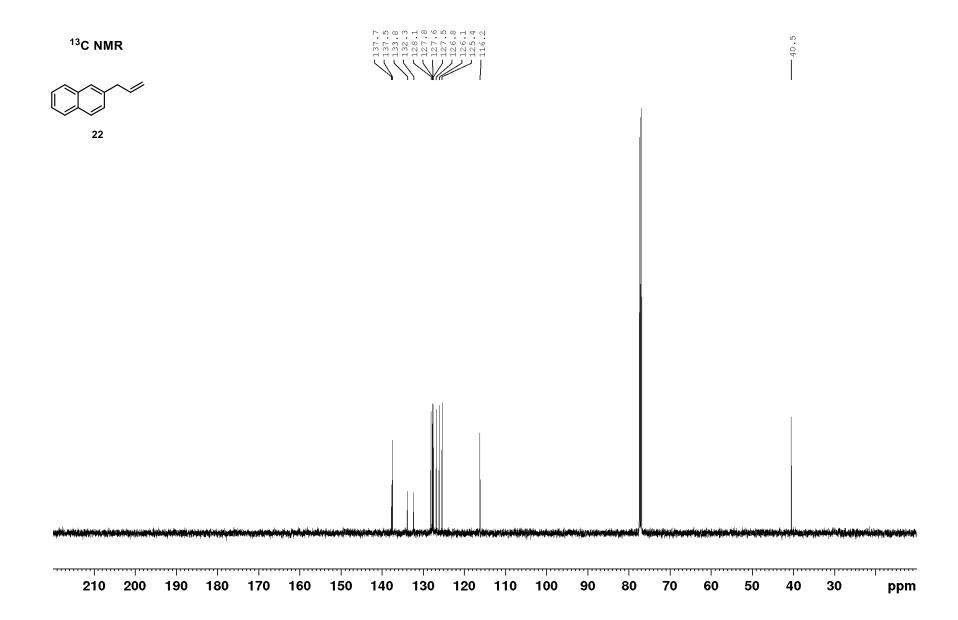


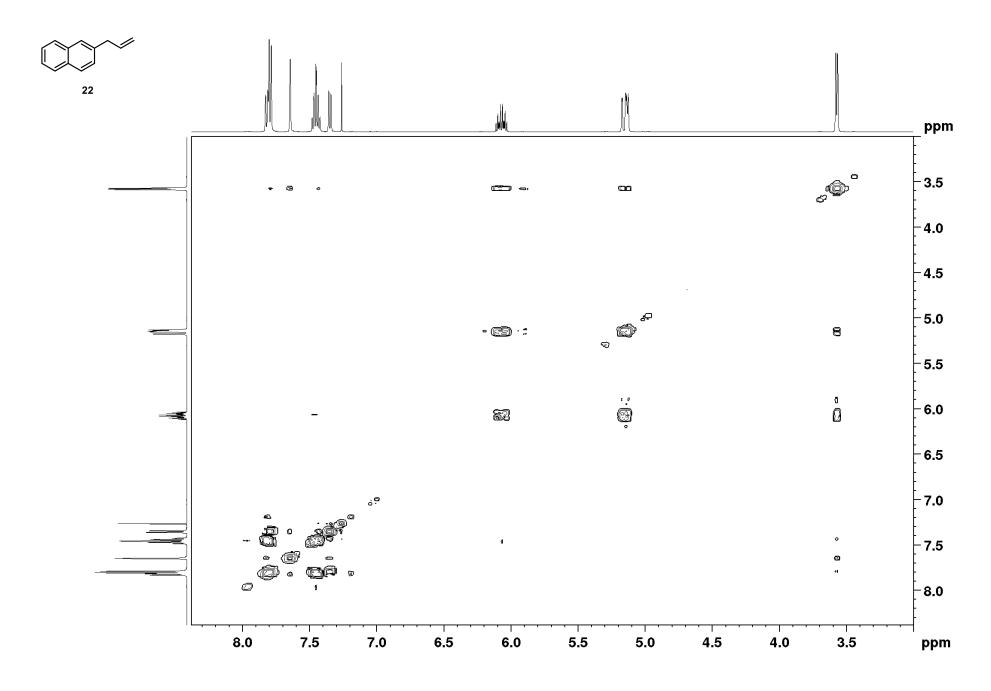




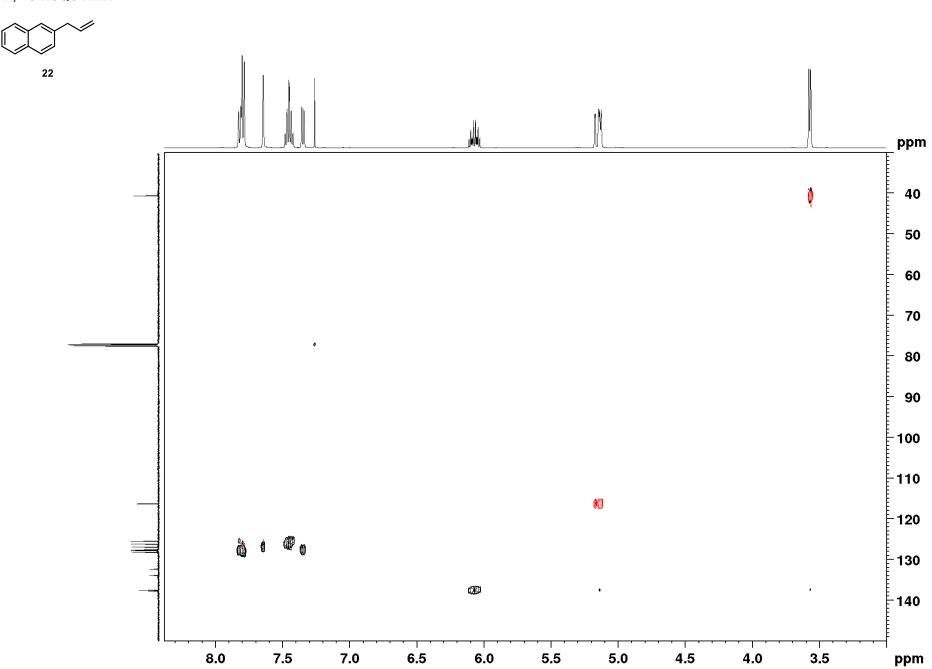


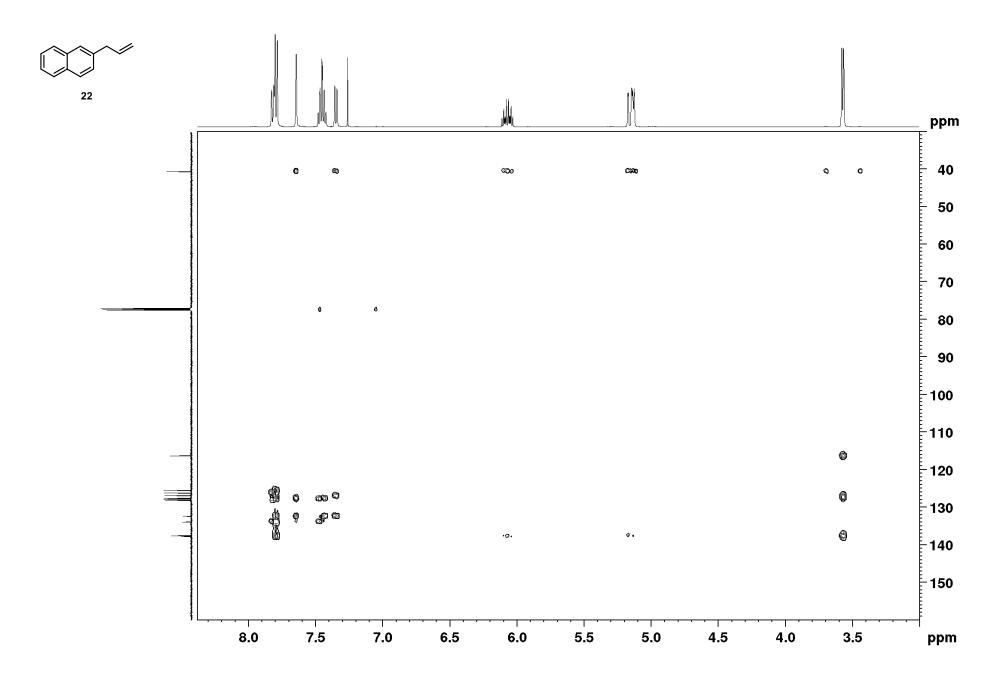


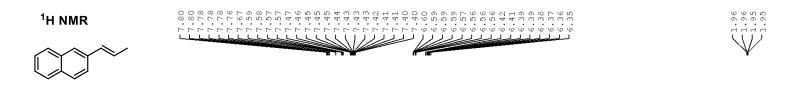


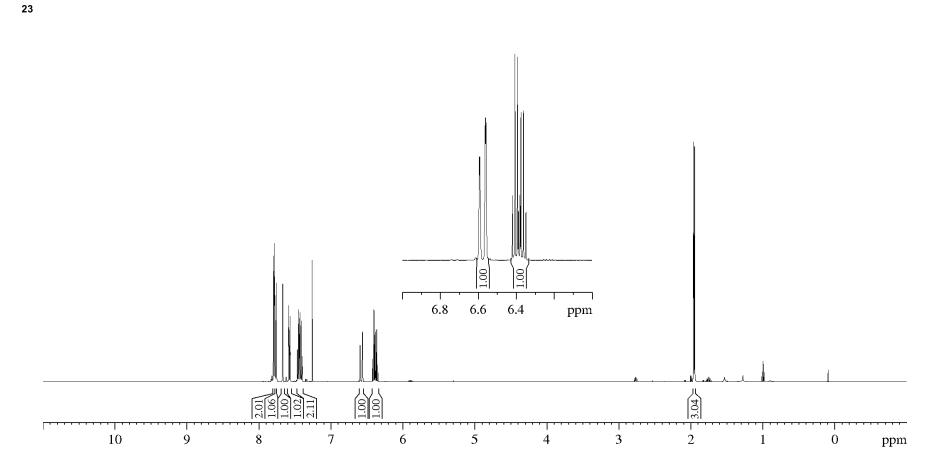


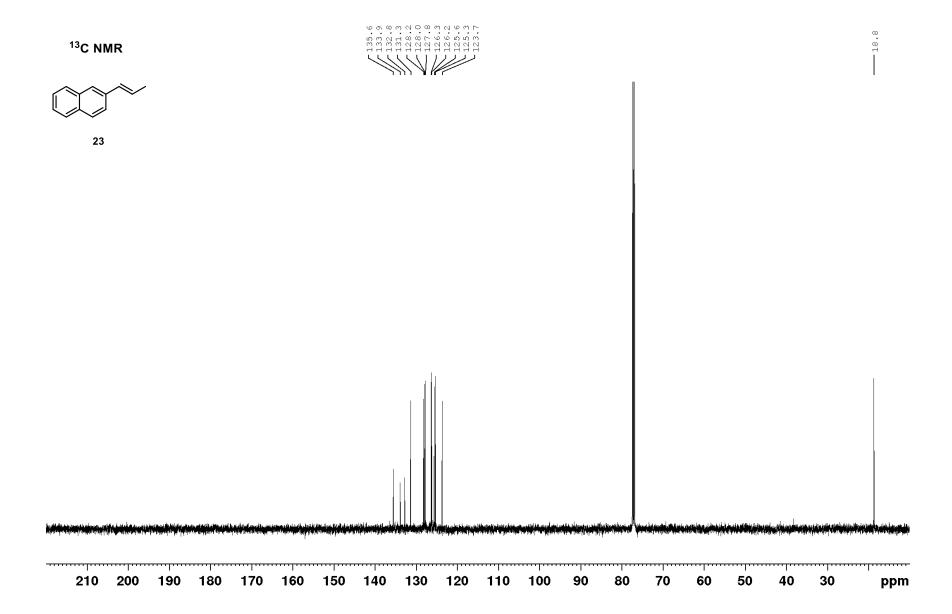


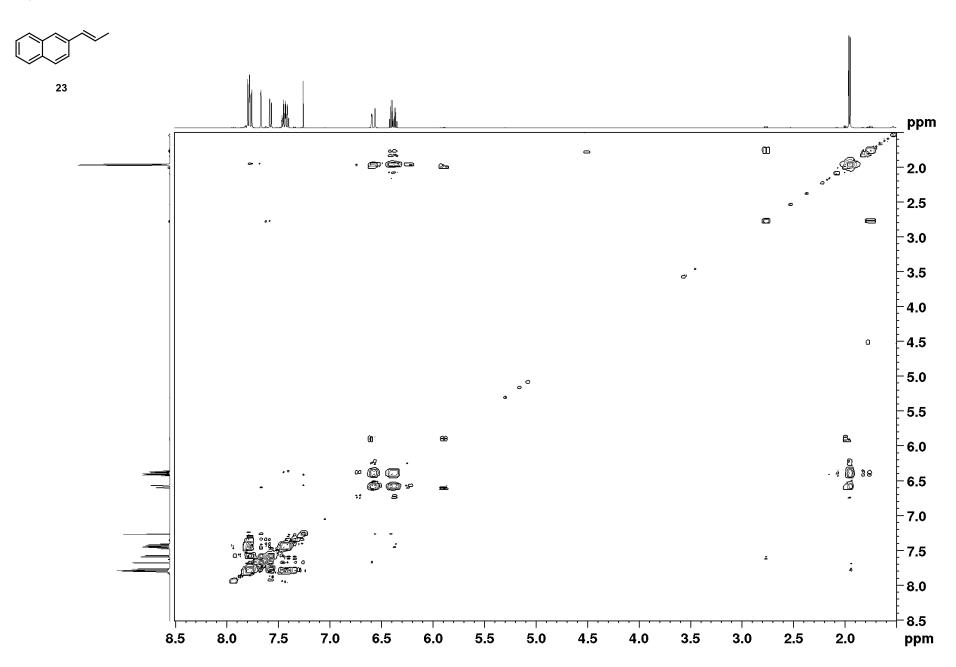


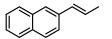




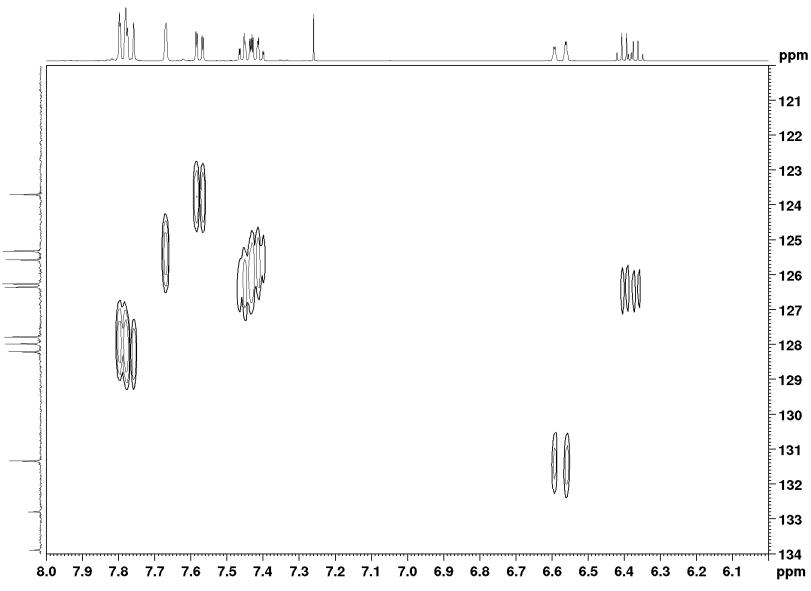


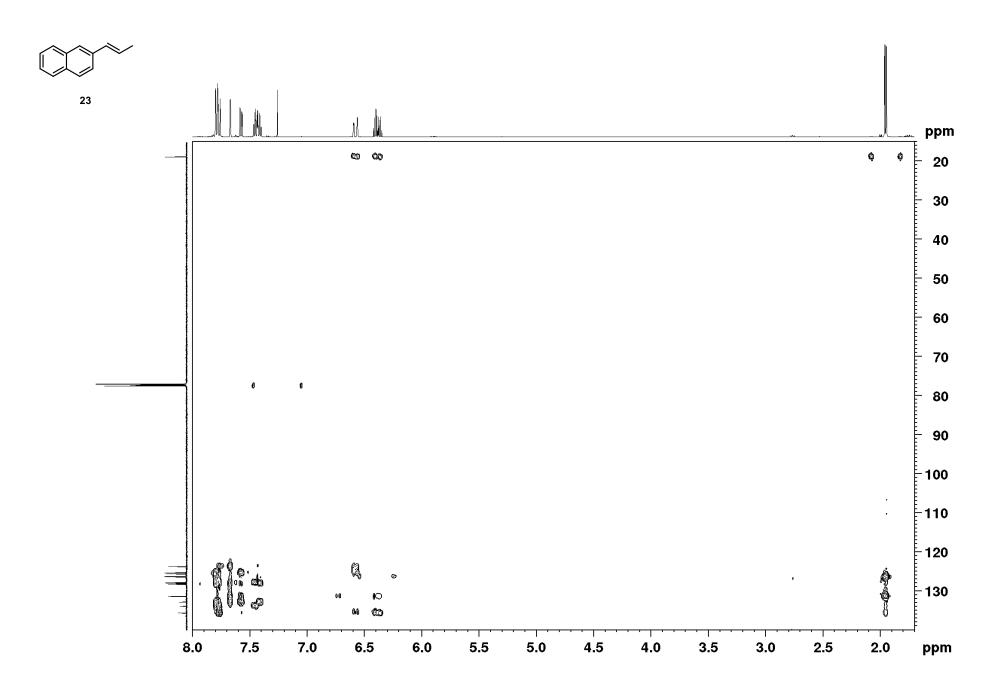


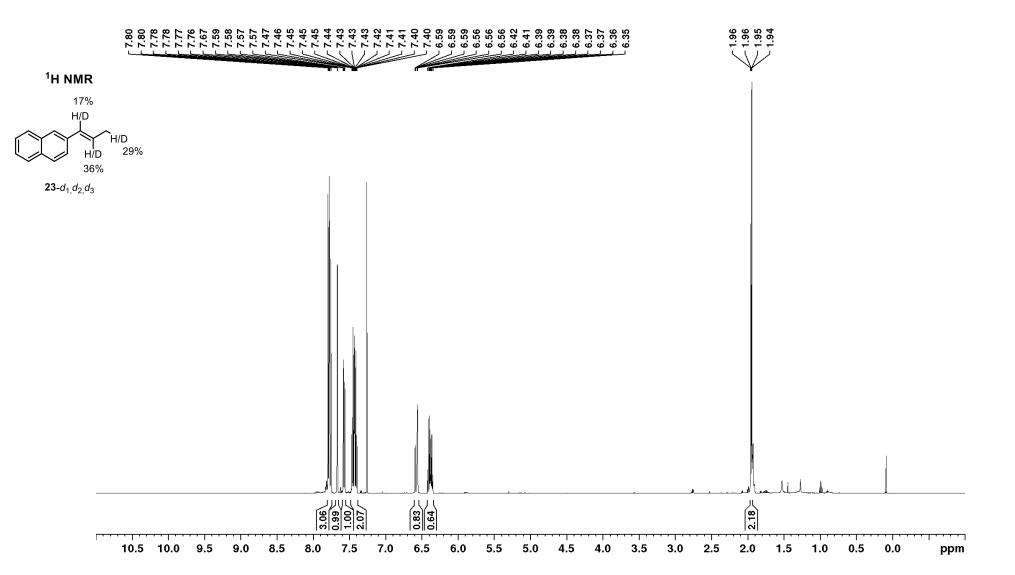


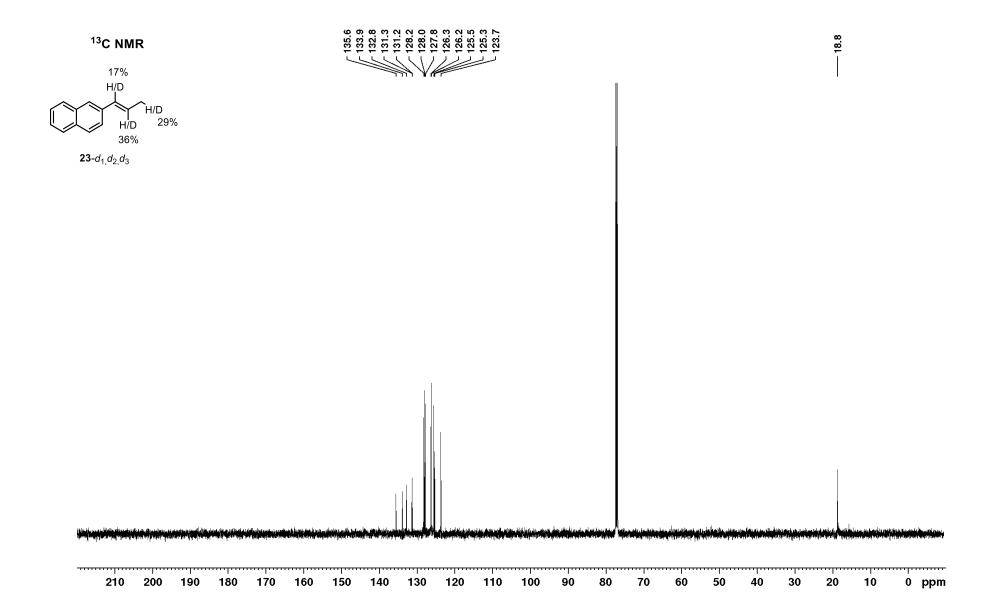




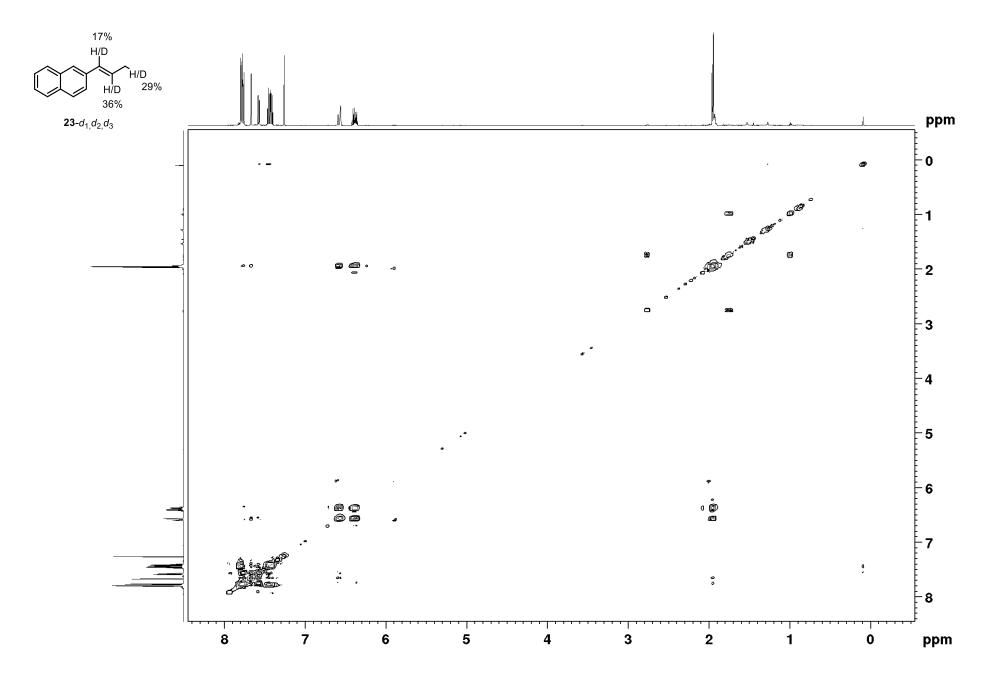




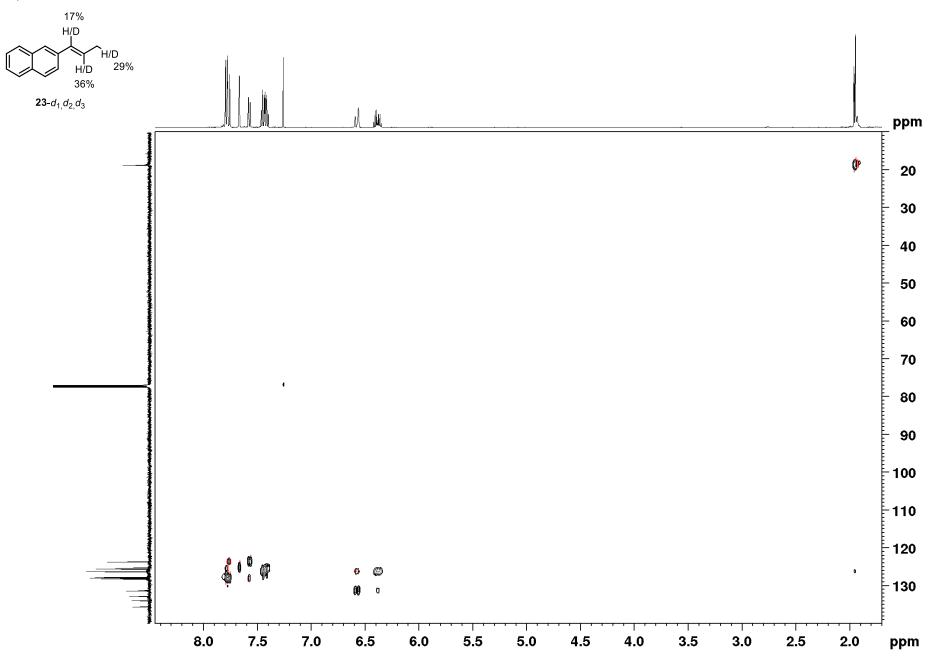




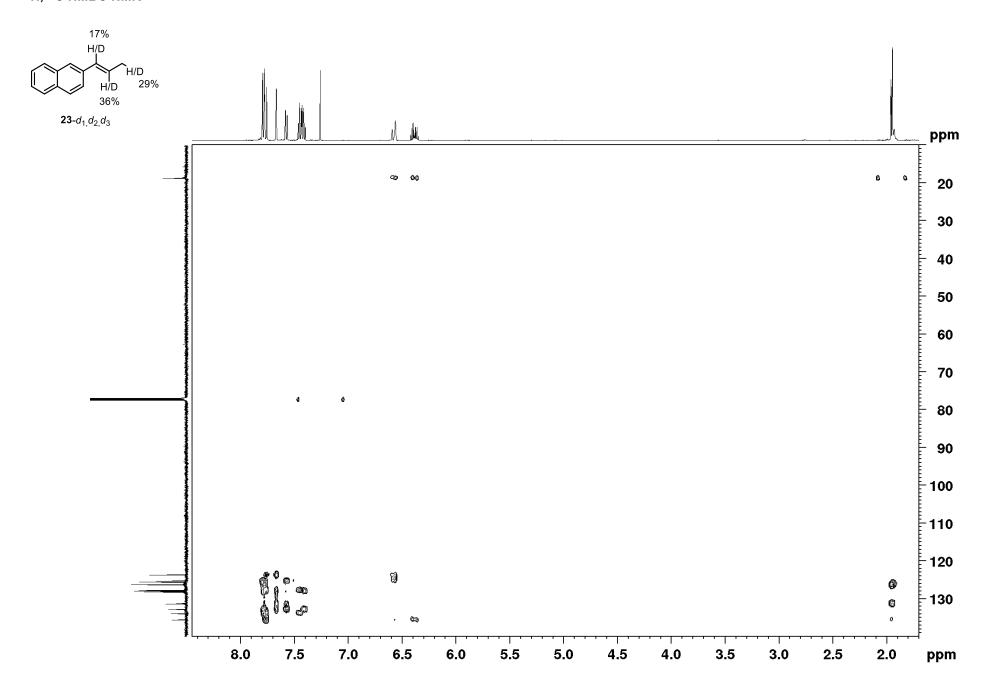
## <sup>1</sup>H, <sup>1</sup>H COSY NMR



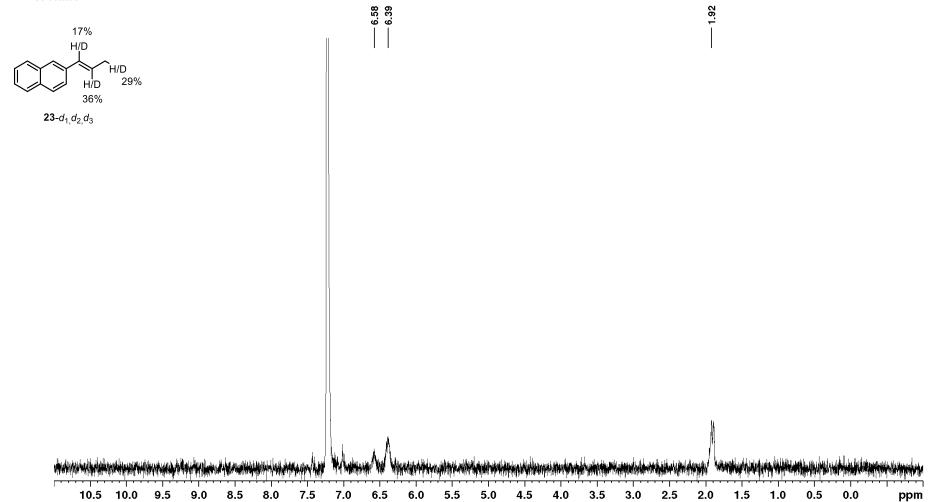


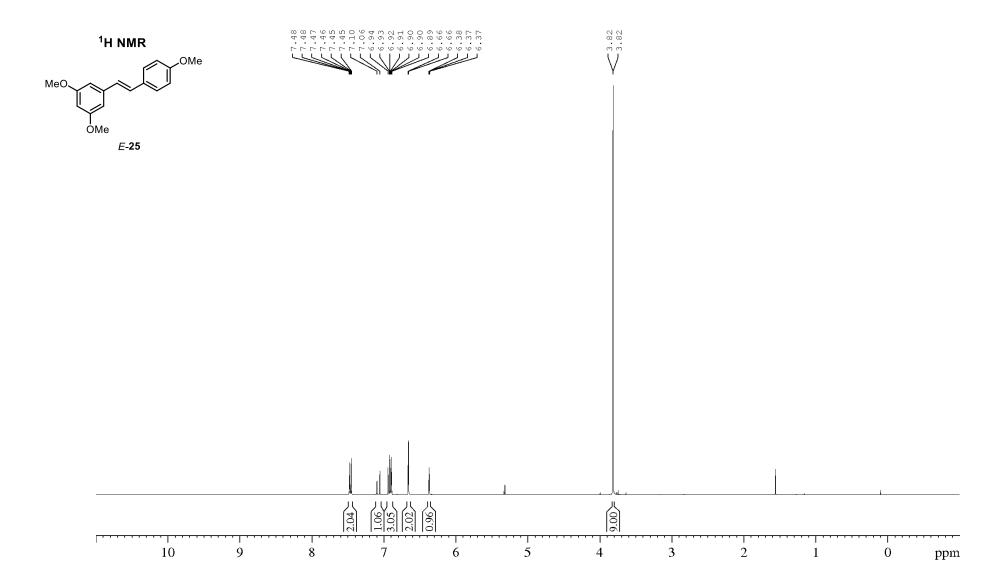


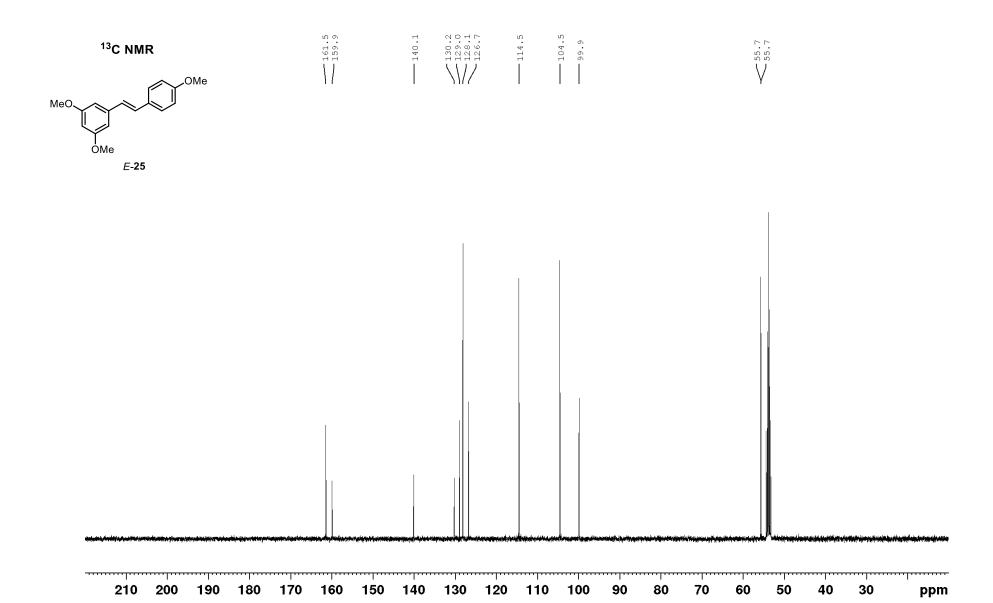
# <sup>1</sup>H,<sup>13</sup>C HMBC NMR

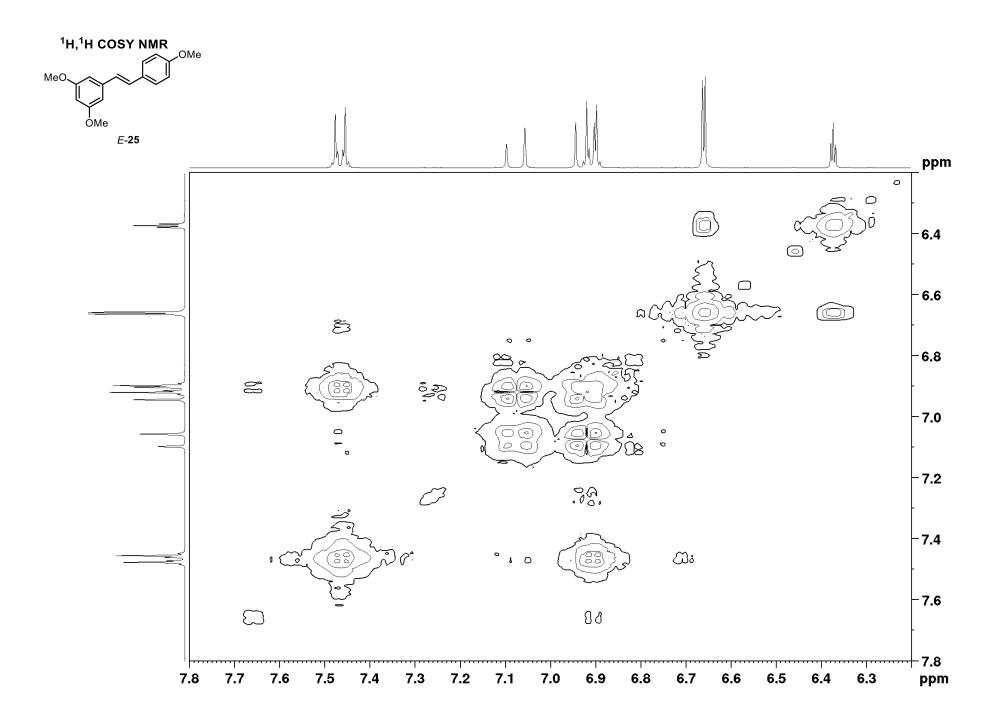




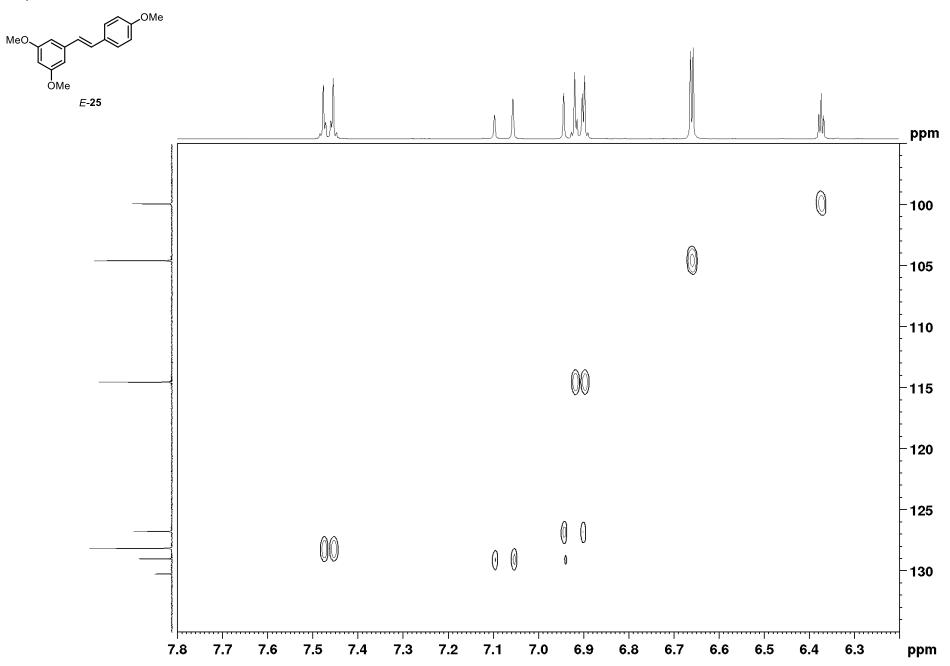




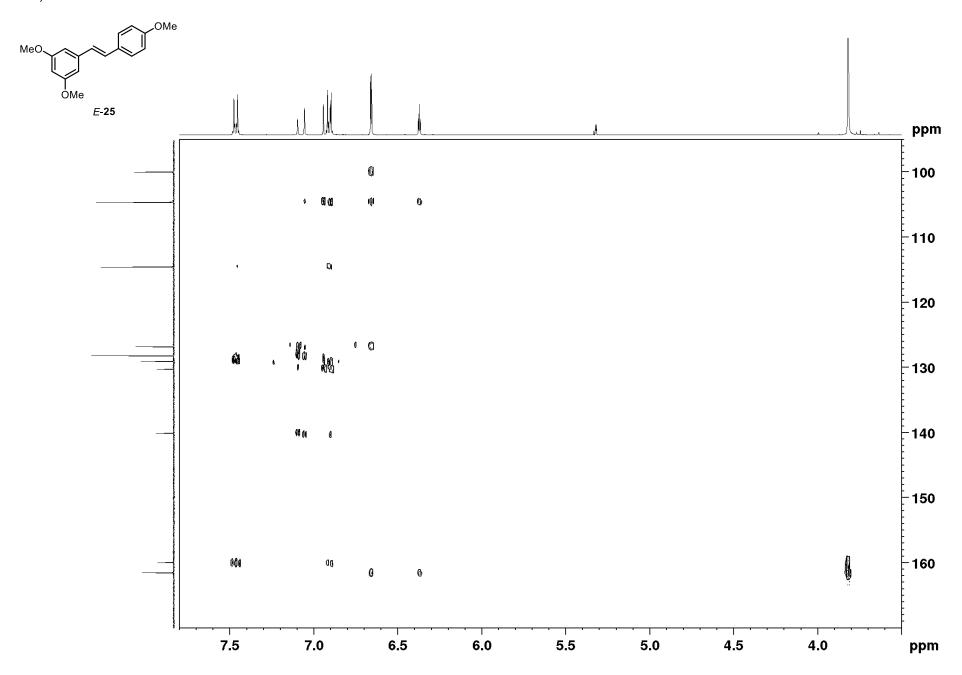




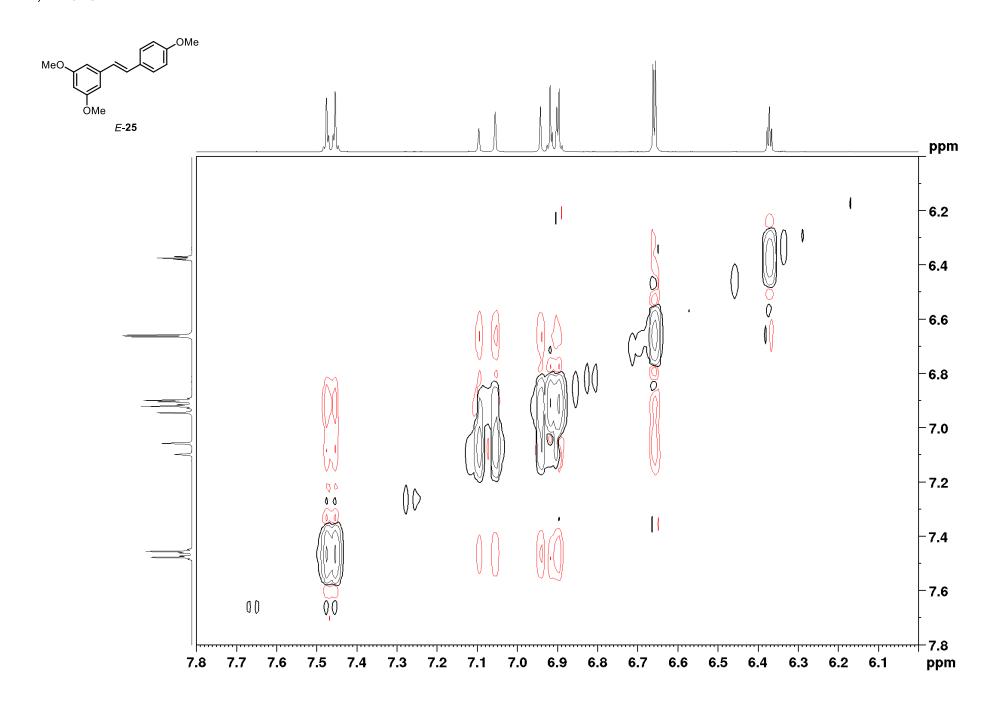


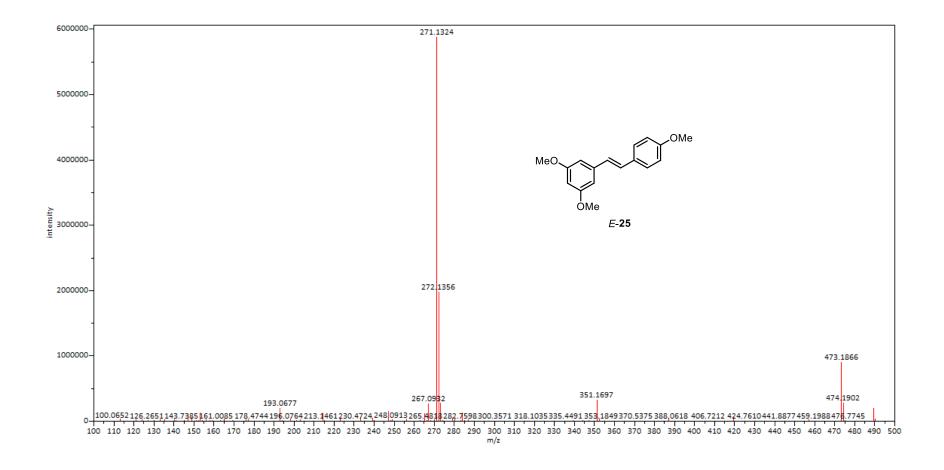


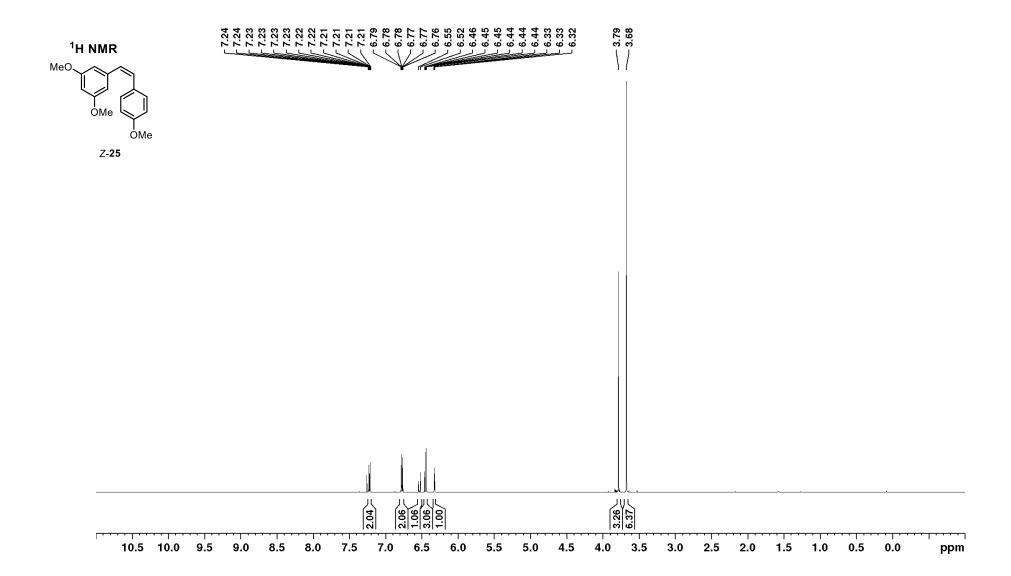
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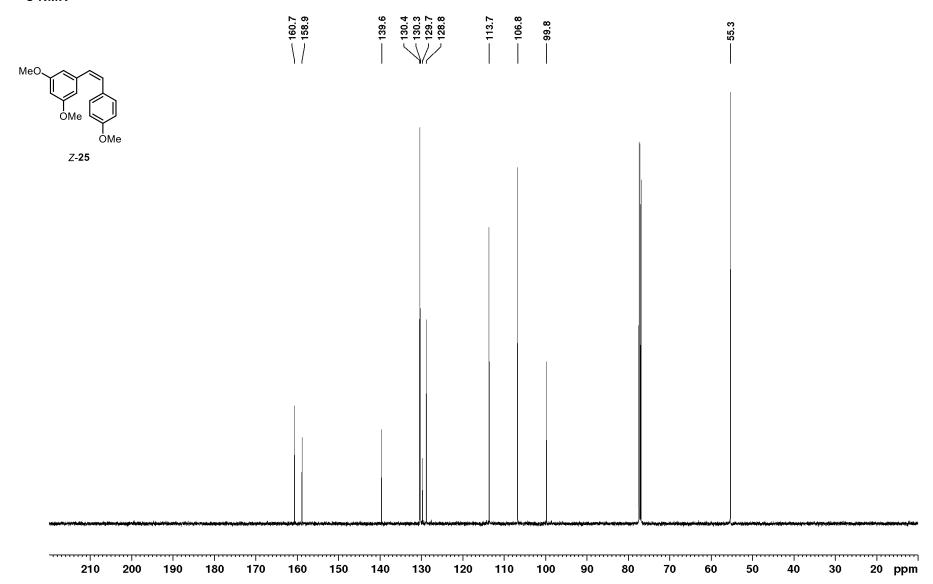
## <sup>1</sup>H, <sup>1</sup>H NOESY NMR



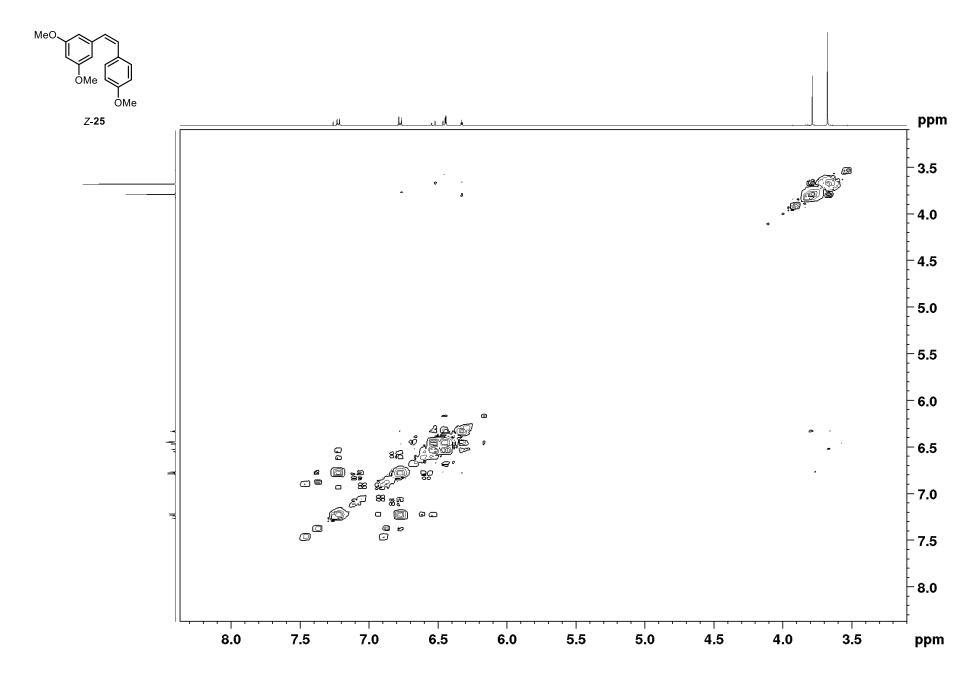




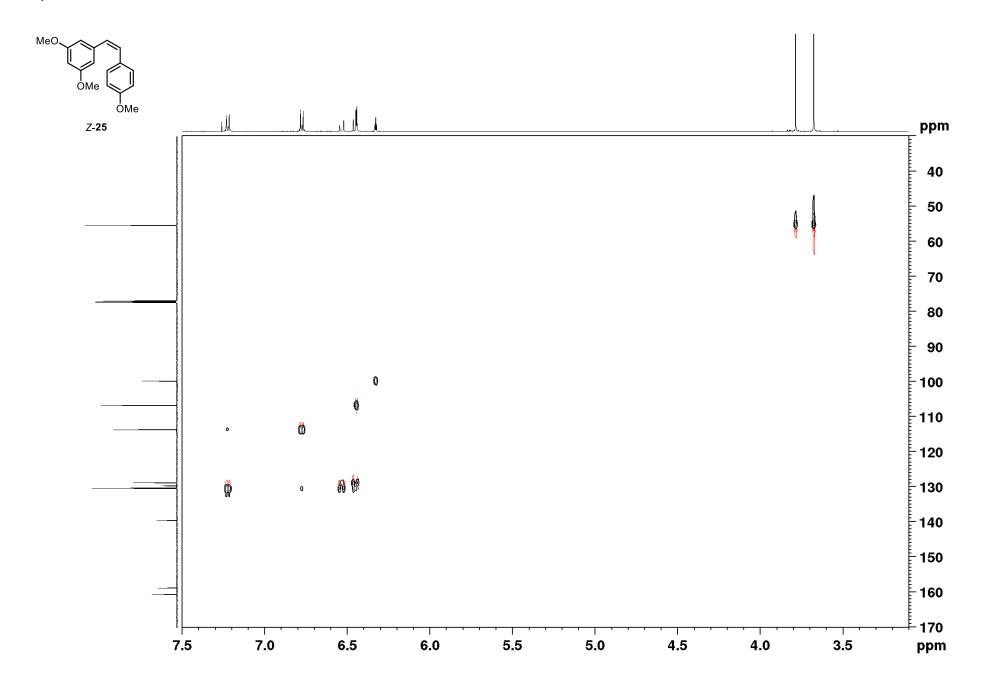




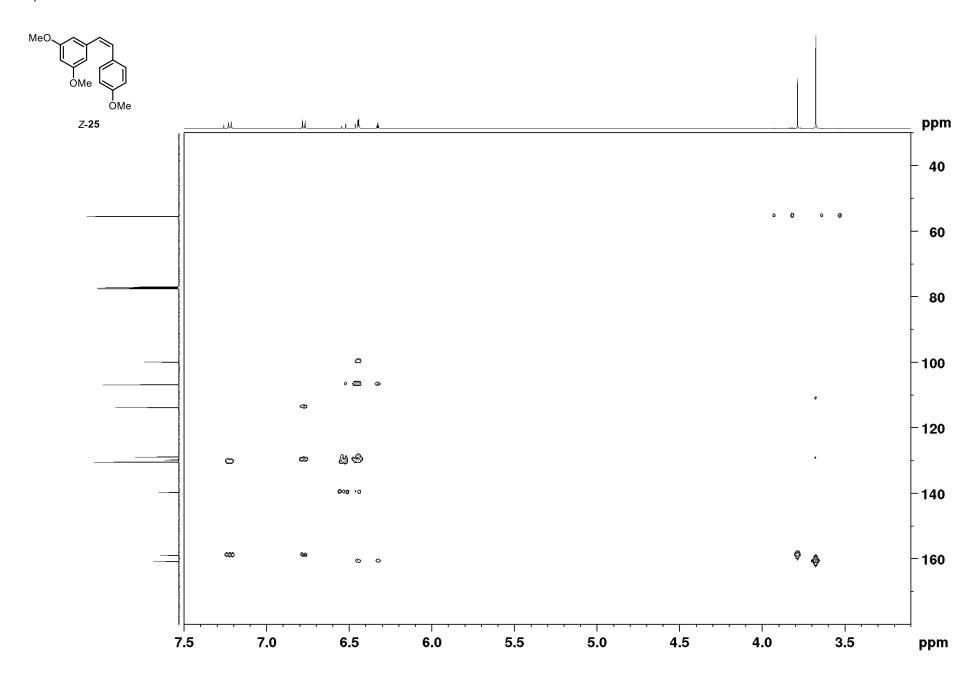
## <sup>1</sup>H, <sup>1</sup>H COSY NMR

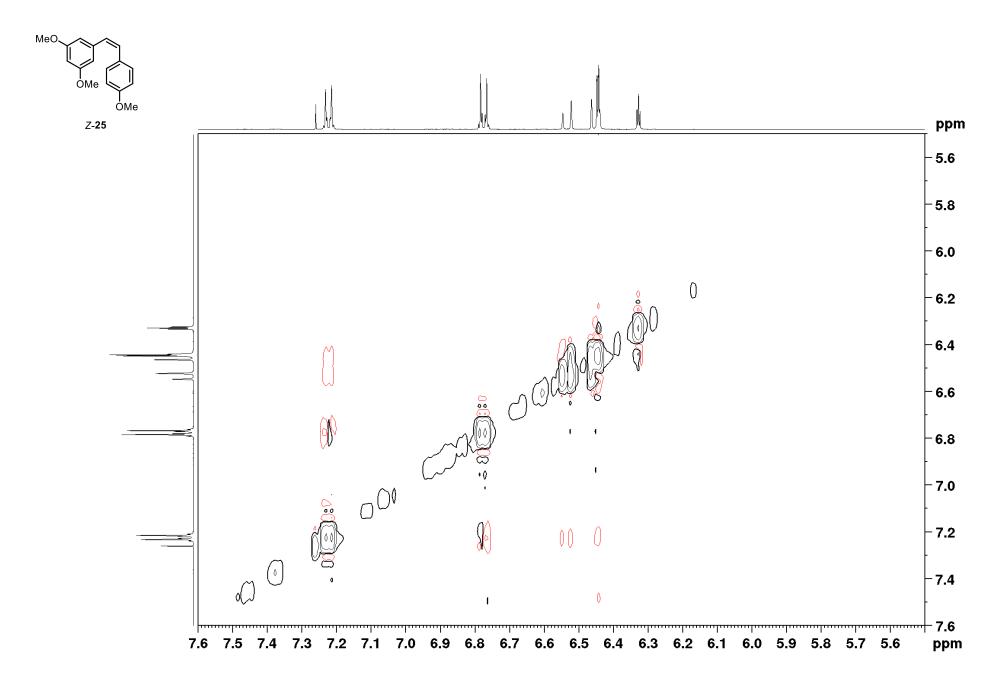


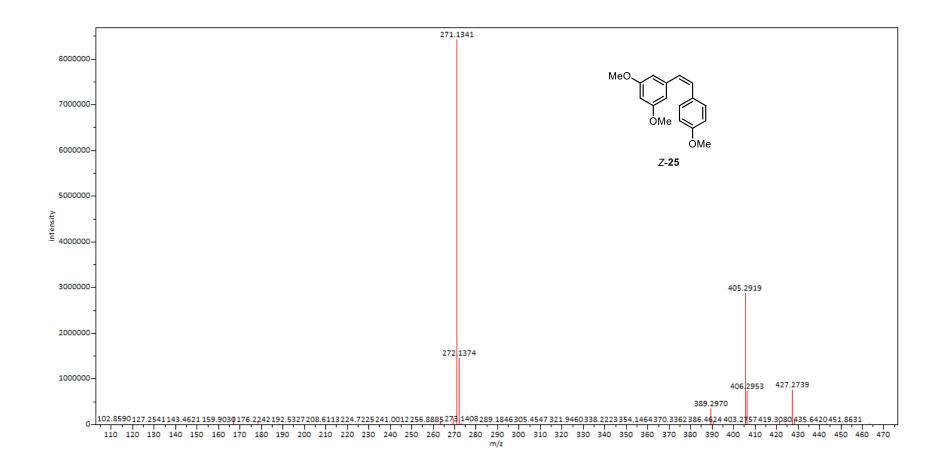
# <sup>1</sup>H,<sup>13</sup>C HSQC NMR

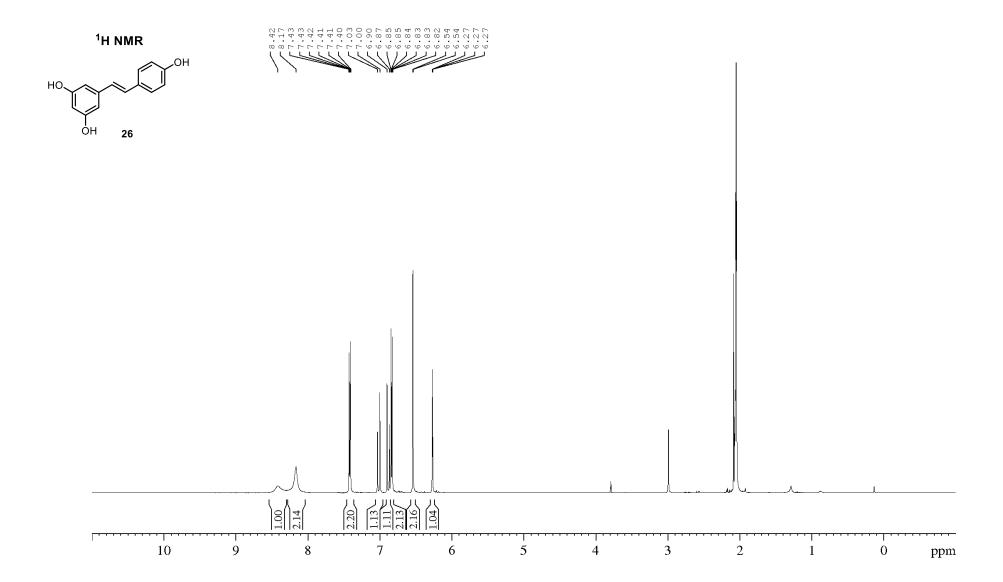


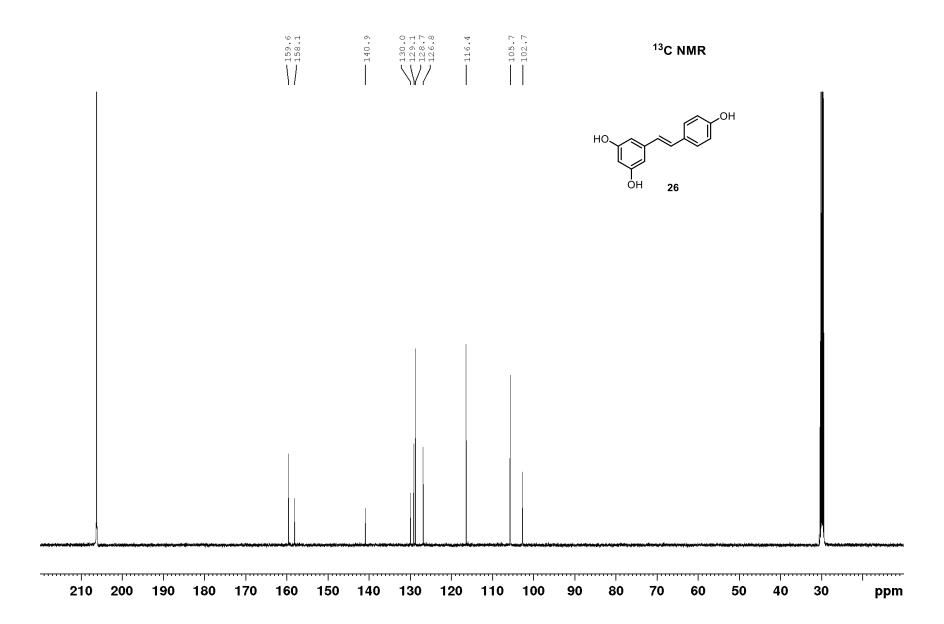
# <sup>1</sup>H,<sup>13</sup>C HMBC NMR



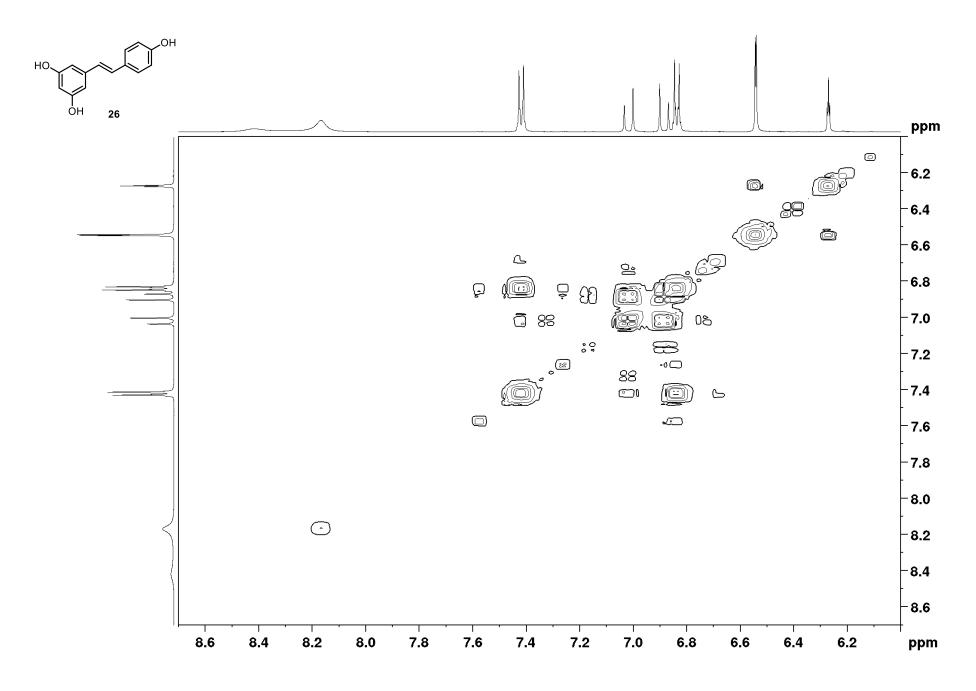


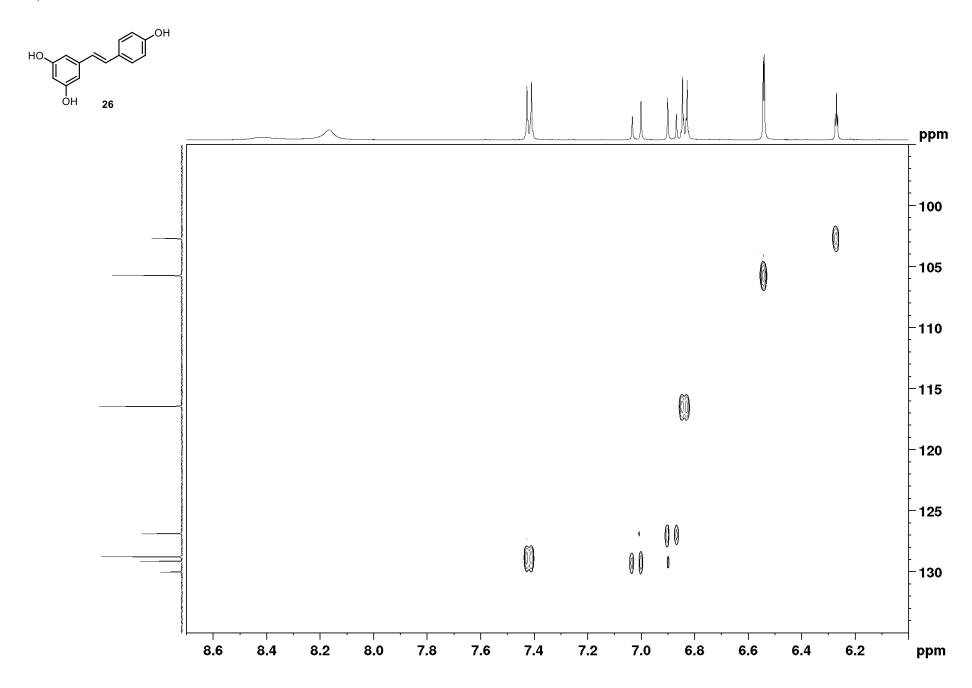


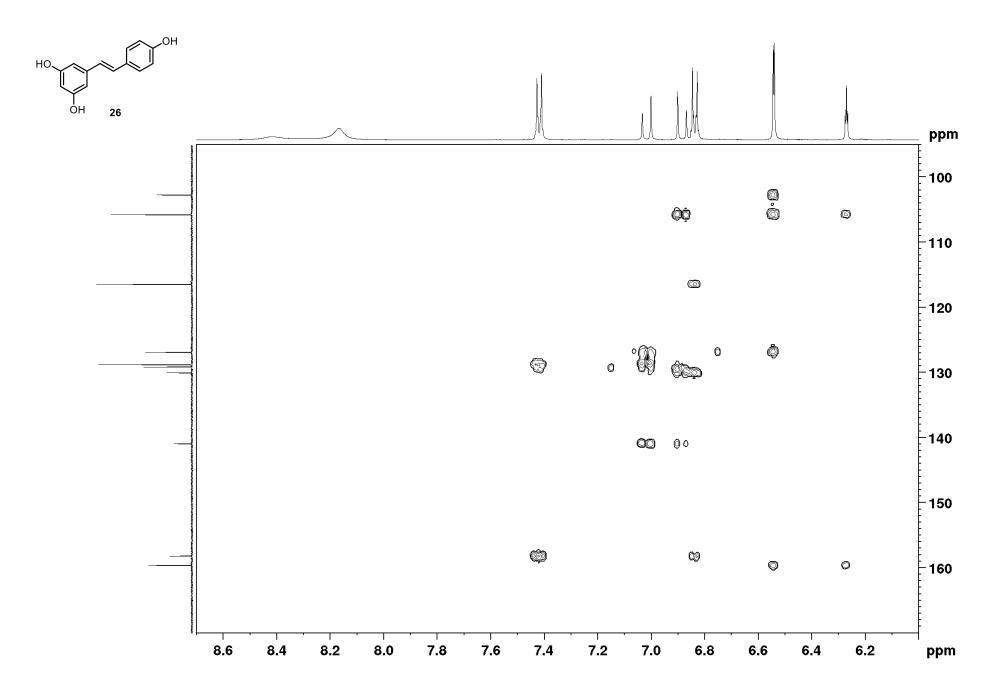




### <sup>1</sup>H, <sup>1</sup>H COSY NMR







### <sup>1</sup>H, <sup>1</sup>H NOESY NMR

