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A diastereoselective $\text{Co}_2(\text{CO})_8$ -mediated Pauson-Khand reaction (PKR) of siloxy-tethered 1,7-enynes for the synthesis of cyclopentaoxasilinones has been developed. This transformation can be performed on a multi-gram scale and is characterized by broad substrate scope, functional group compatibility, and high chemo- and diastereoselectivity. Oxidation of the resulting cyclopentaoxasilinones delivers stereo-enriched β -alkylated cyclopentenones, which are inaccessible by intermolecular PKRs. This research provides a practical solution to the challenges associated with the classical intermolecular PKR.

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Access to Highly Functionalized Cyclopentenones via Diastereoselective Pauson Khand Reaction of Siloxy-Tethered 1,7-Enynes

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ABSTRACT: A diastereoselective $\text{Co}_2(\text{CO})_8$ -mediated Pauson-Khand reaction (PKR) of siloxy-tethered 1,7-enynes for the synthesis of cyclopentaoxasilinones has been developed. This transformation can be performed on a multi-gram scale and is characterized by broad substrate scope, functional group compatibility, and high chemo- and diastereoselectivity. Oxidation of the resulting cyclopentaoxasilinones delivers stereoenriched β -alkylated cyclopentenones, which are inaccessible by intermolecular PKRs. This research provides a practical solution to the challenges associated with the classical intermolecular PKR.

Stereoselective strategies for the synthesis of densely functionalized cyclopentenones are highly sought after because they enable assembly of structural components present in a broad range of biologically active natural products (Scheme 1a).¹ The cobalt-mediated Pauson-Khand Reaction (PKR) exemplifies a convergent, atom-economical,² and fundamental reaction for the synthesis of cyclopentenones.³ Since Khand and Pauson's initial discovery in 1973,⁴ significant advances in the intermolecular PKR have been made.⁵ However, this reaction is generally limited to strained or symmetrical olefins due to the difficulty in controlling the alkene regio- and stereoselectivity (Scheme 1b).⁶ Pioneering studies by Riera and Verdager *et al.* have shown that chiral bidentate PuPhos, CamPhos, PNSO, and ThaxPhos ligands are efficient in cobalt-catalyzed asymmetric intermolecular PKRs. Notwithstanding, these studies are limited to the use of symmetrical and strained norbornadiene.⁷ Carretero and co-workers reported the first example of an asymmetric intermolecular PKR with unstrained olefins employing stoichiometric cobalt-alkyne complexes and *o*-(dimethylamino)phenyl vinyl sulfoxide as a chiral auxiliary.⁸ While intramolecular PKRs are showcased in numerous elegant total syntheses,⁹ the application of the intermolecular variant has been limited.¹⁰ Thus, a general stereoselective PKR strategy to access highly functionalized monocyclic cyclopentenones remains an unsolved challenge.

a) Representative bioactive cyclopentenoid natural products

b) The Intermolecular Pauson-Khand reaction (PKR)

c) This research: Si-O tethered diastereoselective PKR strategy

Scheme 1. (a) Cyclopentanoid natural products. (b) Challenges associated with the intermolecular PKR. (c) **This research:** Si-loxy-tethered diastereoselective PKR from propargyl alcohols.

A tactic to enhance reactivity and control regio- and stereoselectivity is to employ a removable tether, preferably one that allows further functionalization (Scheme 1c).¹¹ Silicon has proven a practical tethering element in a multitude of transformations.¹² It is particularly useful because it serves as a convenient retron for hydroxyl groups *via* Tamao–Fleming oxidation,^{13a–f} as well as a plethora of stereoselective transformations.^{13g} Prior reports of Si–O tethered PKRs suffer from unexpected by-products, low yields, and limited substrate scope.^{14a–f} Brummond’s group reported an example of an allenic Mo(CO)₆-mediated Si–O tethered PKR in 15 – 25% yields.^{14d} Dobbs *et al.* reported four examples with *diisopropyl* Si–O tethered 1,7-enynes derived from primary propargyl alcohols utilizing NMO promoted Co₂(CO)₈-mediated PKR conditions.^{14f} Similarly, Porter and co-workers^{14e} investigated Co₂(CO)₈-mediated PKRs of *diphenyl* Si–O tethered 1,7-enynes employing *n*-BuSMe¹⁵ as the promoter. In a single example, a secondary propargyl alcohol furnished the PKR product in low yield and diastereoselectivity (9%; 1:1.5 dr). Inspired by these reports, we hypothesized that utilizing Si–O tethered 1,7-enynes could lead to a highly diastereoselective PKR.¹⁶ An attractive feature of this approach is the use of enantioenriched secondary propargyl alcohols, readily accessible *via* a variety of well-established methods.^{17–19} Successful execution of such a tactic would provide otherwise difficult to access diastereoenriched β -alkylated cyclopentenones from readily accessible starting materials. (Scheme 1c). Central to our approach is the oxidative cleavage of the Si–C bond (*vide infra*; **7d** and **7f**, Scheme 5), which unveils useful allylic and homoallylic diol moieties for further structural and stereochemical augmentation.²⁰ In this Communication, we describe our efforts toward a cobalt-mediated diastereoselective Si–O tethered PKR of 1,7-enynes for the synthesis of cyclopentaoxasilinones. By employing a functionalizable silicon-tether, the methodology presented herein provides a practical solution to the challenges associated with the intermolecular PKR.

Optimization studies (Table 1) commenced with an evaluation of solvent, temperature, time, concentration, and promoters in the PKR of model substrate **1a** to afford cyclopentaoxasilinone **2a**. Treatment with 1.05 equiv of Co₂(CO)₈ with *N*-oxides^{21,22} at room temperature gave low yields (Table 1, Entries 1 – 2). Cyclohexylamine (CyNH₂) reported as an effective Lewis base promoter²³ led to similar results (22%; Entry 3). We were pleased to observe that upon treatment with 1.05 equiv of Co₂(CO)₈, 3.50 equiv of *n*-BuSMe in *o*-xylenes (0.1M) at 130°C for 12 h resulted in improved yields of **2a** (57%; Entry 6). Notably, reducing the reaction time from 24 h to 12 h did not negatively impact the yield (Entry 5 vs. Entry 6). However, 24 h was required to give comparable yields of **2a** at 110 °C in toluene (Entry 4). Based on Magnus’ proposed mechanism of the PKR,²⁴ Sugihara’s report,¹⁵ and seminal mechanistic studies by the groups of Krafft,^{25a} Nakamura,^{25b} Milet and Gimbert,^{25c} we reasoned that modulating the Lewis basicity of the thioether would impact the rate of alkene insertion and the overall rate of reaction as well as lead to improved yields. To test this hypothesis, we turned our attention to a variety of commercially available and readily accessible thioether additives. While PhSMe gave similar yields (55%; Entry 7) to *n*-BuSMe (57%; Entry 6), BnSMe and 4-OMeBnSMe led to an increase in yield of **2a** to 65% and 64% yields, respectively (Entries 8 – 9). Overall, we found 5.0 equiv of both commercially available furfuryl methyl sulfide

Table 1. Optimization Studies and Discovery of a Recoverable/Reusable PKR Promotor (4-FBnSMe)

Entry ^a	Solvent	Promotor	T (°C)	Time (h)	Yield (%) 2a ^e
1	DCE	NMO ^b	25	8	17
2	DCE	TMANO ^b	25	8	24
3	DCE	CyNH ₂ ^c	85	12	22
4	PhCH ₃	<i>n</i> -BuSMe ^c	110	24	47
5	<i>o</i> -xylenes	<i>n</i> -BuSMe ^c	130	24	55
6	<i>o</i> -xylenes	<i>n</i> -BuSMe ^c	130	12	57
7	<i>o</i> -xylenes	PhSMe ^c	130	12	55
8	<i>o</i> -xylenes	BnSMe ^c	130	12	65
9	<i>o</i> -xylenes	4-OMeBnSMe ^c	130	12	64
10	<i>o</i> -xylenes	furfurylSMe ^d	130	12	72
11	<i>o</i>-xylenes	4-FBnSMe^d	130	12	81
12	<i>o</i> -xylenes	---	130	12	36 ^f

^a1.0 equiv of **1a**, 0.33 mmol scale (0.10 M of solvent). ^b10 equiv. ^c3.5 equiv. ^d5 equiv. ^ePurified/isolated yields represent an average of 3 experiments. ^fPromotor omitted.

(furfurylSMe) or 4-fluorobenzyl(methyl)sulfide (4-FBnSMe), affords **2a** in improved yields (72% and 81% respectively; Entries 10 – 11). Moreover, 4-FBnSMe is conveniently prepared in one-step on a multi-gram scale, is recoverable *via* flash chromatography, and can be reused without loss of reactivity (83% average recovery; See ESI). A control experiment, in which the promotor was omitted (36%; Entry 12), demonstrates the value of 4-FBnSMe as a new, efficient, and recoverable/reusable thioether promotor in the PKR.

With optimized conditions in hand, we initiated a systematic study of the scope and limitation (R²; Scheme 2) of the Si–O

Scheme 2. Variation of Alkynyl Substituents^{a,b,c}

^a1.0 equiv of **1b-j**, 0.33 mmol scale (0.10 M). ^bPurified/isolated yields represent an average of 3 experiments. ^c83% average recovery of 4-FBnSMe.

tethered PKR of 1,7-enynes **1b–1j** containing a variety of alkynyl substituents. Unsubstituted enyne **1b** did not perform well under the current reaction conditions providing **2b** in 25% yield. Trimethylsilane substituted enyne **1c** gave a diminished yield of product **2c** (43%), despite a 24 h extended reaction time. In contrast, isopropyl substituted **2d** reached full conversion in 12 h and was isolated in 74% yield. Methoxymethyl-protected propargyl ether **2e** was furnished in 67% yield, providing an opportunity for post-PKR synthetic manipulations. Phenyl substituted **2f** was isolated in 79% yield while the electron-rich analogue (4-OMe) gave **2g** in a slightly diminished yield of 65%. Furthermore, electron-withdrawing *para*-substituted arenes **2h–j** were obtained in good yields and demonstrate excellent functional group compatibility; –CN (72%), –CO₂Me (76%), –CF₃ (77%).

Building on this initial success, we turned our attention to the development of a diastereoselective PKR from secondary propargyl alcohols (Scheme 3). Upon close examination of molecular models, we hypothesized that the sterically hindered *i*-Pr alkyl substituents of silicon would serve a dual purpose: (1) inducing a Thorpe–Ingold effect,²⁶ thereby increasing the rate of reaction, and (2) imparting a favorable steric influence on the transition state of the cycloaddition, which would lead to improved diastereoselectivity. As delineated in Scheme 3, alkyl substituted propargyl enynes **5a–b** provided products **6a–6b** in moderate selectivity (*syn/anti*; 6:1 and 3:1 dr, respectively) and in moderate yields (31% and 59%, respectively). On the other hand, phenyl substituted **6c** was furnished in high yield with similar selectivity (81%; 5.5:1 dr). Unsurprisingly, decomposition of enyne **5d** was observed *via* TLC analysis upon cobalt complexation,²⁷ and **6d** was not detected. However, benzyl substituted enyne **5e** provided the PKR product **6e** in high yield and selectivity (88% yield, and 13:1 dr). We also performed the reaction with this substrate on gram scale attesting to the robust nature of the reaction (1.13 g, 3.0 mmol of enyne **5e**). Extending the carbon chain length by one methylene unit gave product **6f** in 84% yield, albeit with diminished selectivity (4:1 dr). In all cases, mixtures of diastereomers were readily separable *via* simple flash chromatography. *Much to our delight, enyne 5g with an appended allyl group provided the product 6g in 87% isolated yield as a single diastereomer (>20:1 dr) on a 2.5-gram scale of enyne 5g (7.65 mmol)!* Remarkably, extending the carbon chain length by two methylene groups before the terminal olefin led to a completely chemo- and diastereoselective PKR that furnished the product **6i** in excellent yield (89%). The alternative PKR product, where the terminal olefin engages with the cobaltacycle for the cyclization event instead of the allyl silane, is not detected. By contrast, omitting the olefinic moiety from the starting material furnishes products **6h** and **6j** in good yields (70% and 68%, respectively), however with diminished selectivity (3.5:1 and 4:1 dr, respectively). To our surprise, enyne **5k** with a methyl substituent on the alkynyl position provided product **6k** in high yield and diastereoselectivity (81%; 12:1 dr), which is in contrast with the results observed for **6a–6b** (*vide supra*).

Demonstrated in Scheme 4 is the use of propargyl alcohol (–)-**S15** of 95:5 er (90% *ee*) for the synthesis of enyne (–)-**5g** (81% yield; See ESI). Following our optimized PKR conditions, optically active cyclopentaoxasilinone (–)-**6g** was furnished in 92% yield with 98.5:1.5 er (97% *ee*), presumably as a result of adventitious enantiomeric enrichment during purification of enyne (–)-**5g** and PKR product (–)-**6g**.²⁸ In all cases,

Scheme 3. Scope and Limitation of the Diastereoselective Siloxy-Tethered PKR^{a,b,c,d}

^a 1.0 equiv of (±)-**5a–k**, 0.33 mmol scale (0.10 M) unless otherwise noted. ^b Purified/isolated yields represent an average of 3 experiments. ^c 83% average recovery of 4-FBnSMe. ^d Diastereomer ratios were measured by ¹H NMR analysis of the unpurified material.

as illustrated in Schemes 3 and 4, the major PKR product possesses a *syn* relationship between the propargylic proton and the bridgehead proton of the newly formed stereocenter. The connectivity and selectivity of products **6a–k** was

Scheme 4. Synthesis of Enantio- and Diastereoenriched Cyclopentaoxasilinone (–)-6g**^{a,b}**

^a The er value was determined by chiral HPLC analysis. ^b Diastereomer ratios were measured by ¹H NMR analysis of the unpurified material.

unambiguously established by single-crystal X-ray diffraction studies or by analysis of 2D NOESY experiments (See ESI). The improvement in diastereoselectivity observed for cyclopentaoxasilinones **6e**, **6g**, **6i**, and **6k** is intriguing because it: (1) implicates the appended π -component as the key structural element for control of diastereoselectivity, (2) expands the synthetic utility of the products *via* a terminal olefin that provides a versatile handle for further synthetic manipulations, and (3) accommodates alkyl groups at the alkynyl position, whilst maintaining high yields and selectivity (*cf.* **6k** and **6a–6b**).

As illustrated in Scheme 5, highly diastereoselective transformations of cyclopentaoxasilinone **6e** and **6g** rapidly

Scheme 5. Stereoselective Reactions Involving Cyclopentaoxasilinones (6e**) and (**6g**) Showcasing Utility^a**

^aDiastereomer ratios were measured by ¹H NMR analysis of the unpurified material.

introduce stereochemical complexity and structural diversity for the synthesis of useful synthetic building blocks.²⁹ For example, subjecting **6g** to cerium(III)-mediated Luche reduction³⁰ affords allylic alcohol **7a** in 63% yield, which is poised for substrate-directed stereoselective transformations.²⁰ Treatment of **6e** and **6g** with basic hydrogen peroxide provides **7e** and **7b** in 66% and 68% yields, respectively. Importantly these compounds were isolated as single diastereomers and are endowed with four contiguous stereocenters and an epoxide that can be opened in stereoselective fashion with a variety of nucleophiles. The stereochemical outcome is consistent with nucleophilic attack from the more sterically accessible convex face of the cyclopentaoxasilinone structure. Scission of the Si–O bond furnished silanol **7c** in a 51% yield. Oxidative cleavage of the Si–C bond¹³ in **6e** and **6g** delivered the desired monocyclic cyclopentenones **7d** in 42% (brsm; based on the re-

covery of starting material **6g**), and **7f** in 40% unoptimized yields. Notably, functionalized cyclopentenones **7a–7f** were obtained as single diastereomers and confirmed *via* X-ray crystallographic analysis or 2D NOESY experiments (See ESI). The accessible nature of the precursors, modular one-step synthesis of the enynes, and the scalability of the siloxy-tethered PKR reaction bodes well for future synthetic applications.

In summary, we have developed a diastereoselective Si–O tethered Pauson-Khand reaction that utilizes readily available propargyl alcohols for the synthesis of cyclopentaoxasilinones. The strategy presented provides stereo-enriched/highly functionalized cyclopentenones that are otherwise not accessible *via* intermolecular PKRs. For example, oxidative cleavage of the Si–C bond, enables access to stereo-enriched β -alkylated cyclopentenones with pendant homo- and allylic diol moieties. A recoverable/reusable thioether, namely 4-fluorobenzyl(methyl)sulfide (4-FBnSMe) was found to promote the reaction in improved yields. The utility of the PKR products is showcased in highly diastereoselective transformations to furnish cyclopentenones with multiple functional groups and stereocenters. Moreover, the cyclopentaoxasilinones are structural chemotypes that are of broad scientific interest.²⁹ We are currently working on understanding the selectivity and the fascinating role of the appended olefin/benzyl groups through a combination of computational and experimental studies. Further extensions of this method and applications in the total synthesis of natural products are currently ongoing in our Laboratory and will be reported in due course.

ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge on the ACS Publications website.

Detailed experimental procedures, characterization data, and NMR spectra for all new compounds (PDF)

Accession Codes

CCDC 1944608 – 1944611 contain the supplementary crystallographic data for this paper. These data can be obtained free of charge *via* www.ccdc.cam.ac.uk/data_request/cif, or by emailing data_request@ccdc.cam.ac.uk, or by contacting The Cambridge Crystallographic Data Centre, 12 Union Road, Cambridge CB2 1EZ, UK; fax: +44 1223 336033.

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Notes

The authors declare no competing financial interest.

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REFERENCES

- (1) For selected reviews, see: (a) Simeonov, S. P.; Nunes, J. P. M.; Guerra, K.; Kurteva, V. B.; Afonso, C. A. M. *Chem. Rev.*, **2016**, *116*, 5744 – 5893. (b) Aitken, D. J.; Eijlsberg, H.; Frongia, A.; Ollivier, J.; Piras, P. P. *Synthesis*, **2014**, 46, 00010 – 00024, DOI: 10.1055/s-0033-1340414.
- (2) Trost, B.M. *Science*, **1991**, *254*, 1471–1477.
- (3) (a) R. Rios Torres, *The Pauson Khand Reaction: Scope, Variations, and Applications*, John Wiley & Sons, Ltd., Chichester, U.K., 2012; For selected PKR reviews, see: (b) Ricker, J. D.; Geary, L. M. *Topics in Catalysis*, **2017**, *60*, 609 – 619. (c) Shi, L.; Yang, Z. *Eur. J. Org. Chem.*, **2016**, 2356 – 2368. (d) Lee, H.-W.; Kwong, F.-Y. *Eur. J. Org. Chem.*, **2010**, 789 – 811.
- (4) For seminal PKR publications, see: (a) Khand, I. U.; Knox, G. R.; Pauson, P. L.; Watts, W. E.; Foreman, M. I. *J. Chem. Soc., Perkin Trans. 1*, **1973**, 977 – 981 (b) Khand, I. U.; Knox, G. R.; Pauson, P. L.; Watts, W. E.; *J. Chem. Soc., Perkin Trans. 1*, **1973**, 975 – 977.
- (5) For intermolecular PKR reviews, see: (a) Gibson, S. E.; Mainolfi, N. *Angew. Chem. Int. Ed.*, **2005**, *44*, 3022 – 3037. (b) Laschat, S.; Becheanu, A.; Bell, T.; Baro, A. *Synlett*, **2005**, 17, 2547 – 2570.
- (6) For recent advances in the cobalt-catalyzed intermolecular PKR: (a) Kizirian, J.-C.; Aiguabella, N.; Pesquer, A.; Fustero, S.; Bello, P.; Verdager, X.; Riera, A. *Org. Lett.*, **2010**, *12*, 5620 – 5623. (b) Revés, M.; Lledó, A.; Ji, Y.; Blasi, E.; Riera, A.; Verdager, X. *Org. Lett.*, **2012**, *14*, 3534 – 3537. (c) Fager-Jokela, E.; Muuronen, M.; Khaizourane, H.; Vázquez-Romero, A.; Verdager, X.; Riera, A.; Helaja, J. *J. Org. Chem.*, **2014**, *79*, 10999 – 11010. (d) Cabré, A.; Verdager, X.; Riera, A. *Synthesis*, **2017**, 49, A – G, DOI: 10.1055/s-0036-1588813.
- (7) (a) Lledó, A.; Solà, J.; Verdager, X.; Riera, A.; Maestro, M. A. *Adv. Synth. Catal.*, **2007**, *349*, 2121 – 2128. (b) Sola, J.; Revés, M.; Riera, A.; Verdager, X. *Angew. Chem. Int. Ed.*, **2007**, *46*, 5020 – 5023. (c) Revés, M.; Achard, T.; Solà, J.; Verdager, X.; Riera, A.; Helaja, J. *J. Org. Chem.*, **2008**, *73*, 7080 – 7087. (d) Ferrer, C.; Riera, A.; Verdager, X. *Organometallics*, **2009**, *28*, 4571 – 4576. (e) Ji, Y.; Riera, A.; Verdager, X. *Org. Lett.*, **2009**, *11*, 4346 – 4349. (f) Orgué, S.; León, T.; Riera, A.; Verdager, X. *Org. Lett.*, **2015**, *17*, 250 – 253.
- (8) (a) Rodríguez Rivero, M.; De la Rosa, J. C.; Carretero, J. C. *J. Am. Chem. Soc.*, **2003**, *125*, 14992 – 14993. (b) Rodríguez Rivero, M.; Alonso, I.; Carretero, J. C. *Chem. Eur. J.*, **2004**, *10*, 5443 – 5459.
- (9) (a) Miller, K. A.; Martin, S. F. *Org. Lett.*, **2007**, *9*, 1113 – 1116. (b) Liu, D. D.; Sun, T. W.; Wang, K. Y.; Lu, Y.; Zhang, S. L.; Li, Y. H.; Jiang, Y. L.; Chen, J. H.; Yang, Z. *J. Am. Chem. Soc.*, **2017**, *139*, 5732 – 5735. (c) Zhao, N.; Yin, S.; Xie, S.; Yan, H.; Ren, P.; Chen, G.; Chen, F.; Xu, J. *Angew. Chem. Int. Ed.*, **2018**, *57*, 3386 – 3390. (d) Zhang, W.; Ding, M.; Li, J.; Guo, Z.; Lu, M.; Chen, Y.; Liu, L.; Shen, Y. H.; Li, A. *J. Am. Chem. Soc.*, **2018**, *140*, 4227 – 4231.
- (10) For rare examples of intermolecular PKRs in total synthesis of natural products, see: (a) Iqbal, M.; Evans, P.; Lledó, A.; Verdager, X.; Pericàs, M. A.; Riera, A.; Loeffler, C.; Sinha, A. K.; Mueller, M. *J. Chembiochem*, **2005**, *6*, 276 – 280. (b) Jiang, B.; Li, M.-M.; Xing, P.; Huang, Z.-G. *Org. Lett.*, **2013**, *15*, 871 – 873. (c) Rodriguez, R. A.; Barrios Steed, D.; Kawamata, Y.; Su, S.; Smith, P. A.; Steed, T. C.; Romesberg, F. E.; Baran, P. S. *J. Am. Chem. Soc.*, **2014**, *136*, 15403 – 15413.
- (11) F. Diederich and P. J. Stang, *Templated Organic Synthesis*, Wiley-VCH, Verlag GmbH, D-69469 Weinheim, Federal Republic of Germany, 2000.
- (12) For seminal research employing silicon tethers, see: (a) Nishiyama, H.; Kitajima, T.; Matsumoto, M.; Itoh, K. *J. Org. Chem.*, **1984**, *49*, 2298 – 2300. (b) Stork, G.; Kahn, M. *J. Am. Chem. Soc.*, **1985**, *107*, 500 – 501; For a review, see: (a) Bracegirdle, S.; Anderson, E. A. *Chem. Soc. Rev.*, **2010**, *39*, 4114 – 4129.
- (13) For seminal Tamao-Fleming reports, see: (a) Tamao, K.; Akita, M.; Kumada, M. *J. Organomet. Chem.*, **1983**, *254*, 13 – 22. (b) Tamao, K.; Ishida, N.; Tanaka, T.; Kumada, M. *Organometallics*, **1983**, *2*, 1694 – 1696. (c) Tamao, K.; Kakui, T.; Akita, M.; Iwahara, T.; Kanatani, R.; Yoshida, J.; Kumada, M. *Tetrahedron*, **1983**, *39*, 983 – 990. (d) Fleming, I.; Henning, R.; Plaut, H. *J. Chem. Soc., Chem. Commun.*, **1984**, 29 – 31. (e) Tamao, K.; Ishida, N. *J. Organomet. Chem.*, **1984**, 269, C37 – C39. (f) Fleming, I.; Sanderson, P. E. *J. Tetrahedron Lett.*, **1987**, *28*, 4229 – 4232. For a review on stereoselective silicon transformations, see: (g) Fleming, I.; Barbero, A.; Walter, D. *Chem. Rev.*, **1997**, *97*, 2063 – 2192.
- (14) (a) Kagoshima, H.; Hayashi, M.; Hashimoto, Y.; Saigo, K. *Organometallics*, **1996**, *15*, 5439 – 5441. (b) Reichwein, J. F.; Iacono, S. T.; Pagenkopf, B. L. *Tetrahedron*, **2002**, *58*, 3813 – 3822. (c) Reichwein, J. F.; Iacono, S. T.; Patel, M. C.; Pagenkopf, B. L.; *Tetrahedron Lett.*, **2002**, *43*, 3739 – 3741. (d) Brummond, K. M.; Sill, P. C.; Rickards, B.; Geib, S. J. *Tetrahedron Lett.*, **2002**, *43*, 3735 – 3738. (e) Ishaq, S.; Porter, M. J. *Synthetic Communications*, **2006**, *36*, 547 – 557. (f) Dobbs, A. P.; Miller, I. J.; Martinovic, S. *Beilstein J. Org. Chem.*, **2007**, *3*, No. 21.
- (15) Sugihara, T.; Yamada, M.; Yamaguchi, M.; Nishizawa, M. *Synlett*, **1999**, 771 – 773.
- (16) For rare examples of PKRs employing enantioenriched propargyl alcohols, see: (a) Cai, H.; Nie, J.; Zheng, Y.; Ma, J.-A. *J. Org. Chem.*, **2014**, *79*, 5484 – 5493. (b) Chen, W.; Tay, J.-H.; Ying, J.; Yu, X.-Q.; Pu, L. *J. Org. Chem.*, **2013**, *78*, 2256 – 2265. (c) Turlington, M.; Yue, Y.; Yu, X.-Q.; Pu, L. *J. Org. Chem.*, **2010**, *75*, 6941 – 6952. (d) Sezer, S.; Özdemirhan, D.; Sahin, E.; Tanyeli, C. *Tetrahedron Asymmetry*, **2006**, *17*, 2981 – 2986. (e) Stumpf, A.; Hwang, S. H.; Kim, J. S.; Jeong, N. *Bull. Korean Chem. Soc.*, **2004**, *25*, 1621 – 1622.
- (17) Asymmetric transfer hydrogenation: a) Matsumura, K.; Hashiguchi, S.; Ikariya, T.; Noyori, R. *J. Am. Chem. Soc.*, **1997**, *119*, 8738 – 8739; Asymmetric hydrogenation: b) Noyori, R.; Okuma, T.; Tsutsumi, K.; Utsumi, N.; Murata, K. US pat. US20070225528, 2007; Jap. pat., JP2010285443, 2010; c) Arai, N.; Satoh, H.; Utsumi, N.; Murata, K.; Tsutsumi, K.; Ohkuma, T. *Org. Lett.*, **2013**, *15*, 3030 – 3033.
- (18) For a review on asymmetric allylations, see: Yus, M.; Gonzalez-Gomez, G. C.; Foubelo, F. *Chem. Rev.*, **2013**, *113*, 5595 – 5698.
- (19) Asymmetric alkynylations: (a) Frantz, D. E.; Fässler, R.; Tomooka, C. S.; Carreira, E. M. *Acc. Chem. Res.*, **2000**, *33*, 373 – 381. (b) Pu, L. *Tetrahedron*, **2003**, *59*, 9873 – 9886.
- (20) For a discussion on allylic alcohol asymmetric directed reactions, see: (a) Bhadra, S.; Yamamoto, H. *Chem. Rev.*, **2018**, *118*, 3391 – 3446. For a recent mini-review on allylic alcohols, see: (b) Zhang, J.; Liao, J.; Wei, Y.-F.; Cheng, G.; Luo, R. *Mini-Reviews in Organic Chemistry*, **2018**, *15*, 476 – 487. For a review on synthesis and applications of allylic alcohols, see: (c) Lumbroso, A.; Cooke, M. L.; Breit, B. *Angew. Chem. Int. Ed.*, **2013**, *52*, 1890 – 1932.
- (21) Shambayati, S.; Crewe, W. E.; Schreiber, S. L. *Tetrahedron Letters*, **1990**, *31*, 5289 – 5292.
- (22) Jeong, N.; Chung, Y. K.; Lee, B. Y.; Lee, S. H.; Yoo, S.-E. *Synlett*, **1991**, *3*, 204 – 206.
- (23) Sugihara, T.; Yamada, M.; Ban, H.; Yamaguchi, M.; Kaneko, C. *Angew. Chem., Int. Ed. Engl.*, **1997**, *36*, 2801 – 2804.
- (24) Magnus, P.; Principe, L. M.; *Tetrahedron Letters*, **1985**, *26*, 4851 – 4854.
- (25) (a) Krafft, M. E.; Scott, I. L.; Romero, R. H.; Feibelmann, S.; Van Pelt, C. E. *J. Am. Chem. Soc.*, **1993**, *115*, 7199 – 7207. (b) Yamana, M.; Nakamura, E. *J. Am. Chem. Soc.*, **2001**, *123*, 1703 – 1708. (c) Del Valle, C. P.; Milet, A.; Gimbert, Y.; Greene, A. E. *Angew. Chem. Int. Ed.*, **2005**, *44*, 5717 – 5719.
- (26) For a review on the Thorpe-Ingold effect directly relating to organosilicon compounds, see: Luh, T.-Y.; Hua, Z. *Dalton Trans.*, **2010**, *39*, 9185 – 9192.

(27) Phenyl substituted propargyl alcohols or enynes such as **5d** undergo C–O heterolytic cleavage due to the facile formation of a cobalt-stabilized benzylic cation. For a relevant review of the Nicholas reaction, see: (a) Nicholas, K. M. *Acc. Chem. Res.* **1987**, *20*, 207 – 214.

(28) Martens J.; Bhushan, R. *Helv. Chim. Acta*, **2014**, *97*, 161 – 187.

(29) For reviews on organosilicon compounds for medicinal chemistry applications, see: (a) Ramesh R.; Reddy, D. S. *J. Med. Chem.*, **2018**, *61*, 3779 – 3798. (b) Franz A. K.; Wilson, S. O. *J. Med. Chem.*, **2013**, *56*, 388 – 405.

(30) Luche, J.-L. *J. Am. Chem. Soc.* **1978**, *100*, 2226 – 2227.

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Supporting Information

Access to Highly Functionalized Cyclopentenones via Diastereoselective Pauson Khand Reaction of Siloxy-Tethered 1,7-Enynes

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1. Materials and Methods

Unless otherwise stated, all reactions were performed using syringe-septum cap techniques under an inert atmosphere of N₂. All reagent grade solvents and chemicals were purchased from commercial vendors and used without further purification, unless otherwise stated. All reactions were magnetically stirred in oven- or vacuum flame-dried glassware with commercially available anhydrous solvents; tetrahydrofuran (THF), diethyl ether (Et₂O), methylene chloride (CH₂Cl₂), toluene (PhMe), and *o*-xylenes, unless otherwise noted. Anhydrous N-methylpyrrolidinone (NMP) was purchased from Aldrich and stored under N₂. Unless otherwise stated, chemicals and reagents were used as received. All reactions were monitored by thin-layer chromatography (TLC) using 250 μm precoated silica gel plates and were visualized by staining with KMnO₄ (1.5 g of KMnO₄, 10 g of K₂CO₃ and 2.5 mL of 5% aq. NaOH in 150 mL H₂O), or CAM (4.8 g of (NH₄)₆Mo₇O₂₄·4H₂O and 0.2 g of Ce(SO₄)₂ in 100 mL of a 3.5 N H₂SO₄ solution) stain. Flash column chromatography was performed as described by Still et al.¹ using silica gel (230-400 mesh, Silicycle). Purified compounds were dried on a high vacuum line (2 – 6 torr) to remove trace solvent. Yields refer to chromatographically and spectroscopically pure compounds, unless otherwise stated. All melting points were obtained on a Thomas-Hoover apparatus and are uncorrected. Optical rotations were measured on a Jasco P-2000 polarimeter using a 100 mm path-length cell at 589 nm at the University of Pennsylvania. ¹H and ¹³C NMR spectra were recorded on a Varian 400 MR (at 400 MHz and 101 MHz, respectively), or a Varian Inova 500 (at 500 MHz and 126 MHz, respectively). NMR data is reported relative to internal CDCl₃ (¹H, δ = 7.26), CDCl₃ (¹³C, δ = 77.16). Data for ¹H NMR spectra are reported as follows: chemical shift (δ ppm) (multiplicity, coupling constant (Hz), integration). Multiplicity and qualifier abbreviations are as follows: (s = singlet, d = doublet, t = triplet, q = quartet, qn = quintet, dd = doublet of doublets, ddd = doublet of doublet of doublets, ddt = doublet of doublet of triplets, dt = doublet of triplets, thept = triplet of heptets, m = multiplet, b = broad). ¹³C-NMR spectra are tabulated by observed peak. IR spectra were recorded on a PerkinElmer 100 FT-IR spectrometer and are reported in frequency of absorption (cm⁻¹). Analytical chiral SFC was performed with a Mettler SFC supercritical CO₂ analytical chromatography system (CO₂ = 1450 psi, column temperature = 40 °C) with Chiralcel AD-H, OD-H, columns (4.6 mm x 25 cm). High-resolution mass spectra (HRMS) were acquired at the Drexel Mass Spectral Facility on a Thermo-Electron LTQ-FT 7T

Fourier transform ion cyclotron resonance (FT-ICR) Spectrometer with an atmospheric pressure chemical ionization (APCI) source with direct infusion run in positive ion mode at 5 kV.

X-Ray Structure Determination (*University of Pennsylvania*)

X-ray intensity data were collected on a Bruker D8QUEST² CMOS area detector or a Bruker APEXII³ CCD area detector employing graphite-monochromated Mo-K α radiation ($\lambda=0.71073\text{\AA}$) at a temperature of 100K. Preliminary indexing was performed from a series of twenty-four 0.5° rotation frames with exposures of 10 seconds. Rotation frames were integrated using SAINT,⁴ producing a listing of unaveraged F^2 and $\sigma(F^2)$ values. The intensity data were corrected for Lorentz and polarization effects and for absorption using SADABS.⁵ The structure was solved by direct methods – ShelXT⁶ or ShelXS-97.⁷ Refinement was by full-matrix least squares based on F^2 using SHELXL-2018.⁸ All reflections were used during refinement. Non-hydrogen atoms were refined anisotropically and hydrogen atoms were refined using a riding model. Crystallographic data for compounds can be obtained free of charge from The Cambridge Crystallographic Data Centre (CCDC) via www.ccdc.cam.ac.uk/data_request/cif under CCDC deposition numbers 1944608-1944611. Graphical representation of structures with 50% probability thermal ellipsoids was generated using Mercury visualization software.⁹

Abbreviations:

4-OMeBnSMe – 4-Methoxybenzyl methyl sulfide; **4-FBnSMe** – (4-fluorobenzyl)(methyl)sulfide; **BnSMe** – Benzyl methyl sulfide; **n-BuSMe** – nButyl methyl sulfide; **CAM** – cerium ammonium molybdate; **CyNH₂** – Cyclohexylamine; **DCM** – dichloromethane; **DMAP** – 4-dimethylaminopyridine; **DMF** – dimethylformamide; **dr** – diastereomeric ratio; **er** – enantiomeric ratio; **Et₂O** – diethyl ether; **EtOAc** – ethyl acetate; **FTIR** – Fourier transform infrared; **FurfurylSMe** – 2-((methylthio)methyl)furan; **NMO** – N-Methylmorpholine N-Oxide; **NMP** – N-methylpyrrolidinone; **NMR** – nuclear magnetic resonance; **PhMe** – toluene; **PhSMe** – methyl(phenyl)sulfide; **SFC** – supercritical fluid chromatography; **THF** – tetrahydrofuran; **TLC** – thin layer chromatography; **TMANO** – Trimethylamine N-Oxide **UV** – ultraviolet

2. Substrate Preparation

A. Propargyl Alcohols

The synthesis of the propargyl alcohols **S1** – (–)-**S19**,¹⁰⁻²⁹ allyldiisopropylchlorosilane **S20**,³⁰ and (4-fluorobenzyl)(methyl)sulfide (**4-FBnSMe**) **S21**³¹ were prepared according to previously reported procedures. All the NMR spectra and analytical data of known compounds were in accordance with the reported references. Please see these references for characterization and supporting information.

Propargyl alcohols **S22** – **S24** purchased commercial sources and used as is without further purification.

B. 1,7-Siloxy-Tethered Enynes

General Procedure 1: 1,7-Siloxy-Tethered Enyne Synthesis

A flame dried round-bottom flask equipped with a magnetic stir-bar was sequentially charged with dry CH₂Cl₂ (0.5 M with respect to the propargyl alcohol), allyldiisopropylchlorosilane **S20**²⁹ (1.2 equiv), DMAP (0.2 equiv), and NEt₃ (2.0 equiv) under an inert atmosphere (N₂). The reaction mixture was cooled to 0 °C. In a separate flame-dried pear-shaped flask, the propargyl alcohol (**S1** – **S19** and **S22** – **S24**; 1.0 equiv) was dissolved in CH₂Cl₂ (1.0 M) and added dropwise to the 0 °C reaction mixture via syringe. This was followed by rinsing the pear-shaped flask with an additional portion of CH₂Cl₂ (0.3 mL). The cooling bath was removed, and the reaction mixture allowed to stir at room temperature (25 °C) for 18 h. Upon consumption of the propargyl alcohol, as noted by TLC analysis, the reaction mixture was quenched with sat. aq. NH₄Cl. The aqueous phase was extracted with CH₂Cl₂ (3x 20 mL), and the combined organic phases were washed with brine, dried with MgSO₄, filtered, and concentrated under reduced pressure. Flash chromatography (hexanes - 0.25% Et₂O/hexanes) yielded enynes **1a-j** and **5a-k** as colorless oils.

Allyl(but-2-yn-1-yloxy)diisopropylsilane (1a)

77% yield (2.47 g, 11.0 mmol). Prepared from but-2-yn-1-ol **S23** (1.00 g, 14.3 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (3.18 mL, 3.27 g, 17.2 mmol, 1.20 equiv).

R_f: 0.8 (silica, 1% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 5.90 (ddt, *J* = 17.0, 10.1, 8.1 Hz, 1H), 4.97 (ddt, *J* = 17.0, 2.2, 1.3 Hz, 1H), 4.87 (ddt, *J* = 10.1, 2.2, 1.1 Hz, 1H), 4.33 (q, *J* = 2.4 Hz, 2H), 1.84 (t, *J* = 2.4 Hz, 3H), 1.75 (dt, *J* = 8.1, 1.3 Hz, 2H), 1.10 – 0.99 (m, 14H).

¹³C NMR (101 MHz, CDCl₃): δ 134.56, 113.97, 81.08, 77.83, 52.35, 18.95, 17.58, 17.57, 12.64, 3.75.

IR (neat, cm⁻¹): 2944, 2867, 1630, 1464, 1371, 1263, 1145, 1064, 994, 882, 774.

HRMS (CI⁺, *m/z*): calculated for C₁₃H₂₃OSi [M-H] 233.15127, found 223.15146.

Allyldiisopropyl(prop-2-yn-1-yloxy)silane (1b)

76% yield (1.43 g, 6.78 mmol). Prepared from prop-2-yn-1-ol **S22** (500 mg, 8.92 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (1.99 mL, 2.04 g, 10.7 mmol, 1.20 equiv).

R_f: 0.8 (silica, 1% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 5.89 (ddt, *J* = 16.9, 10.0, 1.3 Hz, 1H), 4.99 (ddt, *J* = 16.9, 2.2, 1.5 Hz, 1H), 4.89 (ddt, *J* = 10.0, 2.2, 1.1 Hz, 1H), 4.38 (dd, *J* = 2.4, 0.6 Hz, 2H), 2.40 (td, *J* = 2.4, 0.6 Hz, 1H), 1.77 (dt, *J* = 8.1, 1.3 Hz, 2H), 1.10 – 1.03 (m, 14H).

¹³C NMR (101 MHz, CDCl₃): δ 134.33, 114.18, 82.40, 73.04, 51.95, 18.86, 17.56, 17.53, 12.61.

IR (neat, cm⁻¹): 2944, 2867, 1630, 1464, 1370, 1264, 1160, 1094, 994, 882, 749.

HRMS (CI⁺, *m/z*): calculated for C₁₂H₂₁OSi [M-H] 209.13562, found 209.13573.

Allyldiisopropyl((3-(trimethylsilyl)prop-2-yn-1-yl)oxy)silane (1c)

81% yield (715 mg, 2.53 mmol). Prepared from 3-(trimethylsilyl)prop-2-yn-1-ol **S1**¹⁰ (881 mg, 3.12 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (0.70 mL, 714 mg, 3.74 mmol, 1.2 equiv).

R_f: 0.8 (silica, 1% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 5.89 (ddt, *J* = 17.0, 10.0, 8.1 Hz, 1H), 4.97 (dt, *J* = 17.0, 2.2, 1.4 Hz, 1H), 4.86 (ddt, *J* = 10.0, 2.2, 1.1 Hz, 1H), 4.36 (s, 2H), 1.76 (dd, *J* = 8.1, 1.3 Hz, 2H), 1.09–1.02 (m, 14H), 0.16 (s, 9H).

¹³C NMR (101 MHz, CDCl₃): δ 134.46, 114.01, 104.52, 89.82, 52.66, 18.97, 17.57, 17.54, 12.70, -0.12.

IR (neat, cm⁻¹): 2945, 2867, 2177, 1630, 1463, 1364, 1250, 1094, 1001, 882, 840, 758.

HRMS (CI⁺, *m/z*): calculated for C₁₅H₃₀OSi₂ [M⁺] 282.18297, found 282.18313.

Allyldiisopropyl((4-methylpent-2-yn-1-yl)oxy)silane (1d)

74% yield (952 mg, 3.77 mmol). Prepared from 4-methylpent-2-yn-1-ol **S2**¹¹ (500 mg, 5.09 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (1.14 mL, 1.17 g, 6.11 mmol, 1.20 equiv).

R_f: 0.8 (silica, 1% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 5.90 (ddt, *J* = 17.0, 10.1, 8.1 Hz, 1H), 5.01 – 4.92 (m, 1H), 4.90 – 4.84 (m, 1H), 4.36 (dd, *J* = 6.8, 2.0 Hz, 3H), 2.57 (thept, *J* = 6.8, 2.0 Hz, 1H), 1.76 (dt, *J* = 8.0, 1.3 Hz, 3H), 1.16 (dd, *J* = 6.8, 0.5 Hz, 6H), 1.06 (qd, *J* = 2.5, 0.9 Hz, 14H).

¹³C NMR (101 MHz, CDCl₃): δ 134.67, 113.90, 91.02, 77.97, 52.37, 22.99, 20.70, 19.03, 17.61, 17.59, 12.70.

IR (neat, cm⁻¹): 2967, 2942, 2866, 2246, 1630, 1463, 1419, 1384, 1396, 1319, 1262, 1185, 1159, 1127, 1088, 1035, 994, 932, 882, 775, 749, 657.

HRMS (CI⁺, *m/z*): calculated for C₁₅H₂₉OSi [M+H]⁺ 253.19822, found 253.19814.

10,10-Diisopropyl-2,4,9-trioxa-10-silatridec-12-en-6-yne (1e)

80% yield (1.31 g, 4.61 mmol). Prepared from 4-(methoxymethoxy)but-2-yn-1-ol **S3**¹² (750 mg, 5.76 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (1.28 mL, 1.32 g, 6.91

mmol, 1.20 equiv).

R_f: 0.8 (silica, 1% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 5.88 (ddt, *J* = 16.9, 10.0, 8.1 Hz, 1H), 4.97 (ddt, *J* = 16.9, 2.1, 1.5 Hz, 1H), 4.88 (ddt, *J* = 10.1, 2.2, 1.1 Hz, 1H), 4.70 (s, 2H), 4.42 (t, *J* = 1.8 Hz, 2H), 4.26 (t, *J* = 1.8 Hz, 2H), 3.38 (s, 3H), 1.75 (dt, *J* = 8.0, 1.3 Hz, 2H), 1.08 – 1.04 (m, 14H).

^{13}C NMR (101 MHz, CDCl_3): δ 134.33, 114.15, 94.85, 84.85, 80.52, 55.67, 54.49, 52.13, 18.87, 17.56, 17.54, 12.61.

IR (neat, cm^{-1}): 2943, 2867, 1630, 1464, 1371, 1151, 1131, 1084, 1043, 990, 922, 882, 777.

HRMS (CI^+) m/z calculated for $\text{C}_{15}\text{H}_{27}\text{OSi}$ $[\text{M}-\text{H}]^+$ 283.17240, found 283.17248.

Allyldiisopropyl((3-phenylprop-2-yn-1-yl)oxy)silane (1f)

85% yield (4.61 g, 16.1 mmol). Prepared from 3-phenylprop-2-yn-1-ol **S24** (2.50 g, 18.9 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (4.21 mL, 4.33 g, 22.7 mmol, 1.20 equiv).

R_f : 0.8 (silica, 1% EtOAc/hexanes).

^1H NMR (400 MHz, CDCl_3): δ 7.50 – 7.45 (m, 2H), δ 7.36 – 7.31 (m, 3H), 5.98 (ddt, J = 16.9, 10.1, 8.0 Hz, 1H), 5.05 (ddt, J = 16.9, 2.2, 1.5 Hz, 1H), 4.94 (ddt, J = 10.1, 2.2, 1.1 Hz, 1H), 4.64 (s, 2H), 1.86 (dt, J = 8.0, 1.3 Hz, 2H), 1.18 – 1.12 (m, 14H).

^{13}C NMR (101 MHz, CDCl_3): δ 134.37, 131.68, 128.34, 128.32, 123.08, 114.11, 114.08, 87.89, 84.93, 52.60, 18.97, 17.58, 17.56, 12.69.

IR (neat, cm^{-1}): 3076, 2943, 2893, 2866, 2244, 1630, 1599, 1490, 1463, 1443, 1419, 1369, 1259, 1159, 1086, 1069, 994, 962, 882, 775, 754, 690, 658.

HRMS (CI^+ , m/z): calculated for $\text{C}_{15}\text{H}_{26}\text{OSi}$ $[\text{M}+\text{H}]^+$ 263.14618, found 263.14632.

Allyldiisopropyl((3-(4-methoxyphenyl)prop-2-yn-1-yl)oxy)silane (1g)

76% yield (1.48 g, 4.68 mmol). Prepared from 3-(4-methoxyphenyl)prop-2-yn-1-ol **S4**¹³ (1.00 g, 6.17 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (1.37 mL, 1.41 g, 7.40 mmol, 1.20 equiv).

R_f : 0.6 (silica, 1% EtOAc /hexanes).

^1H NMR (400 MHz, CDCl_3): δ 7.40 – 7.34 (m, 2H), 6.86 – 6.81 (m, 2H), 5.94 (ddt, J = 16.9, 10.1, 8.1 Hz, 1H), 5.00 (ddt, J = 16.9, 2.2, 1.2 Hz, 1H), 4.90 (ddt, J = 10.1, 2.2, 1.1 Hz, 1H), 4.59 (s, 2H), 3.80 (s, 3H), 1.81 (dt, J = 8.0, 1.3 Hz, 2H), 1.18 – 1.04 (m, 14H).

^{13}C NMR (101 MHz, CDCl_3): δ 159.72, 134.51, 133.19, 115.21, 114.06, 114.02, 86.49, 84.87, 55.38, 52.70, 19.01, 17.62, 17.60, 12.72.

IR (neat, cm^{-1}): 2942, 2865, 1629, 1607, 1569, 1509, 1463, 1442, 1418, 1368, 1323, 1291, 1247, 1172, 1084, 1066, 1034, 995, 964, 932, 882, 830, 799, 775, 749, 659, 618, 563, 535.

HRMS (Cl^+ , m/z): calculated for $\text{C}_{19}\text{H}_{29}\text{O}_2\text{Si}$ $[\text{M}+\text{H}]^+$ 317.19313, found 317.19334.

4-(3-((Allyldiisopropylsilyl)oxy)prop-1-yn-1-yl)benzonitrile (**1h**)

73% yield (1.45 g, 4.65 mmol). Prepared from 4-(3-hydroxyprop-1-yn-1-yl)benzonitrile **S5**¹⁴ (1.00 g, 6.36 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (2.31 mL, 2.38 g, 7.63 mmol, 1.20 equiv).

R_f: 0.65 (silica, 1% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl_3): δ 7.62 – 7.58 (m, 2H), 7.52 – 7.48 (m, 2H), 5.91 (ddt, J = 16.9, 10.0, 8.1 Hz, 1H), 5.00 (ddt, J = 16.9, 2.1, 1.2 Hz, 1H), 4.90 (ddt, J = 10.0, 2.1, 1.1 Hz, 1H), 4.62 (s, 2H), 1.79 (dt, J = 8.1, 1.3 Hz, 2H), 1.13 – 1.05 (m, 14H).

¹³C NMR (101 MHz, CDCl_3): δ 134.17, 132.22, 132.16, 132.13, 127.95, 118.52, 114.32, 111.83, 92.54, 83.34, 52.52, 18.87, 17.56, 17.54, 12.64.

IR (neat, cm^{-1}): 2943, 2866, 2229, 1738, 1630, 1605, 1500, 1463, 1369, 1261, 1160, 1088, 994, 961, 932, 882, 839, 776, 751, 659, 617, 554.

HRMS (Cl^+ , m/z): calculated for $\text{C}_{19}\text{H}_{26}\text{NOSi}$ $[\text{M}+\text{H}]^+$ 312.178986, found 312.178368.

Methyl 4-(3-((allyldiisopropylsilyl)oxy)prop-1-yn-1-yl)benzoate (**1i**)

78% yield (1.41 g, 4.09 mmol). Prepared from methyl 4-(3-hydroxyprop-1-yn-1-yl)benzoate **S6**¹⁵ (1.00 g, 5.26 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (1.17 mL, 1.20 g, 6.31 mmol, 1.20 equiv).

R_f: 0.55 (silica, 1% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl_3): δ 8.00 – 7.93 (m, 2H), 7.50 – 7.42 (m, 2H), 5.90 (ddt, J = 17.0, 10.1, 8.1 Hz, 1H), 4.99 (ddt, J = 16.9, 2.2, 1.6 Hz, 1H), 4.89 (ddt, J = 10.1, 2.2, 1.1 Hz, 1H), 4.60 (s, 2H), 3.89 (s, 3H), 1.79 (dt, J = 8.1, 1.3 Hz, 2H), 1.11 – 1.06 (m, 14H).

¹³C NMR (101 MHz, CDCl_3): δ 166.49, 134.21, 131.54, 129.67, 129.51, 127.69, 114.17, 90.95, 84.15, 52.52, 52.23, 18.86, 17.52, 17.50, 12.62.

IR (neat, cm^{-1}): 2945, 2866, 1725, 1630, 1606, 1506, 1463, 1436, 1406, 1367, 1307, 1272, 1192, 1176, 1090, 1019, 993, 966, 932, 882, 857, 827, 768, 738, 695, 659, 620, 527.

HRMS (Cl^+ , m/z): calculated for $\text{C}_{20}\text{H}_{27}\text{O}_3\text{Si}$ $[\text{M}+\text{H}]^+$ 343.171438, found 343.172948.

Allyldiisopropyl((3-(4-(trifluoromethyl)phenyl)prop-2-yn-1-yl)oxy)silane (1j)

73% yield (649 mg, 1.83 mmol). Prepared from 3-(4-(trifluoromethyl)phenyl)prop-2-yn-1-ol **S7**¹⁶ (500 mg, 2.50 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (0.56 mL, 572 mg, 3.00 mmol, 1.20 equiv).

R_f: 0.7 (silica, 1% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 7.60 – 7.50 (m, 4H), 5.93 (ddt, *J* = 17.0, 10.0, 8.0 Hz, 1H), 5.01 (ddt, *J* = 17.0, 2.2, 1.2 Hz, 1H), 4.91 (ddt, *J* = 10.0, 2.2, 1.1 Hz, 1H), 4.62 (s, 2H), 1.81 (dt, *J* = 8.0, 1.3 Hz, 2H), 1.13 – 1.07 (m, 14H).

¹³C NMR (101 MHz, CDCl₃): δ 134.29, 131.96, 130.68, 130.35, 130.03, 129.71, 125.42, 125.40, 125.38, 125.34, 125.31, 114.26, 90.50, 83.63, 52.56, 18.93, 17.58, 17.56, 12.69. (¹J_{C-F} = 130.68, 130.35, 130.03, 129.71)

IR (neat, cm⁻¹): 2945, 2867, 1630, 1617, 1463, 1405, 1367, 1322, 1264, 1167, 1128, 1104, 1065, 1018, 995, 964, 932, 897, 882, 842, 776, 740, 713, 659, 619, 597, 521.

HRMS (CI⁺, *m/z*): calculated for C₁₉H₂₆F₃OSi [M+H]⁺ 355.16995, found 355.17023.

Allyldiisopropyl((6-methylhept-2-yn-4-yl)oxy)silane (5a)

73% yield (813 mg, 2.90 mmol). Prepared from 6-methylhept-2-yn-4-ol **S8**¹⁷ (500 mg, 3.97 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (0.89 mL, 909 mg, 4.76 mmol, 1.20 equiv).

R_f: 0.7 (silica, 1% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 5.91 (ddt, *J* = 16.9, 10.1, 8.0 Hz, 1H), 4.96 (ddt, *J* = 17.0, 2.6, 1.3 Hz, 1H), 4.85 (ddt, *J* = 10.1, 2.2, 1.1 Hz, 1H), 4.45 (tq, *J* = 7.2, 3.9 Hz, 1H), 1.82 (dd, *J* = 8.9, 2.2 Hz, 3H), 1.77 (dt, *J* = 8.1, 1.3 Hz, 2H), 1.61 – 1.46 (m, 2H), 1.09 – 1.02 (m, 15H), 0.90 (dd, *J* = 8.9, 6.6, 0.8 Hz, 6H).

¹³C NMR (101 MHz, CDCl₃): δ 135.00, 113.67, 81.36, 80.25, 62.09, 48.22, 24.74, 22.87, 22.72, 19.51, 17.76, 17.68, 17.67, 17.65, 13.03, 12.98, 3.65.

IR (neat, cm⁻¹): 2957, 2867, 1630, 1465, 1386, 1159, 1064, 994, 883, 851, 747.

HRMS (CI⁺, *m/z*): calculated for C₁₇H₃₃OSi [M+H]⁺ 281.22952, found 281.22961.

Allyl(hept-2-yn-4-yloxy)diisopropylsilane (**5b**)

73% yield (607 mg, 2.28 mmol). Prepared from hept-2-yn-4-ol **S9**¹⁸ (350 mg, 3.12 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (0.70 mL, 714 mg, 3.74 mmol, 1.20 equiv).

R_f: 0.7 (silica, 1% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 5.91 (ddt, *J* = 17.0, 10.0, 8.1 Hz, 1H), 4.96 (ddt, *J* = 16.9, 2.2, 1.5 Hz, 1H), 4.85 (ddt, *J* = 10.0, 2.2, 1.2 Hz, 1H), 4.40 (tq, *J* = 6.4, 2.1 Hz, 1H), 1.82 (d, *J* = 2.1 Hz, 3H), 1.79 – 1.75 (m, 2H), 1.66 – 1.58 (m, 2H), 1.49 – 1.39 (m, 2H), 1.08 – 1.02 (m, 14H), 0.92 (t, *J* = 7.4 Hz, 3H).

¹³C NMR (101 MHz, CDCl₃): δ 135.02, 113.66, 81.26, 80.14, 63.30, 41.37, 19.43, 18.62, 17.74, 17.65, 17.63, 14.02, 12.98, 12.92, 3.67.

IR (neat, cm⁻¹): 2963, 2865, 2946, 1631, 1464, 1390, 1348, 1157, 1110, 1065, 1038, 883, 762.

HRMS (CI⁺, *m/z*): calculated for C₁₆H₃₀OSi [M⁺] 266.206594, found 266.206481.

Allyldiisopropyl((5-methyl-1-phenylhex-1-yn-3-yl)oxy)silane (**5c**)

81% yield (730 mg, 2.13 mmol). Prepared from 5-methyl-1-phenylhex-1-yn-3-ol **S10**¹⁹ (500 mg, 2.66 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (0.59 mL, 609 mg, 3.19 mmol, 1.20 equiv).

R_f: 0.7 (silica, 1% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 7.43 – 7.37 (m, 2H), 7.33 – 7.27 (m, 3H), 5.94 (ddt, *J* = 16.9, 10.1, 8.1 Hz, 1H), 4.98 (ddt, *J* = 16.9, 2.2, 1.5 Hz, 1H), 4.87 (ddt, *J* = 10.0, 2.2, 1.2 Hz, 1H), 4.72 (t, *J* = 7.0 Hz, 1H), 1.92 (pd, *J* = 6.8, 5.3 Hz, 1H), 1.83 (dq, *J* = 8.2, 1.4 Hz, 2H), 1.13 – 1.04 (m, 16H), 0.98 – 0.93 (m, 6H).

¹³C NMR (101 MHz, CDCl₃): δ 134.86, 131.62, 128.39, 128.21, 123.33, 113.88, 90.41, 84.40, 62.35, 47.94, 24.82, 22.86, 22.84, 19.50, 17.79, 17.73, 17.70, 13.05, 13.00.

IR (neat, cm⁻¹): 2956, 2867, 1630, 1492, 1462, 1084, 754, 880.

HRMS (CI⁺, *m/z*): calculated for C₂₂H₃₅OSi [M+H]⁺ 343.24517, found 343.24537.

Allyl((1,3-diphenylprop-2-yn-1-yl)oxy)diisopropylsilane (**5d**)

84% yield (732 mg, 2.02 mmol). Prepared from 1,3-diphenylprop-2-yn-1-ol **S11**²⁰ (500 mg, 2.40 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (0.54 mL, 550 mg, 2.88 mmol, 1.20 equiv).

R_f : 0.7 (silica, 1% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 7.60 – 7.56 (m, 2H), 7.46 – 7.35 (m, 4H), 7.34 – 7.28 (m, 4H), 5.94 (ddt, J = 16.5, 10.0, 8.1 Hz, 1H), 5.82 (s, 1H), 4.99 (ddt, J = 16.9, 2.2, 1.5 Hz, 1H), 4.88 (ddt, J = 10.0, 2.1, 1.0 Hz, 1H), 1.89 (dt, J = 8.1, 1.3 Hz, 2H), 1.16 – 1.05 (m, 14H).

¹³C NMR (101 MHz, CDCl₃): δ 141.90, 134.60, 131.72, 128.46, 128.39, 127.83, 126.25, 122.99, 114.13, 90.34, 85.72, 65.41, 19.42, 17.75, 17.72, 17.70, 13.00, 12.98.

IR (neat, cm⁻¹): 3073, 2944, 2867, 1694, 1630, 1599, 1492, 1451, 1273, 1060, 885, 755, 692.

HRMS (CI⁺, m/z): calculated for C₂₄H₃₁OSi [M+H]⁺ 363.21387, found 363.21418.

Allyl((1,4-diphenylbut-3-yn-2-yl)oxy)diisopropylsilane (**5e**)

81% yield (1.37 g, 3.64 mmol). Prepared from 1,4-diphenylbut-3-yn-2-ol **S12**²¹ (1.00 g, 4.50 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (1.00 mL, 1.03 g, 5.4 mmol, 1.20 equiv).

R_f : 0.7 (silica, 1% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 7.39 – 7.21 (m, 10H), 5.83 (ddt, J = 17.0, 10.0, 8.1 Hz, 1H), 4.93 (ddt, J = 16.9, 2.2, 1.5 Hz, 1H), 4.84 (ddt, J = 10.0, 2.2, 1.5 Hz, 1H), 4.82 (d, J = 6.6 Hz, 1H), 3.07 (dd, J = 7.0, 0.4 Hz, 2H), 1.71 (ddt, J = 8.1, 5.4, 1.3 Hz, 2H), 1.11 – 0.95 (m, 14H).

¹³C NMR (101 MHz, CDCl₃): δ 137.57, 134.74, 131.57, 130.17, 128.39, 128.32, 128.19, 126.70, 123.09, 113.88, 90.66, 85.24, 65.01, 45.47, 19.25, 17.63, 17.58, 12.89, 12.85.

IR (neat, cm⁻¹): 3032, 2944, 2866, 1630, 1490, 1463, 1342, 1266, 1159, 1083, 993, 882, 754, 690.

HRMS (CI⁺, m/z): calculated for C₂₅H₃₃OSi [M+H]⁺ 377.22952, found 377.22973.

Allyl((1,5-diphenylpent-1-yn-3-yl)oxy)diisopropylsilane (**5f**)

82% yield (1.02 g, 2.60 mmol). Prepared from 1,5-diphenylpent-1-yn-3-ol **S13**²² (0.71 mL, 750 mg, 3.17 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (725 mg, 3.80 mmol, 1.20 equiv).

R_f : 0.7 (silica, 1% EtOAc/hexanes).

^1H NMR (400 MHz, CDCl_3): δ 7.46 – 7.40 (m, 2H), 7.35 – 7.15 (m, 8H), 5.93 (ddt, J = 17.0, 10.1, 2.0 Hz, 1H), 4.97 (ddt, J = 16.9, 3.7, 2.2 Hz, 1H), 4.87 (ddt, J = 10.0, 2.1, 1.0 Hz, 1H), 4.72 (td, J = 6.3, 1.9 Hz, 1H), 2.90 – 2.82 (m, 2H), 2.15 – 2.07 (m, 2H), 1.85 – 1.80 (m, 2H), 1.14 – 1.05 (m, 14H).

^{13}C NMR (101 MHz, CDCl_3): δ 141.92, 134.76, 131.66, 128.64, 128.52, 128.43, 128.34, 125.99, 123.16, 113.93, 90.77, 84.79, 63.11, 40.56, 31.63, 19.41, 17.77, 17.72, 17.69, 13.02, 12.96.

IR (neat, cm^{-1}): 3027, 2943, 2865, 1630, 1602, 1490, 1462, 1340, 1159, 1090, 991, 882, 843, 754, 690.

HRMS (Cl^+ , m/z): calculated for $\text{C}_{26}\text{H}_{35}\text{OSi}$ $[\text{M}+\text{H}]^+$ 391.24517, found 391.24552.

Allyldiisopropyl((1-phenylhex-5-en-1-yn-3-yl)oxy)silane (5g)

80% yield (3.79 g, 11.6 mmol). Prepared from 1-phenylhex-5-en-1-yn-3-ol **S14**²³ (2.50 g, 14.5 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (3.23 mL, 3.32 g, 17.4 mmol, 1.20 equiv).

R_f : 0.8 (silica, 1% EtOAc/hexanes).

^1H NMR (400 MHz, CDCl_3): δ 7.46 – 7.40 (m, 2H), 7.34 – 7.29 (m, 3H), 6.03 – 5.90 (m, 2H), 5.23 – 5.13 (m, 2H), 5.01 (ddt, J = 16.9, 2.3, 1.2 Hz, 1H), 4.90 (dt, J = 10.1, 2.2, 1.2 Hz, 1H), 4.73 (dt, J = 6.4, 1.1 Hz, 1H), 2.56 (dt, J = 7.3, 2.3 Hz, 2H), 1.85 (dt, J = 8.0, 1.3 Hz, 2H), 1.15 – 1.06 (m, 14H).

^{13}C NMR (101 MHz, CDCl_3): δ 134.73, 134.07, 131.67, 128.38, 128.30, 123.16, 117.87, 113.95, 90.62, 84.84, 63.54, 43.51, 19.38, 17.73, 17.67, 17.65, 12.98, 12.93.

IR (neat, cm^{-1}): 3079, 2943, 2866, 1630, 1490, 1463, 1342, 1159, 1084, 993, 914, 882, 754, 689.

HRMS (Cl^+ , m/z): calculated for $\text{C}_{21}\text{H}_{31}\text{OSi}$ $[\text{M}+\text{H}]^+$ 327.21387, found 327.21409.

Allyldiisopropyl((1-phenylhex-1-yn-3-yl)oxy)silane (5h)

79% yield (1.34 g, 4.08 mmol). Prepared from 1-phenylhex-1-yn-3-ol **S15**²⁴ (750 mg, 4.3 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (0.96 mL, 85 mg, 5.16 mmol, 1.20 equiv).

R_f : 0.7 (silica, 1% EtOAc/hexanes).

^1H NMR (400 MHz, CDCl_3): δ 7.43 – 7.38 (m, 2H), 7.32 – 7.28 (m, 3H), 5.94 (ddt, J = 16.9, 10.0, 8.1 Hz, 1H), 4.98 (ddt, J = 16.9, 2.1, 1.5 Hz, 1H), 4.87 (ddt, J = 10.0, 2.2, 1.1 Hz, 1H), 4.68

(t, J = 6.4 Hz, 1H), 1.82 (dt, J = 8.1, 1.4 Hz, 2H), 1.79 – 1.72 (m, 2H), 1.58 – 1.47 (m, 2H), 1.16 – 1.03 (m, 14H), 0.96 (t, J = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, CDCl_3): δ 134.86, 131.64, 128.38, 128.20, 123.34, 113.85, 91.31, 84.30, 63.58, 41.13, 19.44, 18.68, 17.77, 17.71, 17.70, 17.68, 14.05, 13.03, 12.97.

IR (neat, cm^{-1}): 2960, 2942, 2866, 1630, 1490, 1463, 1341, 1111, 1082, 1038, 994, 882, 754, 689.

HRMS (Cl^+ , m/z): calculated for $\text{C}_{21}\text{H}_{33}\text{OSi}$ $[\text{M}+\text{H}]^+$ 329.22952, found 329.22952.

Allyldiisopropyl((1-phenyloct-7-en-1-yn-3-yl)oxy)silane (5i)

73% yield (1.03 g, 2.91 mmol). Prepared from 1-phenyloct-7-en-1-yn-3-ol **S16**²⁵ (800 mg, 3.99 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (0.89 mL, 914 mg, 4.79 mmol, 1.20 equiv).

R_f : 0.5 (silica, 1% EtOAc/hexanes).

^1H NMR (400 MHz, CDCl_3): δ 7.43 – 7.38 (m, 2H), 7.32 – 7.28 (m, 3H), 6.00 – 5.77 (m, 2H), 5.07 – 4.99 (m, 2H), 4.97 (dt, J = 2.2, 1.2 Hz, 1H), 4.87 (ddt, J = 10.0, 2.2, 1.1 Hz, 1H), 4.69 (t, J = 6.3 Hz, 1H), 2.12 (tdd, J = 14.1, 6.9, 1.4 Hz, 2H), 1.82 (dt, J = 8.1, 1.3 Hz, 2H), 1.81 – 1.76 (m, 2H), 1.66 – 1.57 (m, 2H), 1.12 – 1.05 (m, 14H).

^{13}C NMR (101 MHz, CDCl_3): δ 138.83, 134.83, 131.64, 128.40, 128.24, 123.27, 114.75, 113.89, 91.14, 84.41, 63.62, 38.34, 33.58, 24.62, 19.42, 17.77, 17.70, 17.69, 13.01, 12.96.

IR (neat, cm^{-1}): 3078, 2943, 2866, 1630, 1490, 1461, 1091, 882, 754.

HRMS (Cl^+ , m/z): calculated for $\text{C}_{24}\text{H}_{35}\text{OSi}$ $[\text{M}+\text{H}]^+$ 355.24517, found 355.24503.

Allyldiisopropyl((1-phenyloct-1-yn-3-yl)oxy)silane (5j)

74% yield (785 mg, 2.20 mmol). Prepared from 1-phenyloct-1-yn-3-ol **S17**²⁶ (600 mg, 2.97 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (0.66 mL, 680 mg, 3.56 mmol, 1.20 equiv).

R_f : 0.7 (silica, 1% EtOAc/hexanes).

^1H NMR (400 MHz, CDCl_3): δ 7.49 – 7.41 (m, 2H), 7.36 – 7.29 (m, 3H), 5.99 (ddt, J = 16.9, 8.6, 1.5 Hz, 1H), 5.03 (dt, J = 16.9, 1.8 Hz, 1H), 4.92 (dt, J = 10.1, 1.8 Hz, 1H), 4.72 (td, J = 6.5, 1.6 Hz, 1H), 1.87 (dd, J = 8.1, 1.5 Hz, 2H), 1.85 – 1.78 (m, 2H), 1.61 – 1.51 (m, 2H), 1.43 – 1.34 (m, 4H), 1.20 – 1.10 (m, 14H), 0.95 (d, J = 7.0 Hz, 3H).

^{13}C NMR (101 MHz, CDCl_3): δ 134.79, 131.60, 131.59, 128.35, 128.16, 123.32, 113.84, 91.30, 84.30, 63.78, 38.91, 31.69, 25.03, 22.76, 19.41, 17.74, 17.69, 17.67, 17.66, 14.16, 13.00, 12.95.

IR (neat, cm^{-1}): 2943, 2865, 1630, 1490, 1464, 1382, 1340, 1159, 1088, 1067, 1041, 993, 882, 754, 689, 658.

HRMS (CI^+ , m/z): calculated for $\text{C}_{23}\text{H}_{37}\text{OSi}$ $[\text{M}+\text{H}]^+$ 357.26082, found 357.26109.

Allyl(hept-1-en-5-yn-4-yloxy)diisopropylsilane (5k)

82% yield (984 mg, 3.72 mmol). Prepared from hept-1-en-5-yn-4-ol **S18**²⁷ (500 mg, 4.54 mmol, 1.00 equiv) and allylchlorodiisopropylsilane **S20** (1.01 mL, 1.04 g, 5.45 mmol, 1.20 equiv).

R_f : 0.7 (silica, 1% EtOAc/hexanes).

^1H NMR (400 MHz, CDCl_3): δ 5.96 – 5.82 (m, 2H), 5.14 – 5.06 (m, 2H), 4.96 (ddt, J = 16.9, 2.2, 1.5 Hz, 1H), 4.86 (ddt, J = 10.0, 2.2, 1.1 Hz, 1H), 4.43 (tq, J = 6.3, 2.1 Hz, 1H), 2.40 (ddt, J = 6.8, 1.3 Hz, 2H), 1.83 (d, J = 2.1 Hz, 3H), 1.77 (dt, J = 8.1, 1.3 Hz, 2H), 1.09 – 1.02 (m, 14H).

^{13}C NMR (101 MHz, CDCl_3): δ 134.75, 134.73, 134.28, 117.45, 117.43, 113.73, 80.60, 63.20, 43.67, 19.32, 17.64, 17.55, 17.53, 12.91, 12.84, 3.56, 3.54.

IR (neat, cm^{-1}): 3077, 2943, 2867, 1630, 1464, 1343, 1157, 1084, 991, 914, 882, 748.

HRMS (CI^+ , m/z): calculated for $\text{C}_{16}\text{H}_{29}\text{OSi}$ $[\text{M}+\text{H}]^+$ 265.19822, found 265.19843.

3. Pauson-Khand Reaction (PKR) of Siloxy-Tethered 1,7-enynes

A. PKR General Procedure

General Procedure 2: Pauson-Khand Reaction of Siloxy-Tethered 1,7-enynes *unless otherwise indicated (see 6e and 6g), reactions were performed on a 0.334 mmol scale. The isolated yields reported represent an average of three experiments.*

A flame dried 30 mL vial equipped with a magnetic stir-bar was sequentially charged with the enyne (**1a-j** and **5a-k**; 0.334 mmol, 1.00 equiv), *o*-xylene (3.40 mL, 0.10 M), $\text{Co}_2(\text{CO})_8$ (120 mg, 0.35 mmol, 1.05 equiv), and stirred for 2 h at room temperature (25 °C) under inert atmosphere (N_2). After 2 hours, the reaction was monitored by TLC analysis to ensure full conversion of the enyne to the cobalt-alkyne complex. To the reaction mixture 4-fluorobenzyl(methyl)sulfide **S21**³⁰ (4-FBnSMe) (261 mg, 1.67 mmol, 5.00 equiv) was added, and the vial was immediately placed in a pre-heated oil bath (130 °C) for 12 h. The solvent was removed under reduced pressure and the crude reaction mixture dry loaded on silica gel. Flash chromatography (silica, 100% hexanes) provided the recovered the promoter 4-FBnSMe **S21** (83% average recovery). Increasing the polarity of the solvent system (1% – 10% EtOAc/hexanes) yields **2a-j** and **6a-k** as a colorless oils or white to clear crystalline solids.

Note: For enynes derived from secondary propargyl alcohols, the crude reaction mixture was first filtered through a plug of silica to remove paramagnetic cobalt. Diastereomeric ratios were then determined by ^1H NMR analysis. The mixture of diastereomers was further purified to obtain the clean spectra and yields of the major (syn) PKR products.

B. Relative Stereochemistry Determination

The diagnostic ^1H NMR signals to differentiate the diastereomeric major (*syn*) vs. minor (*anti*) PKR products are the δ H_a and H_b in both compounds: For example, δ H_a in **6h** major (*syn*) is 5.23 ppm and δ H_a in **6h** minor (*anti*) is 5.10 ppm. δ H_b in **6h** major (*syn*) is 3.26 ppm and δ H_b in **6h** minor (*anti*) is 3.17 ppm. The chemical shift difference between the two sets of diastereomeric protons δ H_a and H_b is consistent with a broad range of PKR products. The relative stereochemistry assigned is further corroborated through single X-ray diffraction studies of **6e**, **6g**, **7c**, and **7e**.

3,3-Diisopropyl-7-methyl-3,4,4a,5-tetrahydrocyclopenta[*d*][1,2]oxasilin-6(1*H*)-one (2a)

81% yield (68.2 mg, 0.27 mmol); colorless oil. 4-FBnSMe **S21** (216 mg, 83% recovery).

R_f: 0.4 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 4.93 (d, *J* = 17.4 Hz, 1H), 4.77 (d, *J* = 17.6 Hz, 1H), 3.06 (dddq, *J* = 13.5, 7.3, 3.7, 1.8 Hz, 1H), 2.76 (ddd, *J* = 18.8, 6.2, 1.0 Hz, 1H), 2.07 (dt, *J* = 18.9, 0.9 Hz, 1H), 1.66 – 1.62 (m, 3H), 1.30 (dd, *J* = 14.5, 5.3 Hz, 1H), 1.09 (tdd, *J* = 4.8, 3.4, 2.0 Hz, 7H), 0.98 (ddt, *J* = 11.2, 4.3, 1.9 Hz, 7H), 0.54 (dd, *J* = 14.5, 13.5 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 208.09, 172.78, 133.49, 63.38, 45.50, 35.59, 17.38, 17.19, 17.12, 16.98, 14.91, 13.04, 12.70, 7.61.

IR (neat, cm⁻¹): 2940, 2921, 2892, 2865, 1702, 1649, 1463, 1409, 1382, 1329, 1292, 1205, 1163, 1120, 1048, 995, 880, 800, 759, 727.

HRMS (CI⁺, *m/z*): calculated for C₁₄H₂₅O₂Si [M+H]⁺ 253.1612483, found 253.16197.

3,3-Diisopropyl-3,4,4a,5-tetrahydrocyclopenta[*d*][1,2]oxasilin-6(1*H*)-one (2b)

25% yield (20.0 mg, 0.08 mmol); colorless oil. 4-FBnSMe **S21** (206 mg, 79% recovery).

R_f: 0.5 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 5.90 (dq, *J* = 1.7, 0.9 Hz, 1H), 4.91 (dt, *J* = 16.9, 1.7 Hz, 1H), 4.82 (dt, *J* = 16.8, 1.6 Hz, 1H), 3.16 (dtt, *J* = 13.5, 5.8, 1.6 Hz, 1H), 2.78 (ddd, *J* = 18.7, 6.3, 0.8 Hz, 1H), 2.14 – 2.06 (m, 1H), 1.33 (dd, *J* = 14.5, 5.6 Hz, 1H), 1.13 – 1.06 (m, 7H), 1.02 – 0.94 (m, 7H), 0.61 (dd, *J* = 14.5, 13.5 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 208.21, 181.53, 126.90, 64.40, 46.54, 37.55, 17.46, 17.29, 17.12, 17.01, 15.17, 12.87, 12.78.

IR (neat, cm⁻¹): 2924, 2865, 1714, 1619, 1463, 1409, 1362, 1232, 1175, 1150, 1084, 1002, 917, 881, 771, 752, 719.

HRMS (CI⁺, *m/z*): calculated for C₁₃H₂₃O₂Si [M+H]⁺ 239.14618, found 239.14634.

3,3-Diisopropyl-7-(trimethylsilyl)-3,4,4a,5-tetrahydrocyclopenta[*d*][1,2]oxasilin-6(1*H*)-one (2c)

43% yield (44.7 mg, 0.14 mmol); colorless oil. 4-FBnSMe **S21** (209 mg, 80% recovery).
R_f: 0.45 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 5.01 (dt, *J* = 17.8, 1.2 Hz, 1H), 4.87 (dt, *J* = 17.9, 1.2 Hz, 1H), 3.12 (dddd, *J* = 11.2, 5.3, 4.2, 3.2, 1.5 Hz, 1H), 2.70 (ddd, *J* = 18.5, 6.6, 1.0 Hz, 1H), 2.04 (dd, *J* = 18.3, 2.1 Hz, 1H), 1.30 (dd, *J* = 14.6, 5.3 Hz, 1H), 1.11 – 1.05 (m, 7H), 1.02 – 0.96 (m, 7H), 0.57 (dd, *J* = 14.7, 13.6 Hz, 1H), 0.19 (s, 9H).

¹³C NMR (101 MHz, CDCl₃): δ 212.11, 189.37, 136.91, 65.38, 46.60, 38.86, 17.30, 17.23, 17.12, 17.05, 14.90, 13.12, 12.67, -0.55.

IR (neat, cm⁻¹): 2924, 2866, 1693, 1585, 1462, 1408, 1248, 1098, 936, 881, 838, 750.8, 726.

HRMS (CI⁺, *m/z*): calculated for C₁₆H₃₁O₂Si [M+H]⁺ 310.179900, found 310.178437.

3,3,7-Triisopropyl-3,4,4a,5-tetrahydrocyclopenta[*d*][1,2]oxasilin-6(1*H*)-one (2d)

74% yield (70.1 mg, 0.25 mmol); colorless oil. 4-FBnSMe **S21** (209 mg, 80% recovery).
R_f: 0.4 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 5.02 (dt, *J* = 17.3, 1.2 Hz, 1H), 4.81 (dt, *J* = 17.3, 1.4 Hz, 1H), 3.01 (dddt, *J* = 13.3, 6.9, 5.3, 1.7 Hz, 1H), 2.75 – 2.63 (m, 2H), 2.03 (dt, *J* = 18.8, 0.8 Hz, 1H), 1.29 (dd, *J* = 14.6, 5.2 Hz, 1H), 1.12 (dd, *J* = 7.1, 0.9 Hz, 6H), 1.10 – 1.06 (m, 7H), 1.01 – 0.95 (m, 7H), 0.52 (dd, *J* = 14.6, 13.5 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 207.78, 172.28, 142.31, 63.36, 45.95, 35.24, 24.50, 20.50, 20.11, 17.31, 17.16, 17.11, 17.01, 15.02, 13.06, 12.67.

IR (neat, cm⁻¹): 2929, 2893, 2865, 1699, 1635, 1462, 1408, 1362, 1334, 1294, 1154, 1124, 1089, 992, 917, 881, 802, 761, 729.

HRMS (CI⁺, *m/z*): calculated for C₁₆H₂₉O₂Si [M+H]⁺ 281.19313, found 281.19330.

3,3-Diisopropyl-7-((methoxymethoxy)methyl)-3,4,4a,5-tetrahydrocyclopenta[*d*][1,2]oxasilin-6(1*H*)-one (2e)

67% yield (68.8 mg, 0.22 mmol); colorless oil. 4-FBnSMe **S21** (200 mg, 77% recovery).

R_f: 0.4 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 5.10 (d, *J* = 18.0 Hz, 1H), 4.91 (d, *J* = 18.1 Hz, 1H), 4.59 (s, 2H), 4.19 (d, *J* = 11.8 Hz, 1H), 4.14 (d, *J* = 12.1 Hz, 1H), 3.34 (s, 3H), 3.17 – 3.08 (m, 1H), 2.78 (ddd, *J* = 18.8, 6.3, 1.0 Hz, 1H), 2.09 (dd, *J* = 18.7, 1.9 Hz, 1H), 1.31 (dd, *J* = 14.6, 5.4 Hz, 1H), 1.11 – 1.05 (m, 7H), 1.01 – 0.94 (m, 7H), 0.58 (dd, *J* = 14.6, 13.6 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 206.33, 178.33, 133.77, 96.38, 63.22, 58.29, 55.50, 45.62, 36.08, 17.37, 17.18, 17.15, 16.99, 14.66, 13.02, 12.66.

IR (neat, cm⁻¹): 2927, 2893, 2865, 1702, 1648, 1463, 1409, 1291, 1210, 1151, 1103, 1039, 1021, 919, 881, 802, 763, 733.

HRMS (CI⁺, *m/z*): calculated for C₁₆H₂₇O₂Si [M-H] 311.16731, found 311.16775.

3,3-Diisopropyl-7-phenyl-3,4,4a,5-tetrahydrocyclopenta[*d*][1,2]oxasilin-6(1*H*)-one (2f)

79% yield (81.8 mg, 0.26 mmol); colorless oil. 4-FBnSMe **S21** (224 mg, 86% recovery).

R_f: 0.35 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 7.42 – 7.36 (m, 2H), 7.35 – 7.30 (m, 1H), 7.25 – 7.21 (m, 2H), 5.01 (dt, *J* = 17.1, 1.1 Hz, 1H), 4.93 (dt, *J* = 17.1, 1.7 Hz, 1H), 3.28 – 3.19 (m, 1H), 2.93 (ddd, *J* = 18.8, 6.4, 0.9 Hz, 1H), 2.27 (dd, *J* = 18.9, 1.9 Hz, 1H), 1.41 (dd, *J* = 14.5, 5.4 Hz, 1H), 1.25 (s, 1H), 1.16 – 1.09 (m, 7H), 1.00 – 0.95 (m, 6H), 0.68 (dd, *J* = 14.5, 13.4 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 206.12, 174.43, 137.55, 130.88, 128.92, 128.45, 128.13, 63.78, 46.21, 35.79, 17.43, 17.25, 17.13, 16.99, 15.54, 12.89, 12.72.

IR (neat, cm⁻¹): 2924, 2864, 1695, 1623, 1463, 1294, 1092, 1009, 982, 884, 764, 706.

HRMS (CI⁺, *m/z*): calculated for C₁₉H₂₇O₂Si [M+H]⁺ 315.17762, found 315.17748.

3,3-Diisopropyl-7-(4-methoxyphenyl)-3,4,4a,5-tetrahydrocyclopenta[*d*][1,2]oxasilin-6(1*H*)-one (2g)

65% yield (75.8 mg, 0.22 mmol); colorless oil. 4-FBnSMe **S21** (201 mg, 77% recovery).

R_f: 0.3 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 7.22 – 7.17 (m, 2H), 6.96 – 6.91 (m, 2H), 5.02 (dt, *J* = 17.1, 1.1 Hz, 1H), 4.93 (dt, *J* = 17.0, 1.7 Hz, 1H), 3.82 (s, 3H), 3.26 – 3.17 (m, 1H), 2.91 (ddd, *J* = 18.8, 6.4, 0.9 Hz, 1H), 2.25 (dd, *J* = 18.7, 1.9 Hz, 1H), 1.40 (dd, *J* = 14.5, 5.4 Hz, 1H), 1.15 – 1.09 (m, 7H), 1.01 – 0.93 (m, 7H), 0.66 (dd, *J* = 14.5, 13.4 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 206.56, 173.41, 159.48, 137.04, 130.25, 123.22, 114.02, 63.96, 55.42, 46.27, 35.70, 17.48, 17.30, 17.18, 17.05, 15.63, 12.96, 12.79.

IR (neat, cm⁻¹): 2925, 2864, 1699, 1606, 1510, 1462, 1289, 1247, 1177, 1095, 1032, 988, 915, 881, 827, 783, 761,

HRMS (CI⁺, *m/z*): calculated for C₂₀H₂₉O₃Si [M+H]⁺ 344.180943, found 344.180773.

4-(3,3-Diisopropyl-6-oxo-1,3,4,4a,5,6-hexahydrocyclopenta[*d*][1,2]oxasilin-7-yl)benzonitrile (2h)

72% yield (81.5 mg, 0.24 mmol); colorless oil. 4-FBnSMe **S21** (214 mg, 82% recovery).

R_f: 0.3 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 7.68 (d, *J* = 8.1 Hz, 2H), 7.35 (d, *J* = 8.1 Hz, 2H), 4.94 (dd, *J* = 20.1, 3.5 Hz, 2H), 3.26 (dt, *J* = 13.1, 5.7 Hz, 1H), 2.94 (dd, *J* = 19.0, 6.4 Hz, 1H), 2.28 (dd, *J* = 18.9, 1.9 Hz, 1H), 1.42 (dd, *J* = 14.6, 5.4 Hz, 1H), 1.14 – 1.07 (m, 7H), 1.0 – 0.92 (m, 7H), 0.68 (t, *J* = 14.0 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 205.14, 176.75, 135.86, 135.70, 132.21, 129.65, 118.74, 111.82, 63.55, 46.06, 36.18, 29.80, 17.37, 17.19, 17.10, 16.96, 15.41, 12.84, 12.64.

IR (neat, cm⁻¹): 2941, 2864, 2227, 1701, 1605, 1503, 1462, 1406, 1336, 1293, 1098, 989, 915, 881, 829, 759, 735, 652, 600, 551, 527, 457.

HRMS (CI⁺, *m/z*): calculated for C₂₀H₂₆NO₂Si [M+H]⁺ 339.165700, found 339.165458.

Methyl-4-(3,3-diisopropyl-6-oxo-1,3,4,4a,5,6-hexahydrocyclopenta[*d*][1,2]oxasilin-7-yl)benzoate (2i)

76% yield (93.1 mg, 0.25 mmol); colorless oil. 4-FBnSMe **S21** (206 mg, 79% recovery).

R_f: 0.25 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 8.08 – 8.03 (m, 2H), 7.33 – 7.29 (m, 2H), 4.98 (dt, *J* = 17.3, 1.1 Hz, 1H), 4.94 (dt, *J* = 17.3, 1.6 Hz, 1H), 3.91 (s, 3H), 3.29 – 3.21 (m, 1H), 2.94 (ddd, *J* = 18.9, 6.4, 0.8 Hz, 1H), 2.28 (dd, *J* = 18.8, 2.0 Hz, 1H), 2.06 dd, *J* = 15.7, 6.3 Hz, 1H), 1.41 (dd, *J* = 14.6, 5.4 Hz, 1H), 1.14 – 1.08 (m, 7H), 1.0 – 0.93 (m, 6H), 0.68 (dd, *J* = 14.6, 13.4 Hz, 1H), .

¹³C NMR (101 MHz, CDCl₃): δ 205.57, 175.92, 166.85, 136.69, 135.60, 129.69, 128.96, 63.71, 52.30, 46.17, 36.05, 17.40, 17.23, 17.12, 16.99, 15.46, 12.89, 12.68.

IR (neat, cm⁻¹): 2943, 2864, 1720, 1702, 1607, 1462, 1435, 1406, 1334, 1273, 1184, 1099, 989, 916, 881, 780, 771, 704, 649, 591.

HRMS (Cl⁺, *m/z*): calculated for C₂₁H₂₉O₄Si [M+H]⁺ 372.176548, found 372.175688.

3,3-Diisopropyl-7-(4-(trifluoromethyl)phenyl)-3,4,4a,5-tetrahydrocyclopenta[*d*][1,2]oxasilin-6(1*H*)-one (2j)

77% yield (99.5 mg, 0.26 mmol); colorless oil. 4-FBnSMe **S21** (209 mg, 80% recovery).

R_f: 0.3 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 7.65 (d, *J* = 8.1 Hz, 2H), 7.35 (d, *J* = 8.0 Hz, 2H), 4.97 (dt, *J* = 17.3, 1.6 Hz, 1H), 4.94 (dd, *J* = 17.3, 1.6 Hz, 1H), 3.31 – 3.22 (m, 1H), 2.94 (dd, *J* = 18.9, 6.4 Hz, 1H), 2.28 (dd, *J* = 18.9, 1.9 Hz, 1H), 1.43 (dd, *J* = 14.6, 5.5 Hz, 1H), 1.14 – 1.08 (m, 7H), 1.00 – 0.94 (m, 7H), 0.69 (dd, *J* = 14.6, 13.4 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 205.55, 176.10, 136.36, 134.62, 134.60, 130.64, 130.32, 130.00, 129.67, 129.31, 125.49, 125.46, 125.42, 125.38, 122.79, 63.62, 46.12, 36.09, 29.83, 17.40, 17.21, 17.11, 16.98, 15.46, 12.89, 12.70. (¹J_{C-F} = 130.64, 130.32, 130.00, 129.67).

IR (neat, cm⁻¹): 2943, 2866, 1702, 1615, 1463, 1408, 1322, 1293, 1165, 1120, 1065, 1019, 989, 880, 831, 813, 760, 745, 728, 683, 649, 604.

HRMS (Cl⁺, *m/z*): calculated for C₂₀H₂₆F₃O₂Si [M+H]⁺ 382.156432, found 382.157593.

(1S,4aR)-1-isobutyl-3,3-diisopropyl-7-methyl-3,4,4a,5-tetrahydrocyclopenta[d][1,2]oxasilin-6(1H)-one (6a)

6:1 dr, 31% yield (31.1 mg, 0.101 mmol); white solid. 4-FBnSMe **S21** (200 mg, 77% recovery).

R_f: 0.4 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 5.01 (dd, *J* = 10.1, 3.3 Hz, 1H), 3.06 – 2.96 (m, 1H), 2.70 (dd, *J* = 18.8, 6.2 Hz, 1H), 2.06 (d, *J* = 18.8 Hz, 1H), 2.00 – 1.86 (m, 1H), 1.71 – 1.56 (m, 4H), 1.31 – 1.10 (m, 3H), 1.08 – 1.00 (m, 7H), 0.99 – 0.88 (m, 12H), 0.44 (dd, *J* = 14.5, 13.2 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 208.98, 177.70, 132.92, 70.53, 45.92, 45.67, 34.03, 24.41, 23.74, 21.57, 17.24, 17.14, 17.05, 17.02, 16.10, 13.40, 13.05, 8.02.

IR (neat, cm⁻¹): 2925, 2866, 1703, 1647, 1464, 1383, 991, 880, 759.

HRMS (CI⁺, *m/z*): calculated for C₁₈H₃₃O₂Si [M+H]⁺ 309.224984, found 309.226161.

(1S,4aR)-3,3-diisopropyl-7-methyl-1-propyl-3,4,4a,5-tetrahydrocyclopenta[d][1,2]oxasilin-6(1H)-one (6b)

3:1 dr, 59% yield (26.6 mg, 0.0903 mmol); white solid. 4-FBnSMe **S21** (206 mg, 79% recovery).

R_f: 0.4 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 4.97 (dd, *J* = 8.4, 3.4 Hz, 1H), 3.01 (dtd, *J* = 13.3, 5.8, 1.7 Hz, 1H), 2.72 (dd, *J* = 18.8, 6.1 Hz, 1H), 2.07 (dd, *J* = 18.9, 1.1 Hz, 1H), 1.66 (d, *J* = 1.8 Hz, 3H), 1.55 – 1.39 (m, 2H), 1.28 (dd, *J* = 14.5, 5.7 Hz, 1H), 1.10 – 1.00 (m, 8H), 0.98 – 0.89 (m, 10H), 0.45 (dd, *J* = 14.5, 13.2 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 209.00, 177.23, 133.33, 72.03, 45.62, 39.28, 34.28, 18.54, 17.20, 17.07, 17.01, 16.98, 16.08, 14.01, 13.36, 13.03, 8.14.

IR (neat, cm⁻¹): 2925, 2867, 1703, 1644, 1463, 1411, 1386, 1335, 1297, 1170, 1140, 1106, 1068, 1036, 985, 881, 805, 779, 690.

HRMS (CI⁺, *m/z*): calculated for C₁₇H₃₁O₂Si [M+H]⁺ 295.20878, found 295.20884.

(1S,4aR)-1-isobutyl-3,3-diisopropyl-7-phenyl-3,4,4a,5-tetrahydrocyclopenta[d][1,2]oxasilin-6(1H)-one (6c)

5.5:1 dr, 81% yield (100.4 mg, 0.271 mmol); white solid. 4-FBnSMc S21 (219 mg, 84% recovery).

R_f: 0.4 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 7.39 – 7.33 (m, 2H), 7.32 – 7.28 (m, 1H), 7.19 – 7.15 (m, 2H), 5.31 (d, *J* = 11.3 Hz, 1H), 3.31 – 3.22 (m, 1H), 2.92 (ddd, *J* = 18.6, 6.3, 1.2 Hz, 1H), 2.22 (dd, *J* = 18.5, 2.9 Hz, 1H), 1.87 – 1.74 (m, 1H), 1.38 – 1.28 (m, 2H), 1.17 – 1.10 (m, 7H), 1.09 – 0.98 (m, 7H), 0.98 – 0.82 (m, 2H), 0.71 – 0.63 (m, 3H), 0.58 (d, *J* = 6.5 Hz, 3H).

¹³C NMR (101 MHz, CDCl₃): δ 205.85, 180.36, 137.96, 132.27, 128.96, 128.53, 127.96, 72.15, 46.08, 46.07, 36.79, 23.90, 23.44, 20.19, 18.17, 17.84, 17.27, 17.15, 15.58, 13.82, 12.67.

IR (neat, cm⁻¹): 2953, 2866, 1702, 1466, 1143, 1131, 1085, 1017, 881, 755, 697.

HRMS (CI⁺, *m/z*): calculated for C₂₃H₃₅O₂Si [M+H]⁺ 371.24008, found 371.24017.

(1S,4aR)-1-benzyl-3,3-diisopropyl-7-phenyl-3,4,4a,5-tetrahydrocyclopenta[d][1,2]oxasilin-6(1H)-one (6e)

13:1 dr, 88% yield (1.07 g, 2.64 mmol); white solid. 4-FBnSMc S21 (1.85 g, 89% recovery).

R_f: 0.4 (silica, 10% EtOAc/hexanes).

MP: 121 – 125 °C.

¹H NMR (400 MHz, CDCl₃): δ 7.44 – 7.38 (m, 2H), 7.35 – 7.30 (m, 1H), 7.25 – 7.11 (m, 5H), 6.98 – 6.93 (m, 2H), 5.49 (dt, *J* = 10.4, 1.8 Hz, 1H), 3.29 (ddt, *J* = 13.8, 6.5, 2.6 Hz, 1H), 2.97 (ddd, *J* = 18.7, 6.4, 1.0 Hz, 1H), 2.74 (dd, *J* = 14.7, 2.5 Hz, 1H), 2.58 (dd, *J* = 14.7, 10.5 Hz, 1H), 2.29 (dd, *J* = 18.6, 2.7 Hz, 1H), 1.41 (dd, *J* = 14.6, 4.5 Hz, 1H), 1.16 – 0.93 (m, 14H), 0.75 (t, *J* = 14.4 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 206.23, 177.83, 138.81, 138.78, 132.34, 129.09, 128.93, 128.77, 128.28, 128.16, 126.26, 75.10, 46.20, 42.84, 37.22, 18.03, 17.72, 17.17, 17.15, 15.15, 14.67, 12.52.

IR (neat, cm⁻¹): 2939, 2863, 1594, 1497, 1455, 1686, 1096, 1054, 923, 883, 723, 758, 697.

HRMS (CI⁺, *m/z*): calculated for C₂₆H₃₃O₂Si [M+H]⁺ 405.22443, found 405.22429.

Table S1. Crystal data and structure refinement for (6e).

CCDC Number	1944609
Empirical formula	C ₂₆ H ₃₂ O ₂ Si
Formula weight	404.60
Temperature/K	100
Crystal system	monoclinic
Space group	P2 ₁ /c
a	6.9808(7) Å
b	36.704(4) Å
c	17.5047(16) Å
β	93.658(3)°
Volume	4475.9(7) Å ³
Z	8
d _{calc}	1.201 g/cm ³
μ	0.124 mm ⁻¹
F(000)	1744.0
Crystal size, mm	0.43 × 0.05 × 0.02
2θ range for data collection	5.848 - 50.792°
Index ranges	-8 ≤ h ≤ 8, -44 ≤ k ≤ 44, -21 ≤ l ≤ 21
Reflections collected	70606
Independent reflections	8214[R(int) = 0.0587]
Data/restraints/parameters	8214/0/531
Goodness-of-fit on F ²	1.079
Final R indexes [I ≥ 2σ (I)]	R ₁ = 0.0487, wR ₂ = 0.0951
Final R indexes [all data]	R ₁ = 0.0654, wR ₂ = 0.1012
Largest diff. peak/hole	0.35/-0.32 eÅ ⁻³

(1S,4aR)-3,3-diisopropyl-1-phenethyl-7-phenyl-3,4,4a,5-tetrahydrocyclopenta[d][1,2]oxasilin-6(1H)-one (6f)

4:1 dr, 84% yield (117.6 mg, 0.281 mmol); white solid. 4-FBnSMe **S21**
(209 mg, 77% recovery).

R_f: 0.4 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 7.36 – 7.28 (m, 3H), 7.23 – 7.11 (m, 3H), 7.09 – 7.02 (m, 2H), 6.85 – 6.79 (m, 2H), 5.14 (ddt, *J* = 10.8, 2.5, 1.3 Hz, 1H), 3.30 – 3.20 (m, 1H), 2.92 (ddd, *J* = 18.7, 6.4, 1.2 Hz, 1H), 2.69 (ddd, *J* = 13.2, 8.4, 4.5 Hz, 1H), 2.58 (dt, *J* = 13.7, 8.3 Hz, 1H), 2.23 (dd, *J* = 18.6, 2.8 Hz, 1H), 1.73 – 1.53 (m, 2H), 1.36 (dd, *J* = 14.7, 4.3 Hz, 1H), 1.19 – 1.12 (m, 9H), 1.08 – 1.03 (m, 3H), 1.03 – 0.86 (m, 2H), 0.69 (t, *J* = 14.5 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 207.47, 176.87, 136.10, 134.17, 131.07, 129.14, 128.38, 128.02, 113.82, 64.75, 41.78, 36.11, 35.92, 35.62, 19.50, 19.19, 17.54, 17.47, 17.41, 12.72, 12.68.

IR (neat, cm⁻¹): 3027, 2924, 2864, 1702, 1495, 1462, 1407, 1290, 1129, 1097, 1074, 1050, 989, 919, 881, 857, 805, 754, 696, 667.

HRMS (CI⁺, *m/z*): calculated for C₂₇H₃₅O₂Si [M+H]⁺ 419.24008, found 419.24024.

(1S,4aR)-1-allyl-3,3-diisopropyl-7-phenyl-3,4,4a,5-tetrahydrocyclopenta[d][1,2]oxasilin-6(1H)-one (6g)

>20:1 dr, 87% yield (2.36 g, 6.65 mmol); white solid. 4-FBnSMe **S21**
(5.20 g, 87% recovery).

R_f: 0.4 (silica, 10% EtOAc/hexanes).

MP: 94 – 98 °C.

¹H NMR (400 MHz, CDCl₃): δ 7.43 – 7.28 (m, 3H), 7.23 – 7.15 (m, 2H), 5.75 (ddt, *J* = 17.1, 11.9, 5.4 Hz, 1H), 5.30 (d, *J* = 10.0 Hz, 1H), 4.94 (d, *J* = 10.3 Hz, 1H), 4.75 (d, *J* = 17.1 Hz, 1H), 3.31 – 3.22 (m, 1H), 2.94 (dd, *J* = 18.7, 6.3 Hz, 1H), 2.25 (dd, *J* = 18.7, 2.7 Hz, 1H), 2.20 – 1.99 (m, 2H), 1.37 (dd, *J* = 14.7, 4.3 Hz, 1H), 1.20 – 0.92 (m, 14H), 0.68 (t, *J* = 14.4 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 206.01, 177.89, 138.41, 135.02, 132.24, 128.83, 128.63, 128.13, 117.08, 74.50, 46.03, 40.92, 36.81, 18.08, 17.77, 17.31, 17.11, 15.20, 14.21, 12.62.

IR (neat, cm⁻¹): 2937, 2863, 1696, 1463, 1406, 1292, 1141, 1123, 1082, 915, 882, 808, 758, 698, 669.

HRMS (CI⁺, *m/z*): calculated for C₂₂H₃₁O₂Si [M+H]⁺ 355.20878, found 355.20860.

Table S2. Crystal data and structure refinement for (6g).

CCDC Number	1944610
Empirical formula	C ₂₂ H ₃₀ O ₂ Si
Formula weight	354.55
Temperature/K	100
Crystal system	triclinic
Space group	P $\bar{1}$
a	6.9931(13) Å
b	11.8301(19) Å
c	13.352(2) Å
α	75.235(6)°
β	77.460(6)°
γ	78.348(6)°
Volume	1030.0(3) Å ³
Z	2
d_{calc}	1.143 g/cm ³
μ	0.126 mm ⁻¹
F(000)	384.0
Crystal size, mm	0.16 × 0.08 × 0.03
2 θ range for data collection	3.604 - 50.734°
Index ranges	-8 ≤ h ≤ 8, -13 ≤ k ≤ 14, -16 ≤ l ≤ 16
Reflections collected	19352
Independent reflections	3700[R(int) = 0.0527]
Data/restraints/parameters	3700/0/230
Goodness-of-fit on F ²	1.029
Final R indexes [I ≥ 2 σ (I)]	R ₁ = 0.0397, wR ₂ = 0.0874
Final R indexes [all data]	R ₁ = 0.0593, wR ₂ = 0.0954
Largest diff. peak/hole	0.32/-0.27 eÅ ⁻³

(1S,4aR)-3,3-diisopropyl-7-phenyl-1-propyl-3,4,4a,5-tetrahydrocyclopenta[d][1,2]oxasilin-6(1H)-one (6h)

3.5:1 dr, 74% yield (88.1 mg, 0.247 mmol); white solid. 4-FBnSMe **S21**
(214 mg, 82% recovery).

R_f: 0.4 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 7.40 – 7.34 (m, 2H), 7.32 – 7.27 (m, 1H), 7.20 – 7.16 (m, 2H), 5.23 (dd, *J* = 9.4, 3.4 Hz, 1H), 3.31 – 3.23 (m, 1H), 2.92 (dd, *J* = 18.6, 6.3 Hz, 1H), 2.23 (dd, *J* = 18.5, 2.8 Hz, 1H), 1.47 – 1.22 (m, 6H), 1.16 – 1.11 (m, 7H), 1.08 – 0.98 (m, 6H), 0.97 – 0.87 (m, 1H), 0.72 – 0.62 (m, 3H).

¹³C NMR (101 MHz, CDCl₃): δ 206.05, 179.67, 138.06, 132.37, 128.84, 128.56, 127.97, 73.47, 46.05, 38.87, 36.83, 18.98, 18.13, 17.81, 17.34, 17.17, 15.28, 13.93, 13.11, 12.70.

IR (neat, cm⁻¹): 2942, 2865, 1702, 1495, 1463, 1408, 1288, 1225, 1127, 1071, 1034, 1012, 919, 881, 756, 697, 667.

HRMS (CI⁺, *m/z*): calculated for C₂₃H₃₃O₂Si [M+H]⁺ 357.22443, found 357.22439.

(1S,4aR)-3,3-diisopropyl-1-(pent-4-en-1-yl)-7-phenyl-3,4,4a,5-tetrahydrocyclopenta[d][1,2]oxasilin-6(1H)-one (6i)

>20:1 dr, 89% yield (113.6 mg, 0.297 mmol); white solid. 4-FBnSMe **S21**
(222 mg, 85% recovery).

R_f: 0.4 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 7.43 – 7.37 (m, 2H), 7.36 – 7.30 (m, 1H), 7.21 – 7.17 (m, 2H), 5.62 (ddt, *J* = 16.9, 10.1, 2.0 Hz, 1H), 5.06 – 5.03 (m, 1H), 4.80 – 4.71 (m, 2H), 3.24 – 3.16 (m, 1H), 2.72 (dd, *J* = 19.1, 6.7 Hz, 1H), 2.30 – 2.22 (m, 1H), 2.14 – 2.00 (m, 3H), 1.68 – 1.57 (m, 2H), 1.44 (dt, *J* = 8.1, 1.4 Hz, 2H), 1.27 – 1.12 (m, 1H), 0.93 – 0.75 (m, 14H).

¹³C NMR (101 MHz, CDCl₃): δ 207.47, 176.87, 136.10, 134.17, 131.07, 129.14, 128.38, 128.02, 113.82, 64.75, 41.78, 36.11, 35.92, 35.62, 19.50, 19.19, 17.54, 17.47, 17.41, 12.72, 12.68.

IR (neat, cm⁻¹): 2938, 1865, 1705, 1630, 1463, 1449, 1291, 1138, 1114, 1072, 1026, 929, 882, 828, 785, 758, 712, 697.

HRMS (CI⁺, *m/z*): calculated for C₂₄H₃₅O₂Si [M+H]⁺ 383.24008, found 383.24012.

(1R,4aS)-3,3-diisopropyl-1-pentyl-7-phenyl-3,4,4a,5-tetrahydrocyclopenta[d][1,2]oxasilin-6(1H)-one (6j)

4:1 dr, 68% yield (87.3 mg, 0.227 mmol); white solid. 4-FBnSMe **S21**
(200 mg, 77% recovery).

R_f: 0.4 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 7.43 – 7.27 (m, 3H), 7.20 – 7.13 (m, 2H), 5.21 (d, *J* = 9.7 Hz, 1H), 3.31 – 3.21 (m, 1H), 2.92 (ddd, *J* = 18.5, 6.3, 1.2 Hz, 1H), 2.23 (dd, *J* = 18.6, 2.8 Hz, 1H), 1.45 – 1.18 (m, 7H), 1.16 – 0.98 (m, 15H), 0.97 – 0.82 (m, 2H), 0.75 (t, *J* = 7.1 Hz, 2H), 0.67 (t, *J* = 14.5 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 206.05, 179.69, 132.42, 128.83, 128.60, 127.97, 73.99, 46.07, 36.84, 36.79, 30.82, 25.54, 22.32, 18.16, 17.83, 17.37, 17.17, 15.34, 14.03, 13.96, 12.71.

IR (neat, cm⁻¹): 2926, 2863, 1689, 1460, 1143, 1123, 1081, 1015, 920, 881, 859, 808, 765, 703.

HRMS (CI⁺, *m/z*): calculated for C₂₄H₃₇O₂Si [M+H]⁺ 385.25573, found 385.25566.

(1S,4aR)-1-allyl-3,3-diisopropyl-7-methyl-3,4,4a,5-tetrahydrocyclopenta[d][1,2]oxasilin-6(1H)-one (6k)

12:1 dr, 82% yield (80.1 mg, 0.274 mmol); white solid. 4-FBnSMe **S21**
(206 mg, 79% recovery).

R_f: 0.4 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 5.96 (ddt, *J* = 17.1, 10.3, 6.6 Hz, 1H), 5.19 – 5.10 (m, 2H), 4.94 (d, *J* = 10.6 Hz, 1H), 3.08 – 2.97 (m, 1H), 2.72 (dd, *J* = 18.4, 6.1 Hz, 1H), 2.61 – 2.52 (m, 1H), 2.45 – 2.35 (m, 1H), 2.04 (dd, *J* = 18.4, 2.9 Hz, 1H), 1.69 (s, 3H), 1.25 (dd, *J* = 14.4, 4.3 Hz, 1H), 1.11 – 1.01 (m, 8H), 1.01 – 0.88 (m, 6H), 0.55 (t, *J* = 14.5 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 207.91, 175.35, 134.98, 133.48, 117.36, 74.33, 45.42, 41.68, 36.70, 18.07, 17.77, 17.30, 17.11, 15.16, 13.94, 12.52, 9.19.

IR (neat, cm⁻¹): 2942, 2865, 1702, 1638, 1463, 1410, 1382, 1288, 1221, 1141, 1056, 989, 913, 882, 802, 757, 736, 711.

HRMS (CI⁺, *m/z*): calculated for C₁₇H₂₉O₂Si [M+H]⁺ 293.19313, found 293.19334.

C. Enantioenriched Substrates

(R)-1-phenylhex-5-en-1-yn-3-ol (–)-S19

Propargyl Alcohol (–)-S19 was synthesized following a published procedure by H.C. Brown.^{28a-b}

Spectral data is in agreement with those previously reported in the literature.^{28c}

Racemic

Peak #	T _R [min]	Area [μV·sec]	Height [μV]	Area (%)	Height (%)
1	4.147	987682	182196	49.398	51.600
2	4.397	1011752	170899	50.602	48.400

Enantioenriched

Peak #	T _R [min]	Area [μV·sec]	Height [μV]	Area (%)	Height (%)
1	4.08	94266	20001	5.120	6.311
2	4.302	1747019	296932	94.880	93.689

Allyldiisopropyl((1-phenylhex-5-en-1-yn-3-yl)oxy)silane (–)-5g

81% yield (0.768 g, 2.35 mmol); colorless oil.

R_f: 0.8 (silica, 1% EtOAc/hexanes).

[α]_D²⁵ = – 50.5° (c = 2.0, CHCl₃).

¹H NMR (400 MHz, CDCl₃): δ 7.44 – 7.39 (m, 2H), 7.34 – 7.28 (m, 3H), 6.02 – 5.88 (m, 2H), 5.22 – 5.11 (m, 2H), 4.99 (ddt, *J* = 16.9, 3.7, 1.8 Hz, 1H), 4.88 (ddt, *J* = 10.1, 2.2, 1.1 Hz, 1H), 4.71 (t, *J* = 6.4 Hz, 1H), 2.59 – 2.51 (m, 2H), 1.83 (dt, *J* = 8.1, 1.4 Hz, 2H), 1.15 – 1.04 (m, 14H).

¹³C NMR (101 MHz, CDCl₃): δ 134.76, 134.08, 131.68, 128.39, 128.31, 123.16, 117.88, 113.95, 90.62, 84.83, 77.48, 77.16, 76.84, 63.54, 43.50, 19.38, 17.73, 17.67, 17.65, 12.99, 12.93.

IR (neat, cm^{–1}): 3079, 2943, 2866, 1630, 1490, 1463, 1342, 1159, 1084, 993, 914, 882, 754, 689.

HRMS (Cl⁺, *m/z*): calculated for C₂₁H₃₁OSi [M+H]⁺ 327.21387, found 327.21409.

1-Allyl-3,3-diisopropyl-7-phenyl-3,4,4a,5-tetrahydrocyclopenta[*d*][1,2]oxasilin-6(1*H*)-one (–)-6g

>20:1 *dr*, 98.5:1.5 *er*, 92% yield, (103.0 mg, 0.291 mmol); white solid.

R_f : 0.4 (silica, 10% EtOAc/hexanes). 4-FBnSMe **S21** (222 mg, 85% recovery).

[α]_D²⁵ = – 22.0° (c = 1.0, CHCl₃).

Chiral SFC: (OD-H, 4mL/min, 0.1% IPA in CO₂, λ = 254 nm): t_R (major) = 4.14 min, t_R (minor) = 4.55 min.

¹H NMR (400 MHz, CDCl₃): δ 7.43 – 7.27 (m, 3H), 7.22 – 7.16 (m, 2H), 5.76 (ddt, *J* = 17.0, 10.2, 6.7 Hz, 1H), 5.30 (d, *J* = 10.0 Hz, 1H), 4.94 (dd, *J* = 10.2, 1.8 Hz, 1H), 4.76 (dt, *J* = 17.1, 1.7 Hz, 1H), 3.31 – 3.22 (m, 1H), 2.93 (dd, *J* = 18.6, 6.4 Hz, 1H), 2.24 (dd, *J* = 18.6, 2.7 Hz, 1H), 2.19 – 2.01 (m, 2H), 1.37 (dd, *J* = 14.7, 4.4 Hz, 1H), 1.18 – 1.09 (m, 7H), 1.08 – 0.90 (m, 7H), 0.68 (t, *J* = 14.4 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 205.95, 177.78, 138.45, 135.04, 132.29, 128.87, 128.63, 128.13, 117.05, 77.48, 77.16, 76.84, 74.52, 46.06, 40.93, 36.84, 18.08, 17.78, 17.31, 17.12, 15.17, 14.29, 12.66.

IR (neat, cm^{–1}): 2939, 2864, 1696, 1463, 1407, 1292, 1141, 1123, 1082, 916, 882, 807, 758, 698.

HRMS (Cl⁺, *m/z*): calculated for C₂₂H₃₁O₂Si [M+H]⁺ 355.20878, found 355.20860.

Racemic

Peak #	T _R [min]	Area [$\mu\text{V}\cdot\text{sec}$]	Height [μV]	Area (%)	Height (%)
1	4.420	1455085	103796	50.611	50.921
2	4.857	1419931	100041	49.389	49.079

Enantioenriched

Peak #	T _R [min]	Area [$\mu\text{V}\cdot\text{sec}$]	Height [μV]	Area (%)	Height (%)
1	4.140	1833000	119177	98.524	97.964
2	4.547	27469	2477	1.476	2.036

D. Functionalization of Siloxy-Tethered Cyclopentenones

(1S,4aR,6R)-1-allyl-3,3-diisopropyl-7-phenyl-1,3,4,4a,5,6-hexahydrocyclopenta[d][1,2]oxasilin-6-ol (**7a**)

A flame-dried 25 mL round bottom flask equipped with a magnetic stir bar was placed under inert atmosphere (N_2) and sequentially charged enone **6g** (100 mg, 0.28 mmol, 1.00 equiv), MeOH/THF (4:1, 8:2 mL), and cerium(III) chloride heptahydrate (209 mg, 0.56 mmol, 2.00 equiv) at 0 °C. After stirring the reaction mixture for 10 minutes, $NaBH_4$ (10.3mg, 0.34 mmol, 1.20 equiv) was added in one portion. The reaction was stirred for 30 minutes at 0 °C. TLC analysis indicated the consumption of **6g** at which time the reaction was quenched with water (20 mL). The aqueous phase was extracted with EtOAc (3 x 20 mL) and the combined organic phases were washed with brine (25 mL), dried with $MgSO_4$, filtered, and concentrated under reduced pressure. Flash chromatography (silica, 5% EtOAc/hexanes) provided **7a** (63.7 mg, 0.18 mmol, 63% yield) as a viscous colorless oil.

R_f : 0.4 (silica, 10% EtOAc/hexanes).

1H NMR (400 MHz, $CDCl_3$): δ 7.55 – 7.19 (m, 5H), 5.75 (dddd, J = 17.3, 10.3, 7.2, 6.3 Hz, 1H), 4.89 (ddt, J = 10.3, 2.3, 1.2 Hz, 1H), 4.79 – 4.70 (m, 3H), 2.94 – 2.83 (m, 1H), 2.73 (dt, J = 12.6, 7.3 Hz, 1H), 2.13 – 1.98 (m, 2H), 1.77 (bs, 1H), 1.44 (dt, J = 13.0, 6.6 Hz, 1H), 1.21 (dd, J = 14.4, 4.7 Hz, 1H), 1.10 – 0.98 (m, 14H), 0.67 (dd, J = 14.5, 13.5 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 146.12, 137.71, 136.92, 136.11, 128.95, 128.54, 127.40, 116.24, 79.60, 73.56, 44.30, 42.72, 41.00, 18.14, 17.88, 17.43, 17.29, 16.08, 14.69, 12.79.

IR (neat, cm^{-1}): 3347, 3074, 2941, 2921, 2891, 2864, 1640, 1599, 1492, 1463, 1087, 990, 912, 882, 754, 699.

HRMS (CI^+ , m/z): calculated for $C_{22}H_{31}O_2Si$ $[M-H]^+$ 355.20878, found 355.20911.

(1aS,3aR,7S,7aR)-7-allyl-5,5-diisopropyl-1a-phenyltetrahydro-7H-oxireno[2',3':2,3]cyclopenta[1,2-d][1,2]oxasilin-2(1aH)-one (**7b**)

A flame-dried 25 mL round bottom flask equipped with a magnetic stir bar was sequentially charged with enone **6g** (100 mg, 0.28 mmol, 1.00 equiv), and MeOH/THF (3:1, 6:2 mL). The solution was cooled to 0 °C and 50% aqueous H_2O_2 solution (0.26 mL, 191 mg, 5.64 mmol, 20.0 equiv) was

added dropwise, immediately followed by the dropwise addition of a 4 M aqueous NaOH solution (0.69 mL, 1.97 mmol, 7.00 equiv). The solution was stirred at 0 °C for 4 h. TLC analysis indicated the consumption of enone **6g** at which time the reaction was quenched with 1 M aqueous HCl (5 mL). The solution was diluted with CH₂Cl₂, transferred to a separatory funnel, and washed with water (2 x10 mL). The combined aqueous phases were extracted with CH₂Cl₂ (3 x10 mL). The combined organic phases were dried with Na₂SO₄, filtered, and concentrated under reduced pressure. Flash chromatography (silica, 1% EtOAc/hexanes) provided **7b** (67.9 mg, 0.18 mmol, 66% yield) as a white to clear crystalline solid.

Note: The stereochemistry of the epoxide in 7b is assigned by analogy to that of the epoxide in 7e. Please see S39 for X-ray crystal structure of 7e.

R_f: 0.67 (silica, 10% EtOAc/hexanes).

¹H NMR (400 MHz, CDCl₃): δ 7.44 – 7.28 (m, 5H), 5.69 (dddd, *J* = 17.1, 10.2, 7.9, 5.8 Hz, 1H), 4.90 (ddt, *J* = 10.2, 2.3, 1.1 Hz, 1H), 4.84 (ddt, *J* = 17.2, 2.0, 1.6 Hz, 1H), 4.49 (dd, *J* = 10.6, 2.2 Hz, 1H), 2.96 (dd, *J* = 16.5, 7.2 Hz, 1H), 2.89 (ddd, *J* = 12.7, 7.3, 5.3 Hz, 1H), 1.98 – 1.88 (m, 2H), 1.30 – 1.15 (m, 3H), 1.15 – 0.91 (m, 13H), 0.65 (dd, *J* = 14.9, 12.8 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 210.36, 135.88, 129.30, 128.74, 128.40, 128.28, 116.33, 77.48, 77.16, 76.84, 76.15, 74.53, 68.95, 43.64, 36.60, 34.86, 17.83, 17.58, 17.24, 15.21, 12.27, 11.74.

IR (neat, cm⁻¹): 3082, 2945, 2926, 2866, 1744, 1649, 1462, 1137, 939, 915, 882, 817, 745,

HRMS (CI⁺, *m/z*): calculated for C₂₂H₃₁O₃Si [M+H]⁺ 371.20370, found 371.20408.

(R)-3-((S)-1-hydroxybut-3-en-1-yl)-4-((hydroxydiisopropylsilyl)methyl)-2-phenylcyclopent-2-en-1-one (7c)

Adapted from a procedure by Gevorgyan and coworkers.³¹ To an ice-cooled (0 °C) stirring solution of KH (452 mg, 3.38 mmol, dispersed in mineral oil, 30%, 12.0 equiv) in 3.5 mL of NMP was added tert-butyl hydroperoxide (3.94 mL, 2.76 mmol, 10.0 equiv, 70% in water) dropwise. The mixture was allowed to warm up to room temperature (25 °C) and stirred for 10 min, then

a solution of **6g** (100 mg, 0.28 mmol, 1.00 equiv) in 2.8 mL of NMP was added. The reaction mixture was allowed to stir for 16 h. TBAF (1.41 mL, 1.41 mmol, 1.0 M solution in THF) was added and the mixture was allowed to stir for another 3 h, then cooled to 0°C. To the cooled reaction mixture Na₂S₂O₃•5H₂O (2.0 g) and of water (10 mL) were added. The mixture was stirred at 0°C for 30 min followed by addition of NH₄Cl. The aqueous phase was extracted with EtOAc

(3 × 10 mL), the combined organic phases were washed with H₂O (4 × 10 mL), brine (15 mL), dried with Na₂SO₄, filtered, and concentrated under reduced pressure. Flash chromatography (silica, 15% EtOAc/hexanes) provided **7c** (53.2 mg, 0.14 mmol, 51% yield) as a white to clear crystalline solid.

R_f : 0.2 (silica, 30% EtOAc/Hexanes)

¹H NMR (400 MHz, CDCl₃): δ 7.42 – 7.37 (m, 2H), 7.35 – 7.30 (m, 1H), 7.20 – 7.16 (m, 2H), 5.70 (dddd, *J* = 16.8, 10.2, 7.9, 6.4 Hz, 1H), 5.16 – 5.07 (m, 2H), 4.82 (dd, *J* = 9.1, 4.0 Hz, 1H), 3.36 (ddt, *J* = 11.5, 6.8, 2.5 Hz, 1H), 2.86 (ddd, *J* = 18.8, 6.7, 0.8 Hz, 1H), 2.55 – 2.39 (m, 3H), 2.35 (dd, *J* = 18.8, 2.1 Hz, 1H), 1.57 (bs, 1H), 1.47 (dd, *J* = 14.7, 2.9 Hz, 1H), 1.11 – 1.03 (m, 14H), 0.69 (dd, *J* = 14.7, 11.3 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 207.45, 179.61, 139.80, 133.91, 131.94, 129.09, 128.59, 128.12, 119.27, 70.16, 44.54, 41.90, 34.90, 29.84, 17.55, 17.53, 17.51, 17.44, 17.31, 13.39, 13.34.

IR (neat, cm⁻¹): 3338, 3188, 2957, 2938, 2864, 167, 1625, 1596, 1462, 1343, 1317, 1072, 851, 759, 695.

HRMS (CI⁺, *m/z*): calculated for C₂₂H₃₃O₃Si [M+H]⁺ 373.21935, found 373.21939.

Table S3. Crystal data and structure refinement for (7c).

CCDC Number	1944608
Empirical formula	C ₂₂ H ₃₂ O ₃ Si
Formula weight	372.56
Temperature/K	100
Crystal system	monoclinic
Space group	P2 ₁ /n
a	13.6130(8) Å
b	9.2151(5) Å
c	17.6361(10) Å
β	99.306(2)°
Volume	2183.2(2) Å ³
Z	4
d _{calc}	1.133 g/cm ³
μ	0.125 mm ⁻¹
F(000)	808.0
Crystal size, mm	0.33 × 0.14 × 0.09
2θ range for data collection	6.044 - 50.794°
Index ranges	-16 ≤ h ≤ 16, -11 ≤ k ≤ 11, -21 ≤ l ≤ 20
Reflections collected	28527
Independent reflections	4007[R(int) = 0.0975]
Data/restraints/parameters	4007/0/241
Goodness-of-fit on F ²	1.088
Final R indexes [I ≥ 2σ(I)]	R ₁ = 0.0571, wR ₂ = 0.0986
Final R indexes [all data]	R ₁ = 0.0839, wR ₂ = 0.1074
Largest diff. peak/hole	0.32/-0.39 eÅ ⁻³

(R)-3-((S)-1-hydroxybut-3-en-1-yl)-4-(hydroxymethyl)-2-phenylcyclopent-2-en-1-one (7d)

Adapted from a procedure by Maiti and coworkers.³² To an pre-cooled (0 °C) stirring solution of KF (0.25 g, 4.23 mmol, 5.00 equiv) and KHCO₃ (0.42 g, 4.23 mmol, 5.00 equiv) in MeOH:THF (1:1, 2.1:2.1 mL), was added 30% aqueous H₂O₂ (3.29 mL, 1.43 g, 42.3 mmol, 50 equiv) dropwise under an inert atmosphere (N₂). In a separate flame-dried 10 mL vial, **6g** (0.30 g, 0.84 mmol, 1.00 equiv) was diluted in THF (0.3 mL) and added dropwise at 0 °C. The reaction was allowed to warm to room temperature, fitted with a reflux condenser, and heated to 60 °C for 48 h. The reaction mixture was cooled (0 °C), then Na₂S₂O₃·5H₂O (2.0 g) and water (10 mL) were added. The mixture was stirred at 0 °C for 30 min followed by addition of NH₄Cl (10 mL). The aqueous phase was extracted with EtOAc (3 x 20 mL), the combined organic phases dried over Na₂SO₄, filtered, and concentrated under reduced pressure. Flash chromatography (silica, 5% EtOAc/hexanes) provided the recovered starting material **6g** (161 mg, 0.45 mmol). Increasing the solvent polarity (25% EtOAc/hexanes) provided diol **7d** (42.8 mg, 0.17 mmol, 42% yield; based on the recovery of starting material **6g**) as a viscous colorless oil.

R_f : 0.2 (silica, 1% MeOH/CH₂Cl₂)

¹H NMR (400 MHz, CDCl₃): δ 7.43 – 7.31 (m, 5H), 5.62 (dddd, *J* = 16.7, 10.1, 7.7, 6.3 Hz, 1H), 5.02 (ddt, *J* = 10.2, 1.9, 1.0 Hz, 1H), 4.88 (dq, *J* = 17.1, 1.6 Hz, 1H), 4.10 – 4.04 (m, 2H), 3.78 (dd, *J* = 11.3, 3.9 Hz, 1H), 2.87 (dddd, *J* = 8.9, 3.7, 2.7, 1.0 Hz, 1H), 2.79 (dd, *J* = 17.4, 8.9 Hz, 1H), 2.67 (bs, 1H), 2.23 (dddt, *J* = 14.4, 6.2, 3.0, 1.4 Hz, 2H), 2.16 (dd, *J* = 17.5, 0.9 Hz, 1H), 2.07 – 1.98 (m, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 208.42, 134.19, 129.02, 128.77, 128.38, 127.98, 118.62, 75.81, 70.82, 68.25, 62.98, 39.15, 37.72, 37.49.

IR (neat, cm⁻¹): 3432, 3066, 2927, 1742, 1641, 1502, 1448, 1407, 1281, 1135, 1066, 999, 915, 887, 749, 732.

HRMS (CI⁺, *m/z*): calculated for C₁₆H₁₇O₃ [M-H]⁺ 257.11722, found 257.11741.

(1a*S*,3a*R*,7*S*,7a*R*)-7-benzyl-5,5-diisopropyl-1a-phenyltetrahydro-7*H*-oxireno[2',3':2,3]cyclopenta[1,2-*d*][1,2]oxasilin-2(1a*H*)-one (7e)

A flame-dried 25 mL round bottom flask equipped with a magnetic stir bar was sequentially charged with enone **6g** (100 mg, 0.28 mmol, 1.00 equiv),

and MeOH/THF (3:1, 6:2 mL) under inert atmosphere (N₂). The solution was cooled to 0 °C and 50% aqueous H₂O₂ solution (0.27 mL, 191 mg, 5.64 mmol, 20.0 equiv) was added dropwise, and immediately followed by the dropwise addition of a 4 M aqueous NaOH solution (0.69 mL, 1.97 mmol, 7.00 equiv). The solution was stirred at 0 °C for 4 h. TLC analysis indicated the consumption of enone **6g** at which time the reaction was quenched with 1 M aqueous HCl (5 mL). The solution was diluted with CH₂Cl₂, transferred to a separatory funnel, and washed with water (2 x10 mL). The combined aqueous phases were extracted with CH₂Cl₂ (3 x10 mL). The combined organic phases were dried with Na₂SO₄, filtered, and concentrated under reduced pressure. Flash chromatography (silica, 1% EtOAc/hexanes) provided **7e** (67.9 mg, 0.18 mmol, 66% yield) as a white to clear crystalline solid.

R_f: 0.63 (10% EtOAc/hexanes).

MP: 80-83°C

¹H NMR (400 MHz, CDCl₃): δ 7.48 – 7.33 (m, 5H), 7.20 – 7.09 (m, 3H), 7.05 – 7.00 (m, 2H), 4.58 (dd, *J* = 10.6, 1.7 Hz, 1H), 2.99 (dd, *J* = 16.7, 7.3 Hz, 1H), 2.90 (ddd, *J* = 12.7, 7.3, 5.3 Hz, 1H), 2.51 (dd, *J* = 13.7, 1.7 Hz, 1H), 1.93 (d, *J* = 16.7 Hz, 1H), 1.63 (dd, *J* = 13.7, 10.6 Hz, 1H), 1.18 (dd, *J* = 14.9, 5.4 Hz, 1H), 1.11 – 0.95 (m, 9H), 0.82 (dd, *J* = 35.7, 7.5 Hz, 7H), 0.68 (dd, *J* = 14.9, 12.8 Hz, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 210.31, 139.79, 129.54, 129.43, 128.83, 128.56, 128.34, 127.90, 126.04, 76.27, 75.66, 69.08, 43.73, 38.55, 34.97, 17.36, 17.32, 17.18, 15.55, 11.98, 11.71.

IR (neat, cm⁻¹): 3030, 2935, 2909, 2864, 1746, 1624, 1493, 1668, 1608, 1383, 1343, 1231, 1131, 1085, 1066, 1019, 938, 883, 809, 779, 762.

HRMS (CI⁺, *m/z*): calculated for C₂₆H₃₃O₃Si [M+H]⁺ 421.21935, found 421.211964 .

Table S4. Crystal data and structure refinement for (7e).

CCDC Number	1944611
Empirical formula	C ₂₆ H ₃₂ O ₃ Si
Formula weight	420.60
Temperature/K	100
Crystal system	triclinic
Space group	P $\bar{1}$
a	10.5963(4) Å
b	10.8935(4) Å
c	12.2184(5) Å
α	105.9910(10)°
β	103.3180(10)°
γ	114.5990(10)°
Volume	1132.64(8) Å ³
Z	2
d_{calc}	1.233 g/cm ³
μ	0.128 mm ⁻¹
F(000)	452.0
Crystal size, mm	0.35 × 0.32 × 0.18
2 θ range for data collection	5.826 - 55.078°
Index ranges	-13 ≤ h ≤ 13, -14 ≤ k ≤ 14, -15 ≤ l ≤ 15
Reflections collected	30106
Independent reflections	5207 [R(int) = 0.0276]
Data/restraints/parameters	5207/0/275
Goodness-of-fit on F ²	1.101
Final R indexes [I ≥ 2σ (I)]	R ₁ = 0.0353, wR ₂ = 0.0902
Final R indexes [all data]	R ₁ = 0.0403, wR ₂ = 0.0938
Largest diff. peak/hole	0.35/-0.39 e Å ⁻³

(R)-3-((S)-1-hydroxy-2-phenylethyl)-4-(hydroxymethyl)-2-phenylcyclopent-2-en-1-one (7f)

Adapted from a procedure by Jeon and coworkers.³³ A flame-dried 25 mL RBF equipped with a magnetic stir bar was sequentially charged with cesium hydroxide monohydrate (120 mg, 0.99 mmol, 4.00 equiv), and DMF (2.50 mL, 0.10 M) under inert atmosphere (N₂). The solution was cooled to 0 °C and tert-butyl hydroperoxide (0.74 mL, 5.00 M in decane, 3.71 mmol, 15.0 equiv), followed by tetrabutylammonium fluoride (1.24 mL, 1.24 mmol, 1.0 M in THF solution) was added dropwise. In a separate flame-dried 10 mL pear-shaped flask, cyclopentaoxasilinone **6g** (0.30 g, 0.84 mmol, 1.00 equiv) was diluted with DMF (0.30 mL) and added dropwise to the reaction mixture at 0 °C. Once addition of **6g** was complete, the reaction was warmed to room temperature (25 °C) and allowed to stir for 17 hours. TLC analysis indicated the consumption of **6g** at which time the reaction was quenched with saturated aqueous sodium thiosulfate (10 mL) and stirred for 30 min. The aqueous layer was extracted with EtOAc (3 x 20 mL), the combined organic phases were washed with aqueous HCl (1.0 M, 20 mL), saturated aqueous sodium bicarbonate (20 mL), brine (20 mL), dried over Na₂SO₄, filtered, and concentrated under reduced pressure. Flash chromatography (silica, 25% EtOAc/hexanes) provided **7f** (102 mg, 0.33 mmol, 40% yield) as a clear viscous oil.

R_f : 0.54 (silica, 2% MeOH/CH₂Cl₂)

¹H NMR (400 MHz, CDCl₃): δ 7.46 – 7.40 (m, 4H), 7.21 – 7.13 (m, 3H), 6.74 (dd, *J* = 7.7, 2.0 Hz, 2H), 4.10 (ddd, *J* = 14.1, 11.2, 2.8 Hz, 2H), 3.83 (dd, *J* = 11.2, 4.3 Hz, 1H), 3.00 – 2.95 (m, 1H), 2.82 (dd, *J* = 17.8, 8.9 Hz, 1H), 2.70 (dd, *J* = 13.9, 2.4 Hz, 1H), 2.52 (dd, *J* = 13.8, 10.8 Hz, 1H), 2.18 (dd, *J* = 17.8, 1.2 Hz, 1H), 1.26 (s, 2H), 0.93 – 0.83 (m, 1H).

¹³C NMR (101 MHz, CDCl₃): δ 208.31, 138.09, 129.17, 129.06, 128.81, 128.64, 128.46, 128.09, 126.74, 73.88, 68.42, 62.97, 39.52, 38.91, 37.55.

IR (neat, cm⁻¹): 3338, 3030, 2928, 1747, 1604, 1496, 1449, 1403, 1267, 1132, 1060, 1029, 841, 749, 733, 699.

HRMS (CI⁺, *m/z*): calculated for C₂₀H₁₉O₃ [M-H]⁺ 307.13287, found 307.13301.

3. References

1. W. C. Still, M. Kahn, A. Mitra, *J. Org. Chem.* 1978, **43**, 2923 – 2925.
2. APEX3 2016.1-0: Bruker-AXS, Madison, Wisconsin, USA (2016).
3. APEX2 2014.11-0: Bruker-AXS, Madison, Wisconsin, USA (2014).
4. SAINT v8.34A: Bruker-AXS, Madison, Wisconsin, USA (2014).
5. SADABS v2014/5: L. Krause, R. Herbst-Irmer, G.M. Sheldrick, and D. Stalke, *J. Appl. Cryst.*, 2015, **48**, 3 – 10.
6. SHELXT v2014/4: G.M Sheldrick, *Acta Crystallogr., Sect. A*, 2015, **71**, 3 – 8.
7. SHELXS-97: G.M. Sheldrick, *Acta Crystallogr., Sect. A*, 2008, **64**, 112 – 122.
8. SHELXL-2018/3: G.M. Sheldrick, *Acta Crystallogr., Sect. A*, 2015, **71**, 3 – 8.
9. C. F. Macrae, P. R. Edgington, P. McCabe, E. Pidcock, G. P. Shields, R. Taylor, M. Towler, J. van de Streek, *J. Appl. Cryst.* 2006, **39**, 453 – 457.
10. (S1) M. Hu, J. Li, S. Q. Yao, *Org. Lett.* 2008, **10**, 5529-5531.
11. (S2) S. Aoyagi, T. C. Wang, C. Kibayashi, *J. Am. Chem. Soc.*, 1993, **115**, 11393 –11409.
12. (S3) P. Liu, P.S. Wang, *Chemistry Letters*, 2017, **46**, 1190-1192.
13. (S4) Y. Guan, M. P. Lopez-Alberca, Z. Lu, Y. Zhang, A. A. Desai, A. P. Patwardhan, Y. Dai, M. J. Vetticatt, W. D. Wulff, *Chem. Eur. J.*, 2014, **20**, 13894 – 13900.
14. (S5) M. Maji, D. Mallick, S. Mondal, A. Anoop, S. Sekhar Bag, A. Basak, E. D. Jemmis, *Org. Lett.*, 2011, **13**, 888 – 891.
15. (S6) Y. Guan, M. P. Lopez-Alberca, Z. Lu, Y. Zhang, A. A. Desai, A. P. Patwardhan, Y. Dai, M. J. Vetticatt, W. D. Wulff, *Chem. Eur. J.*, 2014, **20**, 13894 – 13900.
16. (S7) J. Panteleev, R. Y. Huang, E. K. J. Lui, M. Lautens, *Org. Lett.*, 2011, **13**, 5314 – 5317.
17. (S8) K. K. Chan, N. Cohen, J. P. De Noble, A. C. Specian, G. Saucy, *J. Org. Chem.*, 1976, **41**, 3497.
18. (S9) M. Barbazanges, C. Meyer, J. Cossy, *Org. Lett.*, 2008, **10**, 4489 – 4492.
19. (S10) B. S. Chinta, B., Baire, *Eur. J. Org. Chem.*, 2017, **23**, 3381 – 3385.
20. (S11) D. A. Engel, G. B. Dudley, *Org. Lett.*, 2006, **8**, 4027 – 4029.
21. (S12) Gao, G., Moore, D., Ru-Gang, X., Pu, L., *Org Lett.*, 2002, **4**, 4143 – 4146.
22. (S13) A. Boussonniere, R. Beneteau, N. Zimmermann, J. Lebreton, F. Denes, *Chem. Eur. J.*, 2011, **17**, 5613 – 5627.
23. (S14) V. Mamane, T. Gress, H. Krause, A. Furstner, *J. Am. Chem. Soc.*, 2004, **126**, 8654 – 8655.
24. (S15) V. Gudla, R. Balamurugan, *J. Org. Chem.*, 2011, **76**, 9919 – 9933.
25. (S16) K. L. Salazar, K. M. Nicholas, *Tetrahedron*, 2000, **56**, 2211 – 2224.
26. (S17) M. C. Pacheco, V. Gouverneur, *Org. Lett.*, 2005, **7**, 1267 – 1270.
27. (S18) P. H. Dussault, J. A. Schultz, *J. Org. Chem.*, 1999, **64**, 8419 – 8422.
28. (S19) (a) Racherla, U. S.; Brown, H. C. *J. Org. Chem.* **1991**, *56*, 401. (b) Jadhav, P. K.; Bhat, K. S.; Perumal, P. T.; Brown, H. C. *J. Org. Chem.* **1986**, *51*, 432. (c) S. E. Denmark, T. Wynn, *J. Am. Chem Soc.*, **2001**, *123*, 6199 – 6200.
29. (S20) 3M Innovative Properties Company; Outrider Technologies, WO 2009/155106, 2009, A1.
30. (S21) H. L. Holland, F. M. Brown, B. G. Larsen, *Tetrahedron: Asymmetry*, 1995, **6**, 1561 – 1567.
31. M. Parasram, V. O. Laroshenkov, V. Gevorgyan, *J. Am. Chem. Soc.*, 2014, **136**, 17926 – 17929.

32. U. Dutta, S. Maiti, S. Pimparkar, S. Maiti, L. R. Gahan, E. H. Krenske, D. W. Lupton, D. Maiti, *Chem. Sci.* 2019, **10**, 7426 – 7432.
33. Y. Hua, H. H. Nguyen, W. R. Scaggs, J. Jeon, *Org. Lett.* 2013, **15**, 3412 – 3415.

1f

1h

1j

1j

134.29
131.96
130.68
130.35
130.03
129.71
125.42
125.38
125.34
125.31
114.26

— 90.50

— 83.63

— 77.16 CDCl₃

— 52.56

18.93
17.58
17.56
12.69

230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10

—	138.83	—	91.14	—	38.34
—	134.83	—	84.41	—	33.58
—	131.64	—	77.16 CDCl ₃	—	24.62
—	128.40	—	63.62	—	19.42
—	128.24	—		—	17.77
—	123.27	—		—	17.70
—	114.75	—		—	17.69
—	113.89	—		—	13.01
		—		—	12.96

7.26
7.26 CDCl₃

5.03
5.02
5.00
4.99

3.02
2.74
2.72
2.69
2.68

2.09
2.04
1.94
1.65
1.65
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1.28
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0.99
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0.48
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0.44
0.41

~7.56
~7.38
~7.26 CDCl₃
~7.19

—5.75
~5.32
~5.29
~4.96
~4.93
~4.77
~4.73

—3.25
~2.97
~2.90

~2.27
~2.21
~2.08

~1.39
~1.34
~1.12
~0.99
—0.68

— 146.12
137.71
136.92
136.11
128.95
128.54
127.40
— 116.24
— 79.60
— 77.16 CDCl₃
— 73.56
44.30
42.72
41.00
18.14
17.88
17.43
17.29
16.08
14.69
12.79

Si-O_Tethered_PKR_SI_final_draft.pdf (7.97 MiB)

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