

Supporting Information

Biodegradable waste frying oil-based ethoxylated esters as highly efficient plasticizers for poly (lactic acid)

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Number of pages: 7

Number of figures: 3

Number of tales: 1

S1. Characterization of WFOA, CWFOA, WFOPA by NMR

WFOA: ^1H NMR (400 MHz, CDCl_3) δ 5.40 – 5.29 (m, 2H), 2.76 (t, $J = 6.8$ Hz, 1H), 2.30 (dt, $J = 33.2, 7.5$ Hz, 2H), 2.02 (dt, $J = 22.6, 6.4$ Hz, 3H), 1.61 (q, $J = 7.2$ Hz, 2H), 1.40 – 1.15 (m, 20H), 0.87 (q, $J = 6.9$ Hz, 3H). ^{13}C NMR (400 MHz, CDCl_3) δ 130.08, 129.82, 128.17, 128.01, 34.52, 34.50, 34.19, 34.17, 32.05, 32.03, 31.65, 29.89, 29.82, 29.81, 29.80, 29.78, 29.77, 29.72, 29.65, 29.58, 29.56, 29.48, 29.44, 29.39, 29.37, 29.28, 29.27, 29.20, 29.16, 29.16, 27.33, 27.31, 27.30, 27.28, 27.27, 25.75, 25.09, 24.79, 22.80, 22.69, 14.35, 14.22, 14.17.

CWFOA: ^1H NMR (400 MHz, CDCl_3) δ 5.38 – 5.26 (m, 1H), 2.34 (t, $J = 7.5$ Hz, 2H), 2.15 (q, $J = 7.3$ Hz, 1H), 2.12 – 2.06 (m, 1H), 2.01 (q, $J = 6.3$ Hz, 2H), 1.63 (p, $J = 7.1$ Hz, 2H), 1.42 – 1.20 (m, 21H), 0.91 – 0.86 (m, 3H). ^{13}C NMR (400 MHz, CDCl_3) δ 134.87, 134.65, 130.23, 130.13, 129.96, 129.84, 128.86, 128.72, 125.81, 125.70, 34.27, 34.25, 33.03, 32.99, 32.07, 32.05, 31.89, 31.62, 29.91, 29.84, 29.82, 29.79, 29.74, 29.58, 29.57, 29.51, 29.47, 29.42, 29.39, 29.32, 29.29, 29.25, 29.21, 29.18, 29.16, 29.06, 27.80, 27.77, 27.36, 27.29, 24.82, 24.80, 22.83, 22.82, 22.76, 22.70, 14.24, 14.24, 14.22, 14.19.

WFOPA: ^1H NMR (400 MHz, CDCl_3) δ 5.40 – 5.30 (m, 1H), 2.34 (d, $J = 7.6$ Hz, 2H), 2.01 (q, $J = 6.0$ Hz, 2H), 1.63 (p, $J = 7.2, 6.7$ Hz, 2H), 1.38 – 1.19 (m, 19H), 0.88 (t, $J = 6.8$ Hz, 3H). ^{13}C NMR (400 MHz, CDCl_3) δ 130.16, 129.87, 32.08, 32.06, 31.88, 29.92, 29.83, 29.75, 29.68, 29.59, 29.52, 29.48, 29.40, 29.30, 29.22, 29.18, 27.37, 27.31, 24.79, 24.68, 22.84, 22.76, 14.27, 14.23, 14.20.

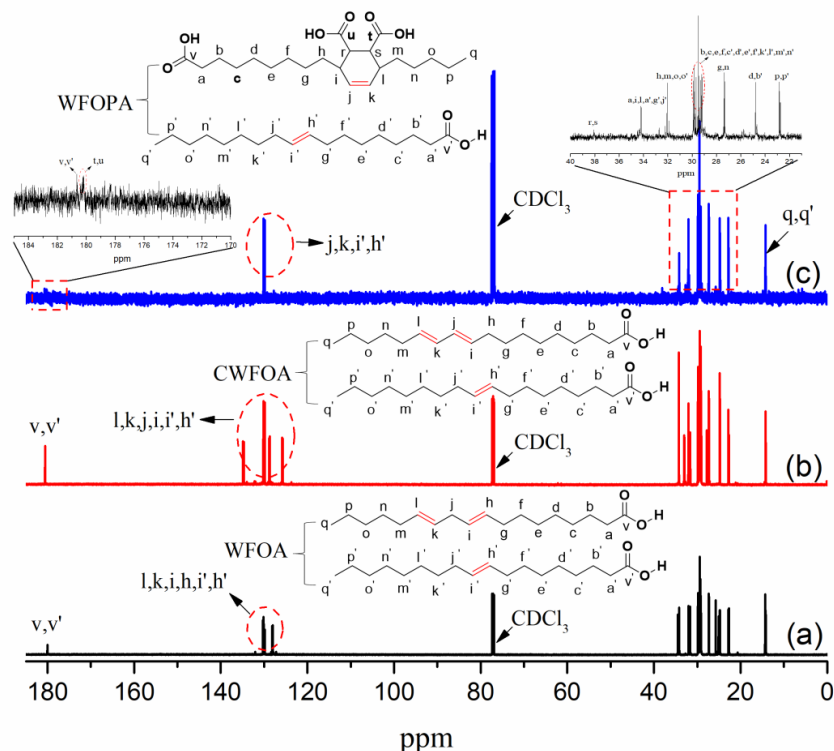


Figure S1. ^{13}C NMR of WFOA (a), CWFOA (b), and WFOPA (c)

S2. Characterization of WFOA- n ($n = 1, 2$, and 3), and WFOPAM by NMR.

Waste frying oil-based polyacid (methoxy ethanol) esters (WFOPA-1, yield: 98.1%): ^1H NMR (400 MHz, CDCl_3) δ 5.36 – 5.29 (m, 1H), 4.27 – 4.17 (m, 3H), 3.61 – 3.55 (m, 2H), 3.37 (s, 4H), 2.32 (t, $J = 7.6$ Hz, 2H), 1.98 (q, $J = 6.7$ Hz, 2H), 1.59 (q, $J = 6.5$ Hz, 2H), 1.35 – 1.16 (m, 20H), 0.86 (t, $J = 6.8$ Hz, 3H). ^{13}C NMR (400 MHz, CDCl_3): 173.95, 130.06, 129.82, 70.51, 63.36, 59.07, 34.26, 32.01, 29.86, 29.62, 29.42, 29.26, 29.20, 27.31, 27.26, 25.00, 22.79, 14.22.

Waste frying oil-based polyacid (2-(2-methoxyethoxy)ethanol) esters (WFOPA-2, yield: 98.7%): ^1H NMR (400 MHz, CDCl_3) δ 5.37 – 5.31 (m, 1H), 4.25 – 4.19 (m, 2H), 3.69 – 3.64 (m, 2H), 3.64 – 3.59 (m, 2H), 3.52 (dd, $J = 5.4, 3.7$ Hz, 2H), 3.35 (d, $J =$

1.3 Hz, 3H), 2.33 (t, J = 7.6 Hz, 2H), 2.00 (q, J = 6.3 Hz, 2H), 1.61 (q, J = 6.7 Hz, 2H), 1.37 – 1.17 (m, 22H), 0.86 (d, J = 7.1 Hz, 3H). ¹³CNMR (400 MHz,) δ 174.02, 130.11, 129.87, 71.87, 70.45, 69.22, 63.28, 59.04, 34.31, 32.04, 29.90, 29.86, 29.63, 29.53, 29.33, 27.32, 25.04, 22.82, 14.26.

Waste frying oil-based polyacid (2-(2-(2-methoxyethoxy)ethoxy)ethanol) esters (WFOPA-3,yield: 99.0%) : ¹H NMR (400 MHz, CDCl₃) δ 5.38 – 5.30 (m, 1H), 4.29 – 4.17 (m, 2H), 3.78 – 3.60 (m, 11H), 3.54 (dd, J = 5.8, 3.5 Hz, 2H), 3.37 (s, 3H), 2.31 (t, J = 7.6 Hz, 2H), 1.99 (q, J = 6.4 Hz, 2H), 1.65 – 1.55 (m, 2H), 1.36 – 1.15 (m, 21H), 0.86 (t, J = 6.7 Hz, 3H). ¹³C NMR (400MHz, CDCl₃) δ 173.95, 130.11, 129.86, 72.05, 70.74, 70.70, 70.69, 69.33, 63.48, 59.17, 34.32, 32.03, 29.89, 29.78, 29.73, 29.65, 29.60, 29.49, 29.40, 29.31, 29.26, 29.24, 27.29, 25.02, 22.81, 14.25.

Waste frying oil-based polyacid methyl esters (WFOPAM, 96.3%) : ¹H NMR (400 MHz, CDCl₃) δ 5.37 – 5.30 (m, 1H), 3.64 (s, 3H), 2.28 (t, J = 7.6 Hz, 2H), 1.99 (q, J = 6.6 Hz, 2H), 1.59 (q, J = 7.0 Hz, 2H), 1.39 – 1.16 (m, 21H), 0.86 (t, J = 6.8 Hz, 3H). ¹³C NMR (400 MHz, CDCl₃) δ 174.45, 174.41, 130.08, 129.83, 51.53, 34.22, 34.20, 32.05, 32.02, 29.88, 29.80, 29.77, 29.71, 29.64, 29.57, 29.49, 29.38, 29.28, 29.24, 29.20, 27.33, 27.27, 22.80, 14.22.

S3. Characterization of neat PLA and plasticized PLA by DSC

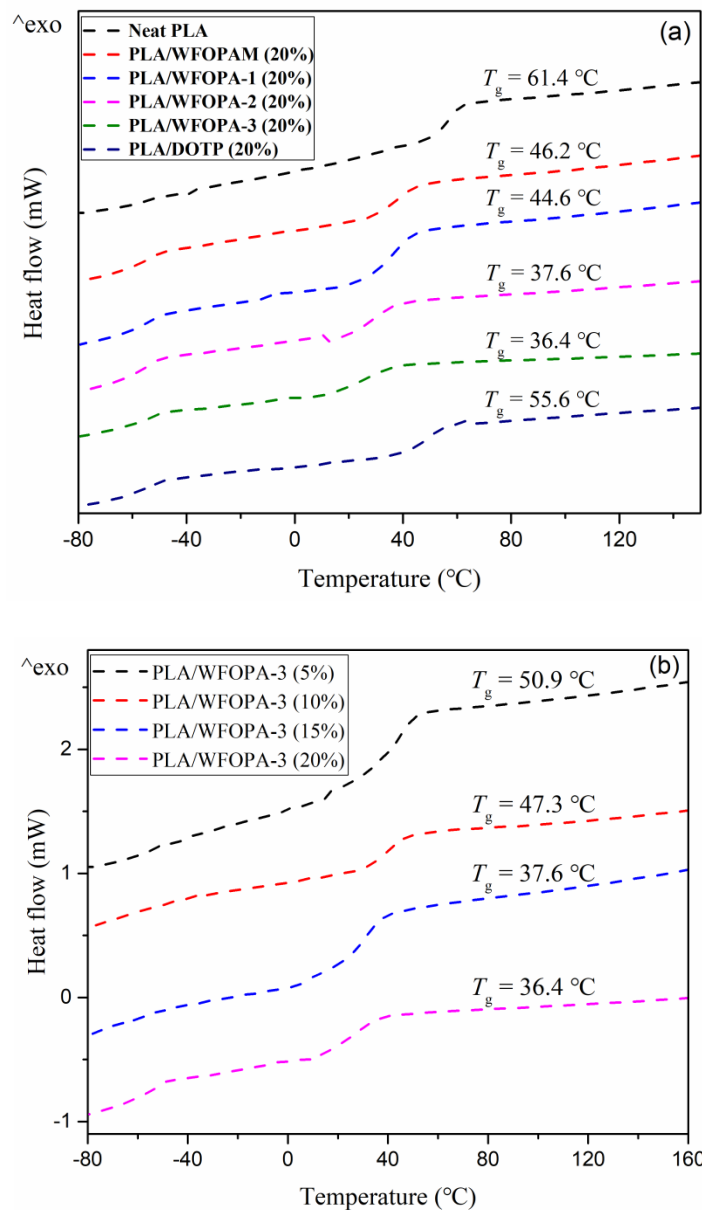


Figure S2. (a) DSC curves of neat PLA and plasticized PLA by plasticizers with 20% addition; (b) DSC curves of plasticized PLA by WFOPA-3 with 5 ~ 20% addition.

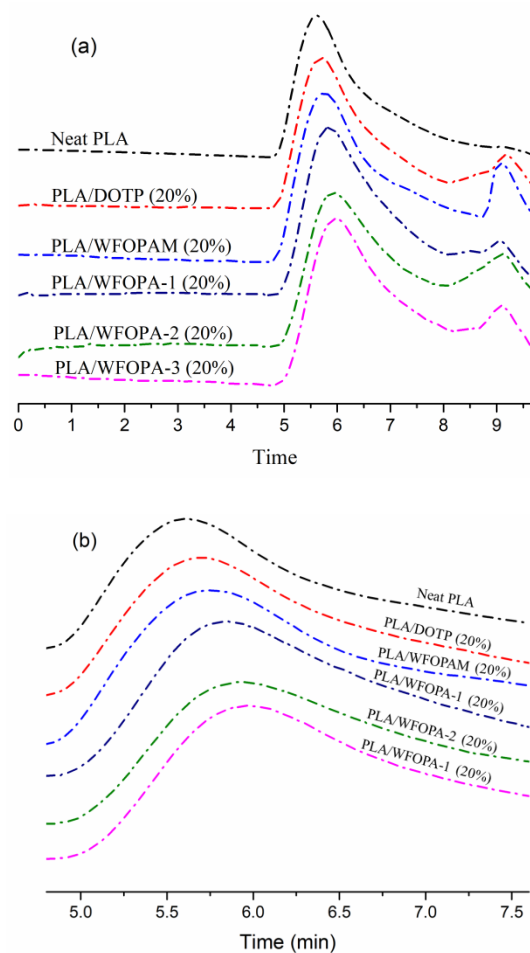


Figure S3. GPC spectra of degradative PLA samples (a); Magnification of GPC spectra at 5.0 ~ 7.5 min (b).

Table S1. The molecular weight of degradative PLA samples determined by GPC

Sample	Mw	Mn	Mw/Mn
Neat PLA	190993	106107	1.8
PLA/DOTP (20%)	185974	88559	2.1
PLA/WFOPAM (20%)	165358	68899	2.4

PLA/WFOPA-1 (20%)	145386	53846	2.7
PLA/WFOPA-2 (20%)	139275	44927	3.1
PLA/WFOPA-3 (20%)	126819	38430	3.3
