## Supporting Information

# Enhancing the catalytic activity of ZnO nanocatalysts reinforced with boron compounds in promoting green and sustainable fixation of $CO_2$ with epoxides

Ahmet Tumbul[a], Eyyup Yasar[b], Ahmet Kilic[b*]

[a]*Department of Mathematics and Science Education, Faculty of Education, 63190, Sanliurfa, Turkey*
[b]*Department of Chemistry, Faculty of Art and Science, Harran University, 63190, Sanliurfa, Turkey*

* To whom correspondence should be addressed: Harran University, Chemistry Department, TR-63190 Sanliurfa, Turkey. Tel: +90 414 318 3587, Fax: +90 414 318 3541, e-mail: kilica63@harran.edu.tr; http://orcid.org/0000-0001-9073-4339 **(A. Kilic)**

## Contents of Supporting Information

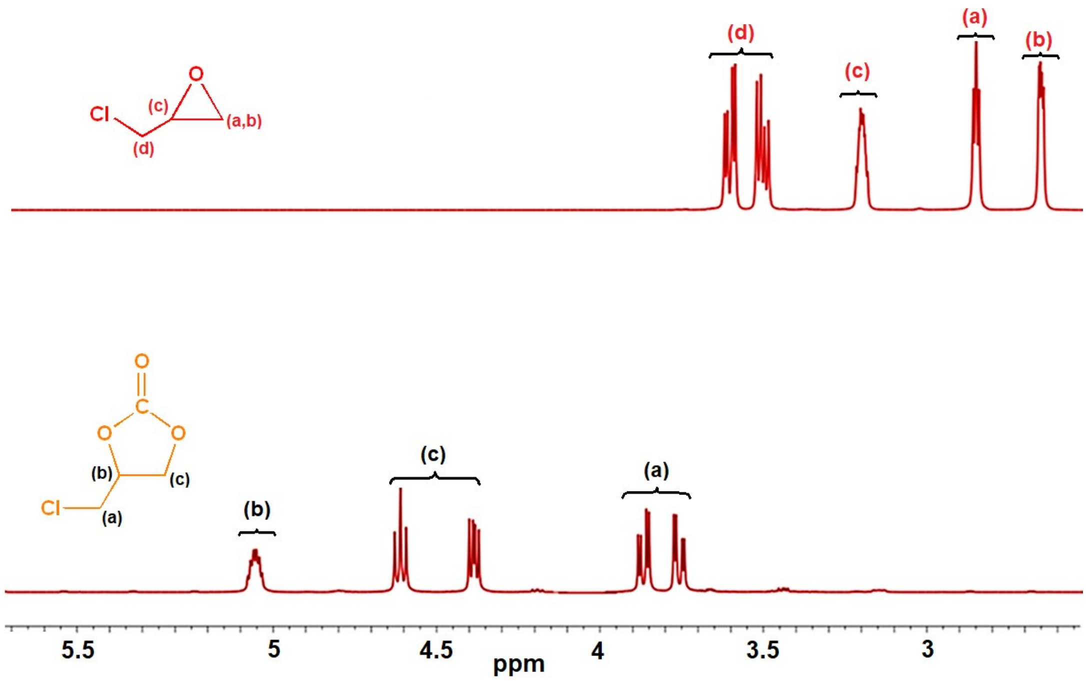



**Figure S1.** [1]H NMR spectra of the epichlorohydrin **(a)** and epichlorohydrin cyclic carbonate (ECHCC) **(b)**

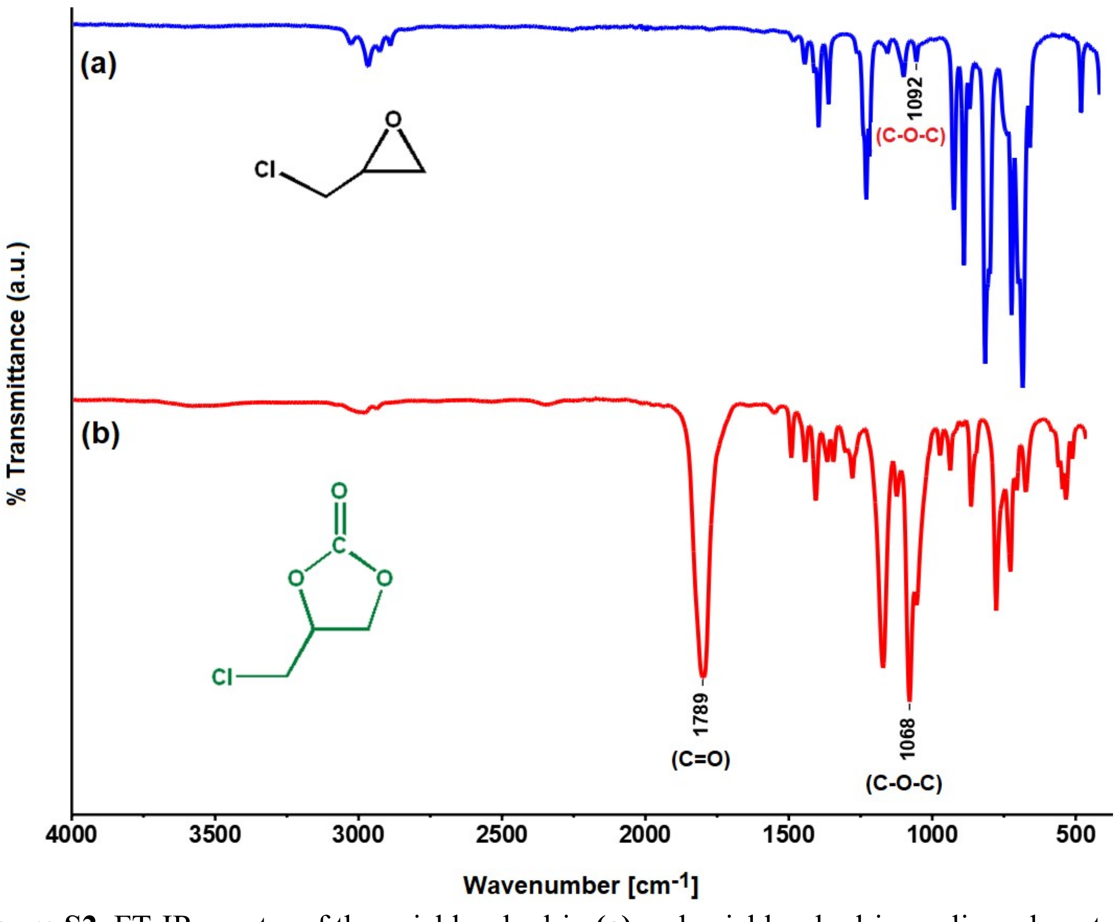



**Figure S2.** FT-IR spectra of the epichlorohydrin **(a)** and epichlorohydrin cyclic carbonate (ECHCC) **(b)**

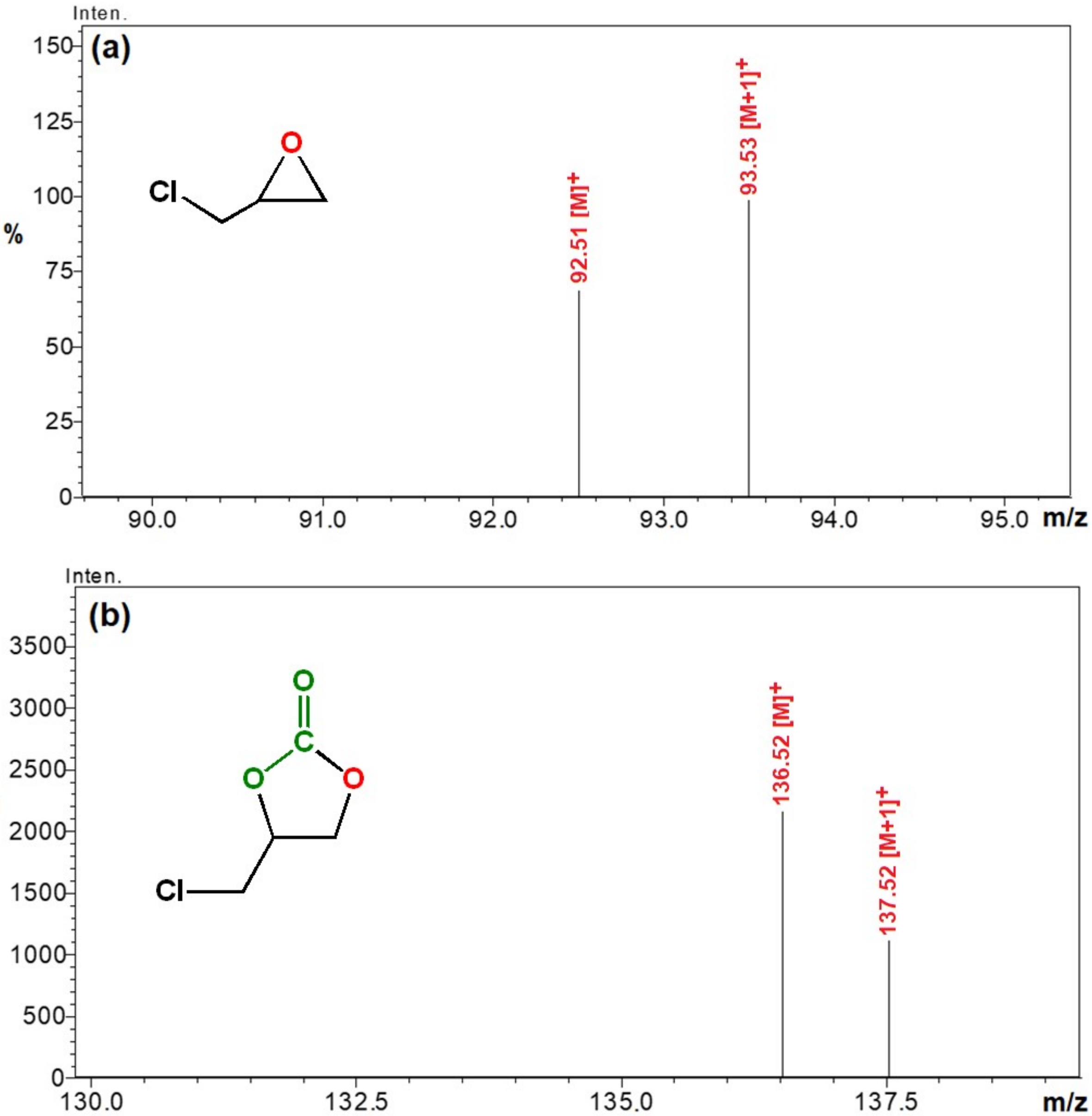
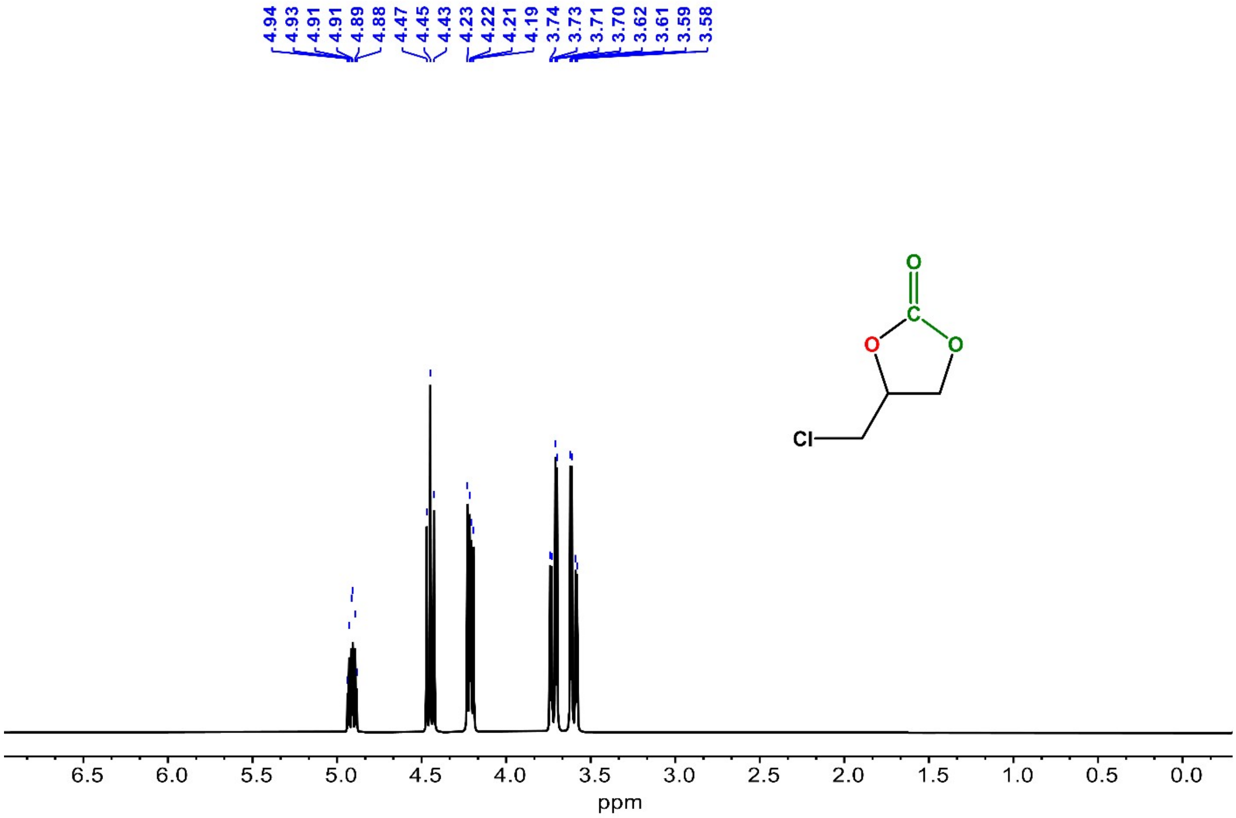
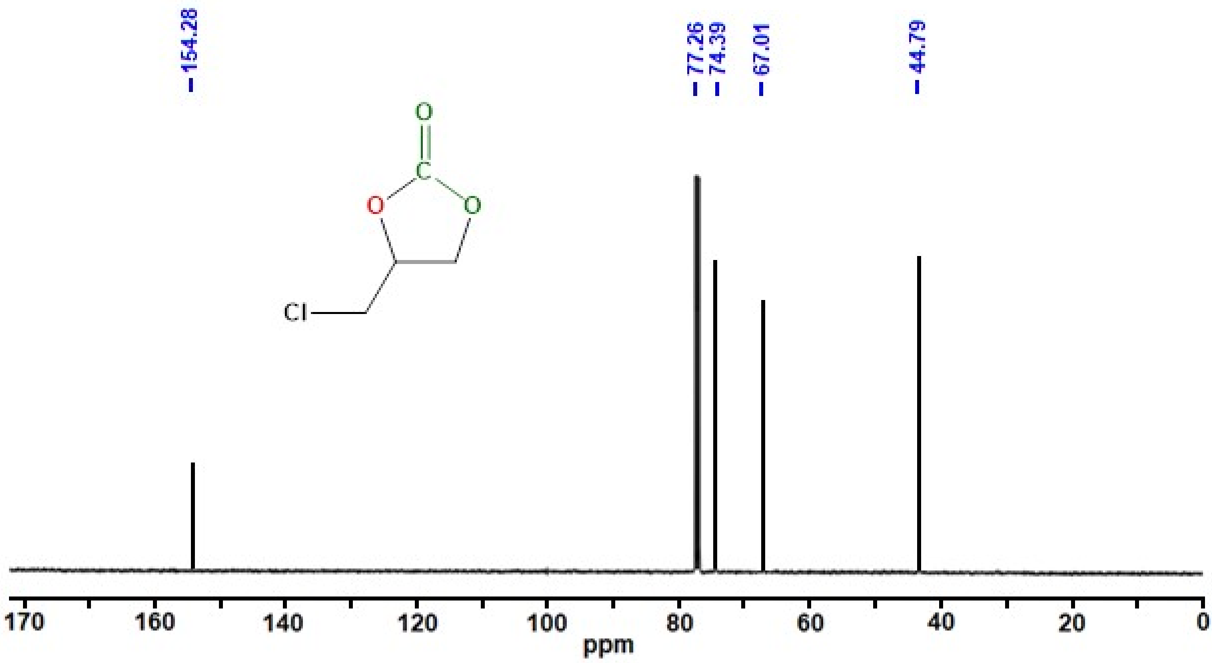


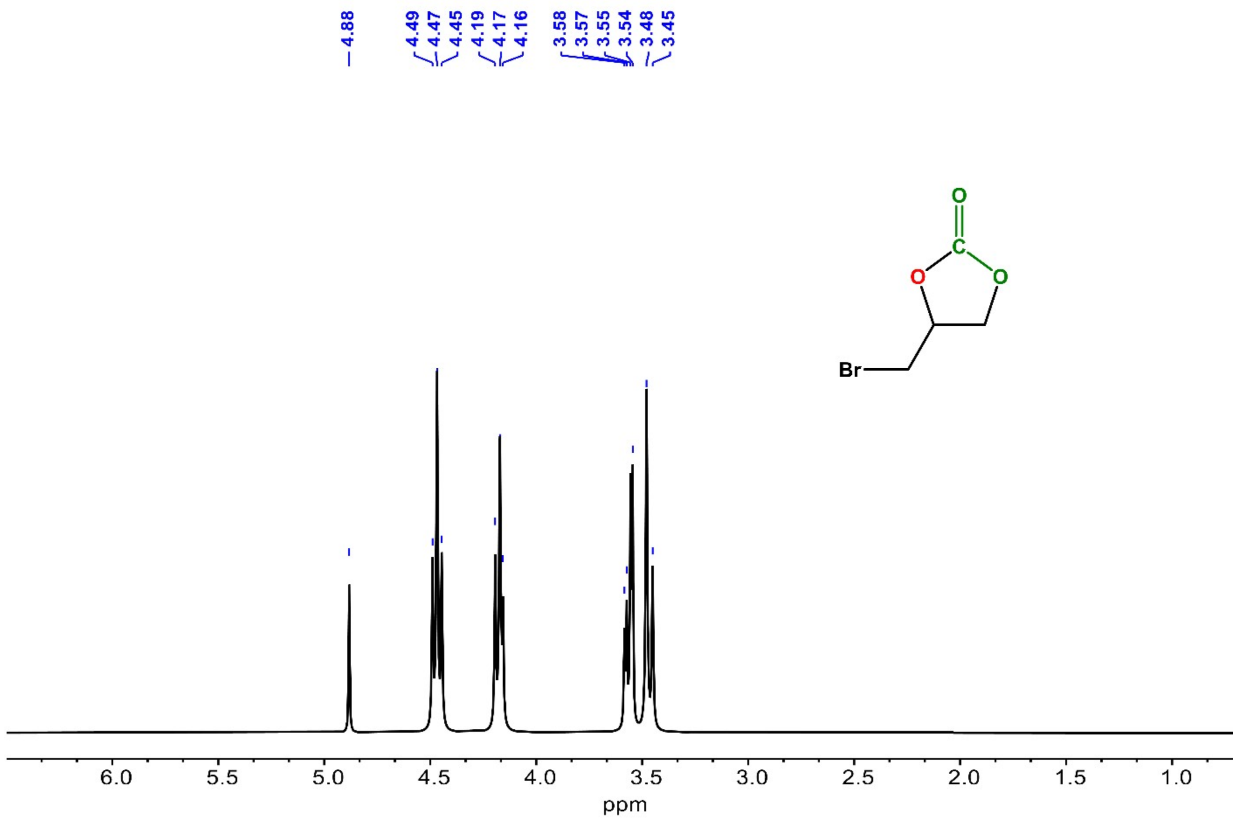

**Figure S3.** LC-MS/MS spectra of the epichlorohydrin **(a)** and epichlorohydrin cyclic carbonate (ECHCC) **(b)**

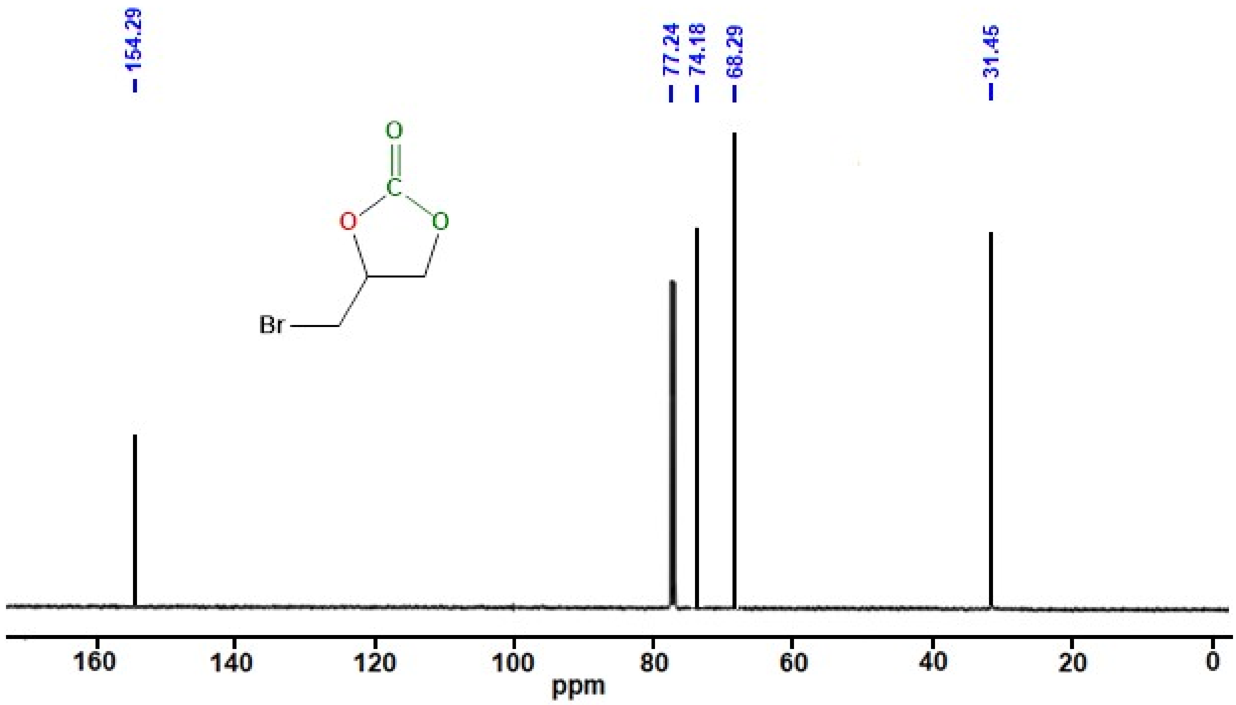
**The $^{1}H$ and $^{13}C$ NMR spectra of the synthesized cyclic carbonates (1-8)**



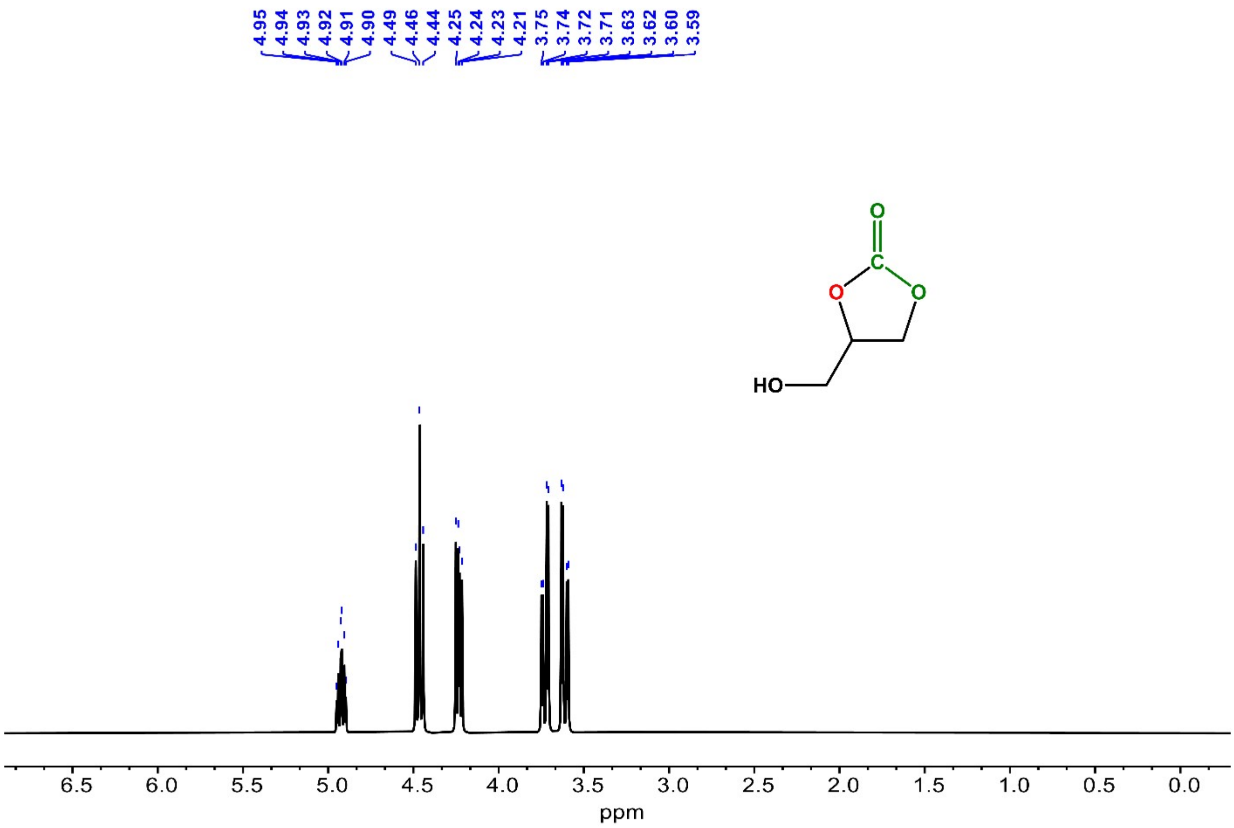



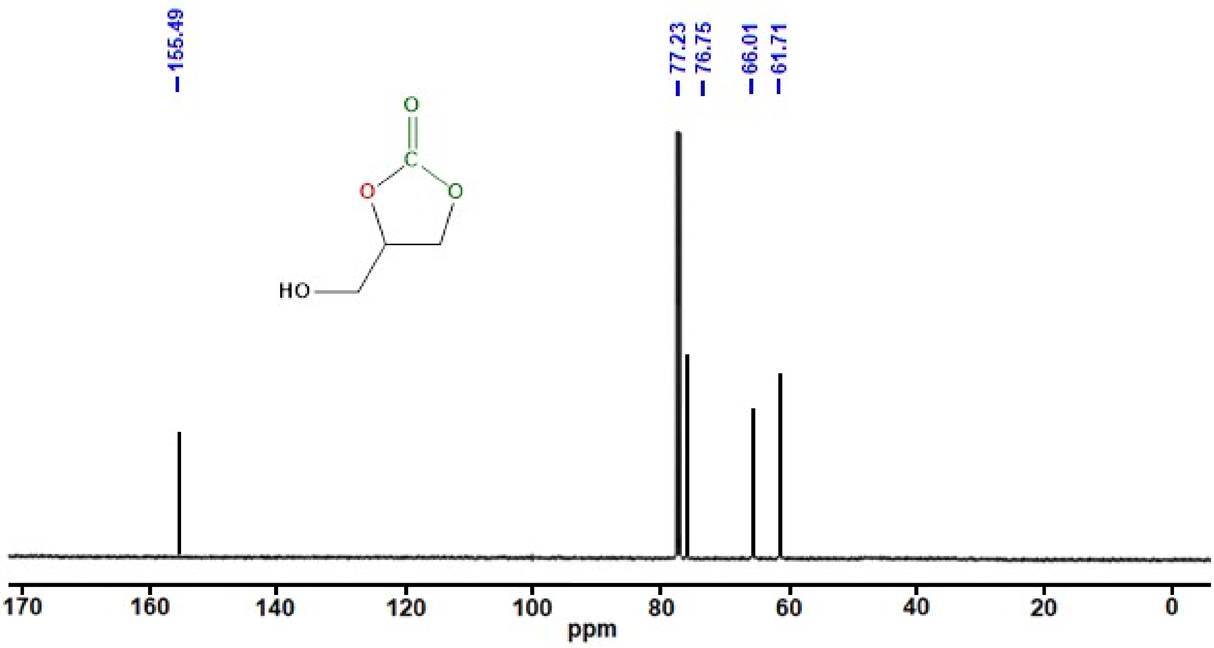

$^{1}H$ NMR (400 MHz, $CDCl_3$): δ (ppm) = 4.94-4.88 (m, 1H, -C<u>*H*</u>), 4.45 (t, 1H, *J* = 8.0 Hz, -C<u>*H*$_2$</u>), 4.23-4.19 (q, 1H, -C<u>*H*$_2$</u>), and 3.74-3.58 (m, 2H, -C<u>*H*$_2$</u>-Cl). $^{13}C$ NMR (100 MHz, $CDCl_3$) δ (ppm) = 154.28 (<u>*C*</u>=O), 74.38 (-<u>*C*</u>H), 67.01 (-CH-<u>*C*</u>H$_2$), and 44.79 (-<u>*C*</u>H$_2$-Cl).



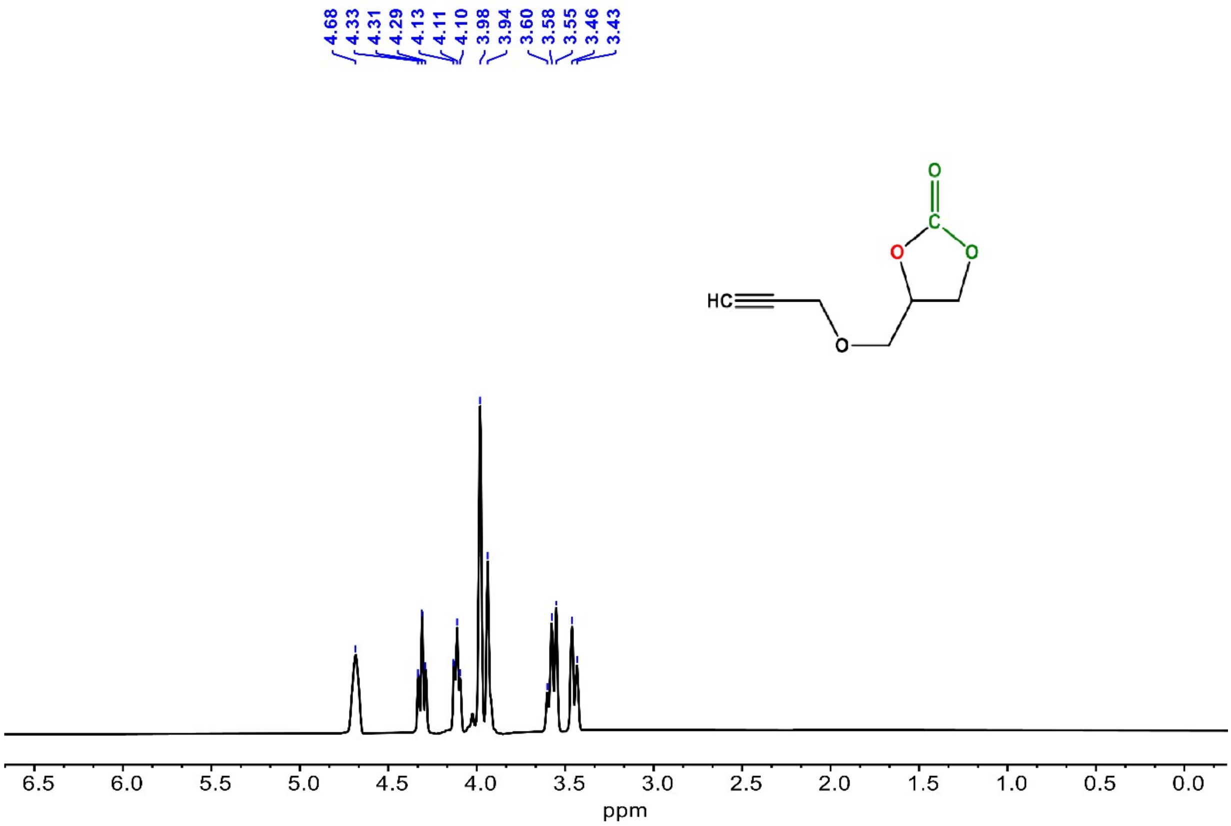



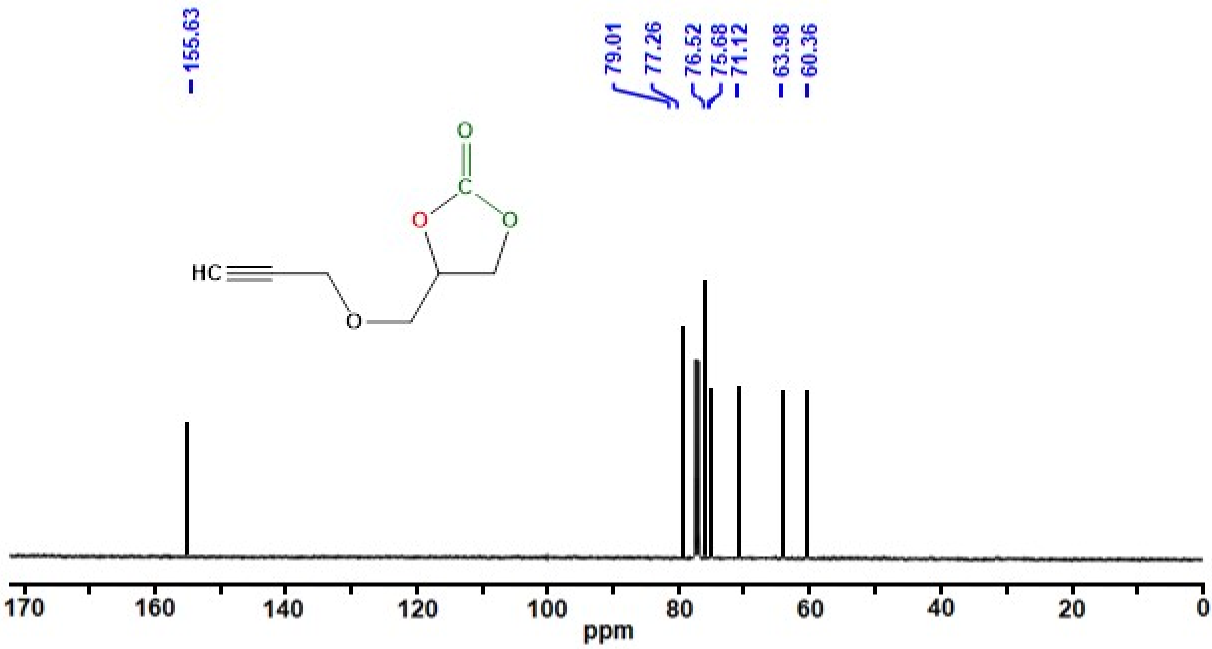

$^{1}$H NMR (400 MHz, $CDCl_3$): δ (ppm) = 4.88 (s, 1H, -C$\underline{H}$), 4.47 (t, 1H, $J$ = 8.0 Hz, -C$\underline{H}_2$), 4.17 (t, 1H, $J$ = 6.0 Hz, -C$\underline{H}_2$), and 3.58-3.45 (m, 2H, -C$\underline{H}_2$-Br). $^{13}$C NMR (100 MHz, $CDCl_3$) δ (ppm) = 154.29 ($\underline{C}$=O), 74.18 (-$\underline{C}$H), 68.29 (-CH-$\underline{C}H_2$), and 31.45 (-$\underline{C}H_2$-Br).



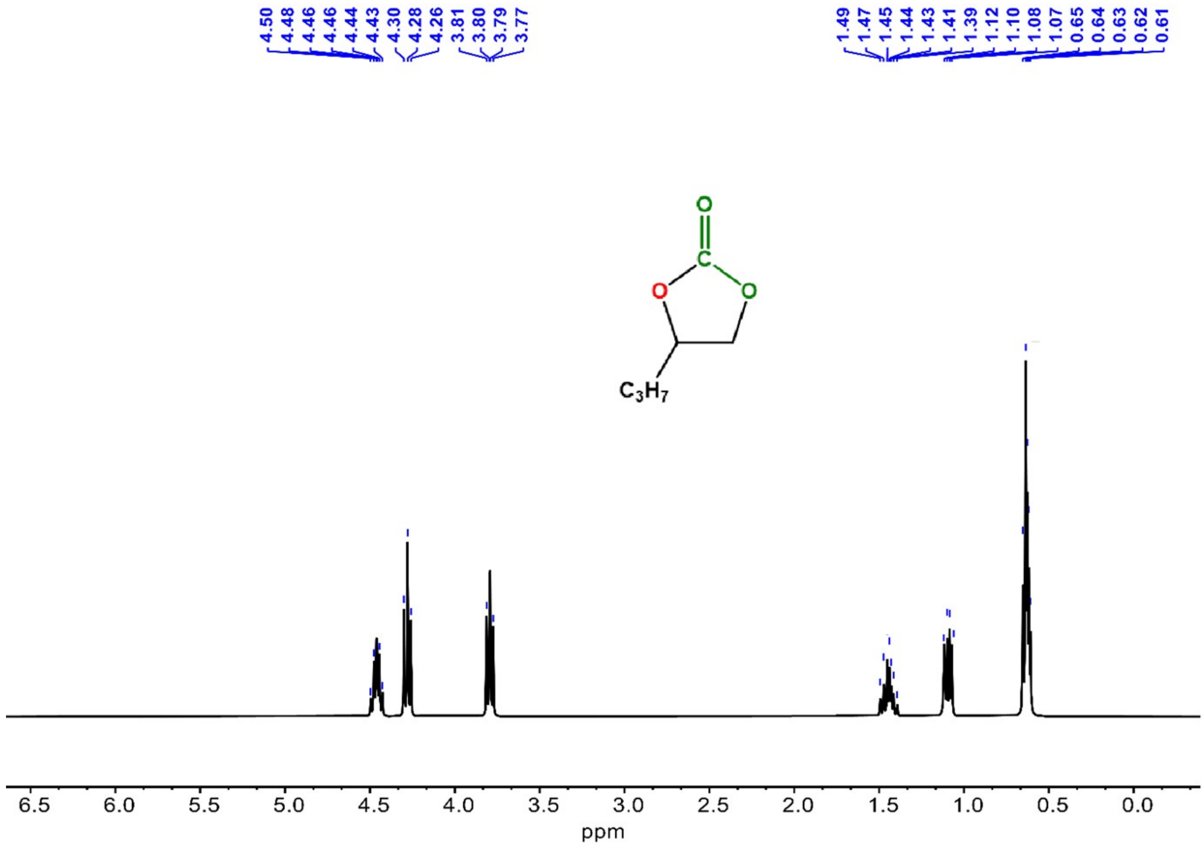



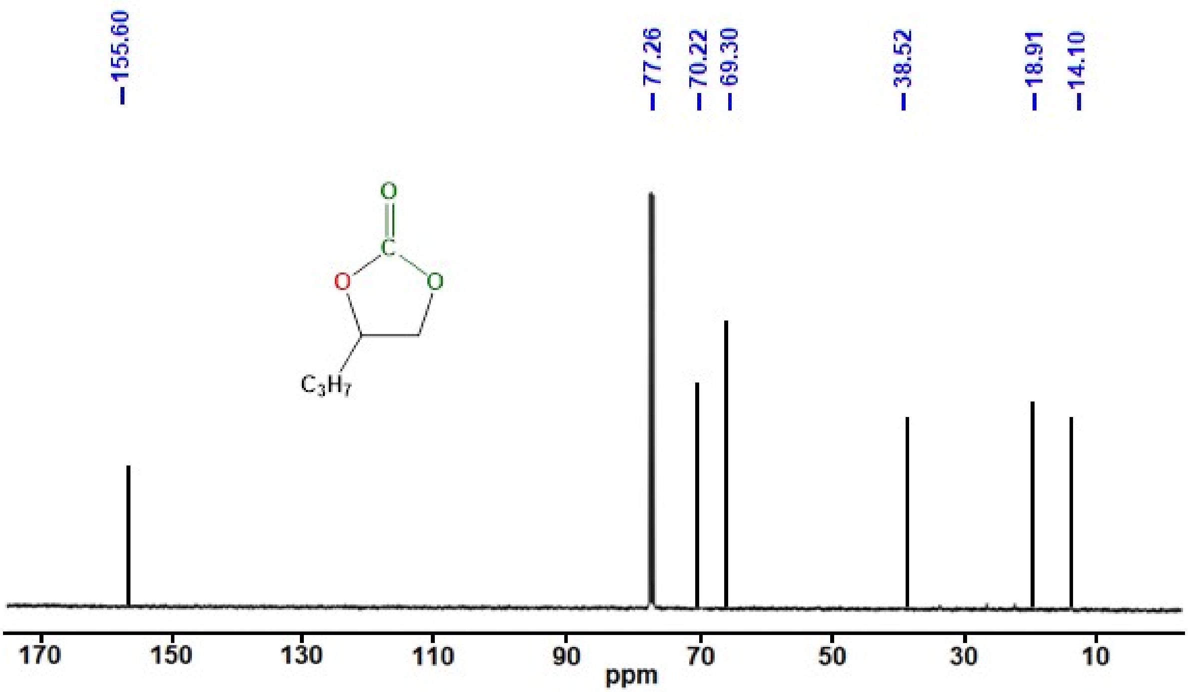

[1]H NMR (400 MHz, $CDCl_3$): δ (ppm) = 4.95-4.90 (m, 1H, -C*H*), 4.46 (t, 1H, *J* = 10 Hz, -C*H*$_2$), 4.25-4.21 (m, 1H, -C*H*$_2$), and 3.75-3.59 (m, 2H, -C*H*$_2$-OH). [13]C NMR (100 MHz, $CDCl_3$) δ (ppm) = 155.49 (*C*=O), 76.75 (-*C*H), 66.01 (-CH-*C*H$_2$), and 61.71 (-*C*H$_2$-OH).



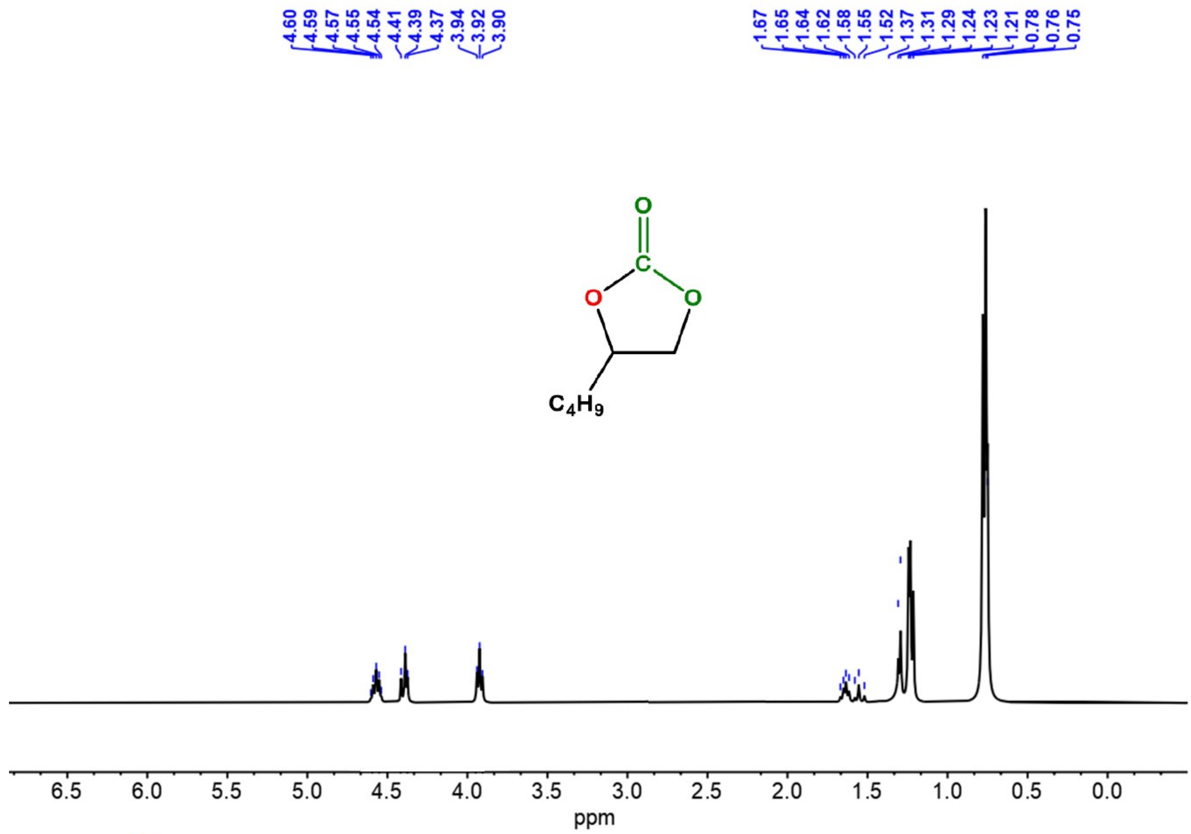



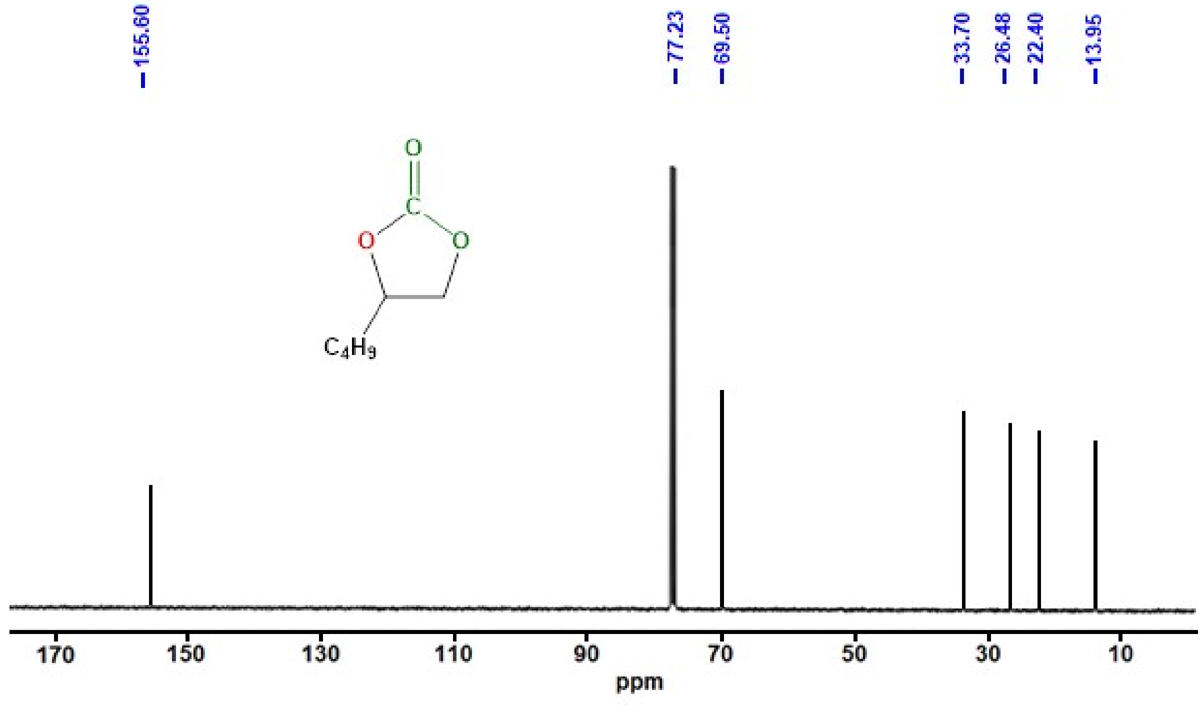

$^1$H NMR (400 MHz, $CDCl_3$): δ (ppm) = 4.68 (m, 1H, -C*H*), 4.31 (t, 1H, *J* = 8.0 Hz, -C*H*$_2$), 4.11 (t, 1H, *J* = 6.0 Hz, -C*H*$_2$), 3.98 (s, 1H, -*H*C≡C-), 3.94 (s, 2H, O-C*H*$_2$), 3.60-3.43 (m, 2H, O-C*H*$_2$). $^{13}$C NMR (100 MHz, $CDCl_3$) δ (ppm) = 155.63 (*C*=O), 79.01 (-HC≡*C*-), 76.52 (-H*C*≡C-), 75.68 (O-*C*H$_2$), 71.12 (-*C*H), 63.98 (-CH-*C*H$_2$) and 60.36 (O-*C*H$_2$).



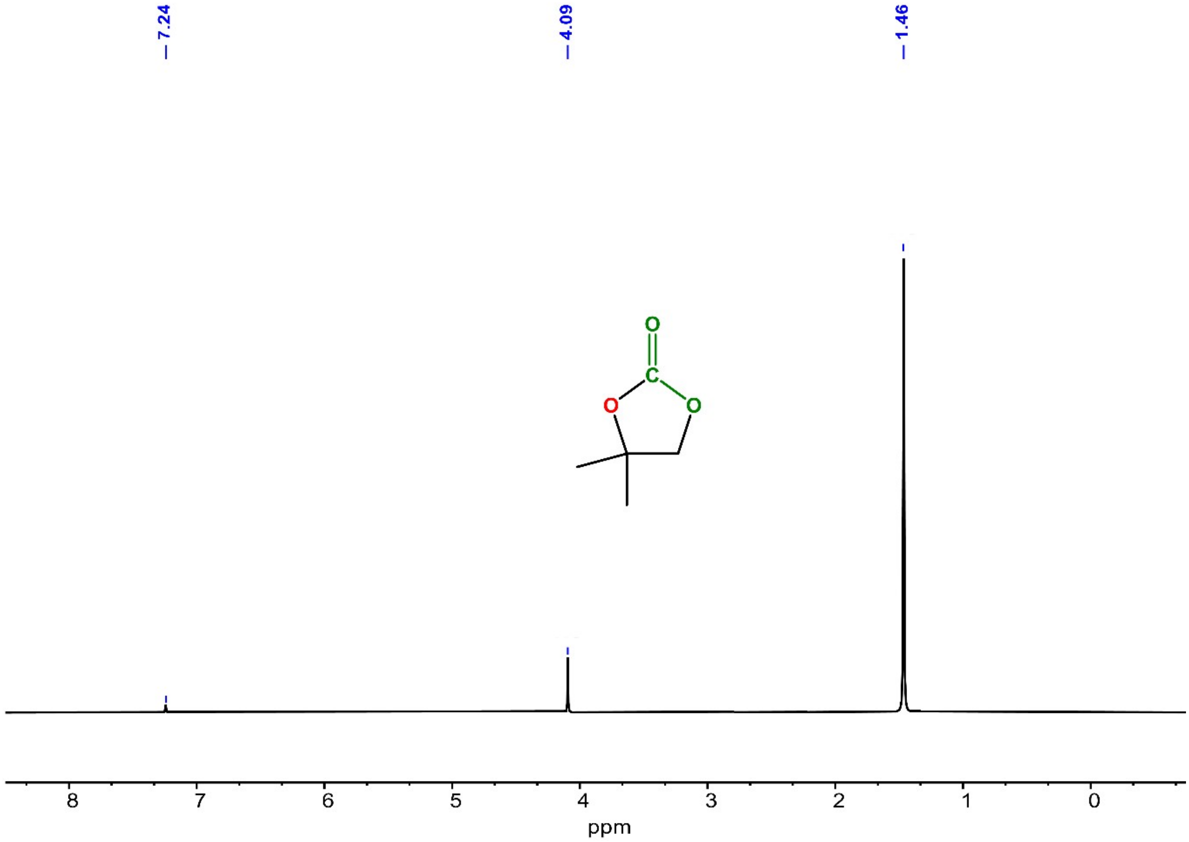


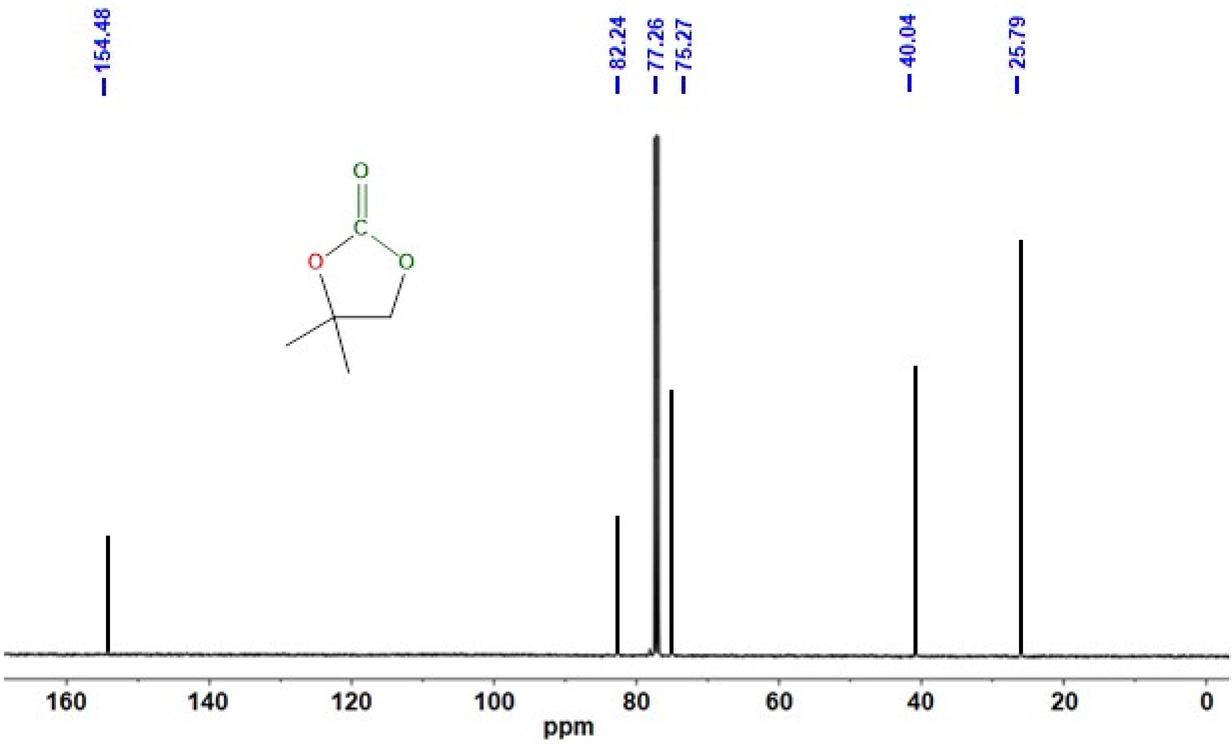
[1]H NMR (400 MHz, $CDCl_3$): δ (ppm) = 4.50-4.43 (m, 1H, -C*H*), 4.28 (t, 1H, *J* = 8.0 Hz, -C*H*$_2$), 3.81-3.77 (m, 1H, -C*H*$_2$), 1.49-1.39 (m, 2H, -C*H*$_2$-$CH_2$-$CH_3$), 1.12-1.07 (m, 2H, -$CH_2$-C*H*$_2$-$CH_3$), and 0.65-0.61 (m, 3H, $CH_2$-$CH_2$-C*H*$_3$). [13]C NMR (100 MHz, $CDCl_3$) δ (ppm) = 155.60 (*C*=O), 70.22 (-*C*H), 66.30 (-CH-*C*$H_2$), 38.52 (-*C*$H_2$-$CH_2$-$CH_3$), 18.91 ($CH_2$-*C*$H_2$-$CH_3$), and 14.10 (-$CH_2$-$CH_2$-*C*$H_3$).



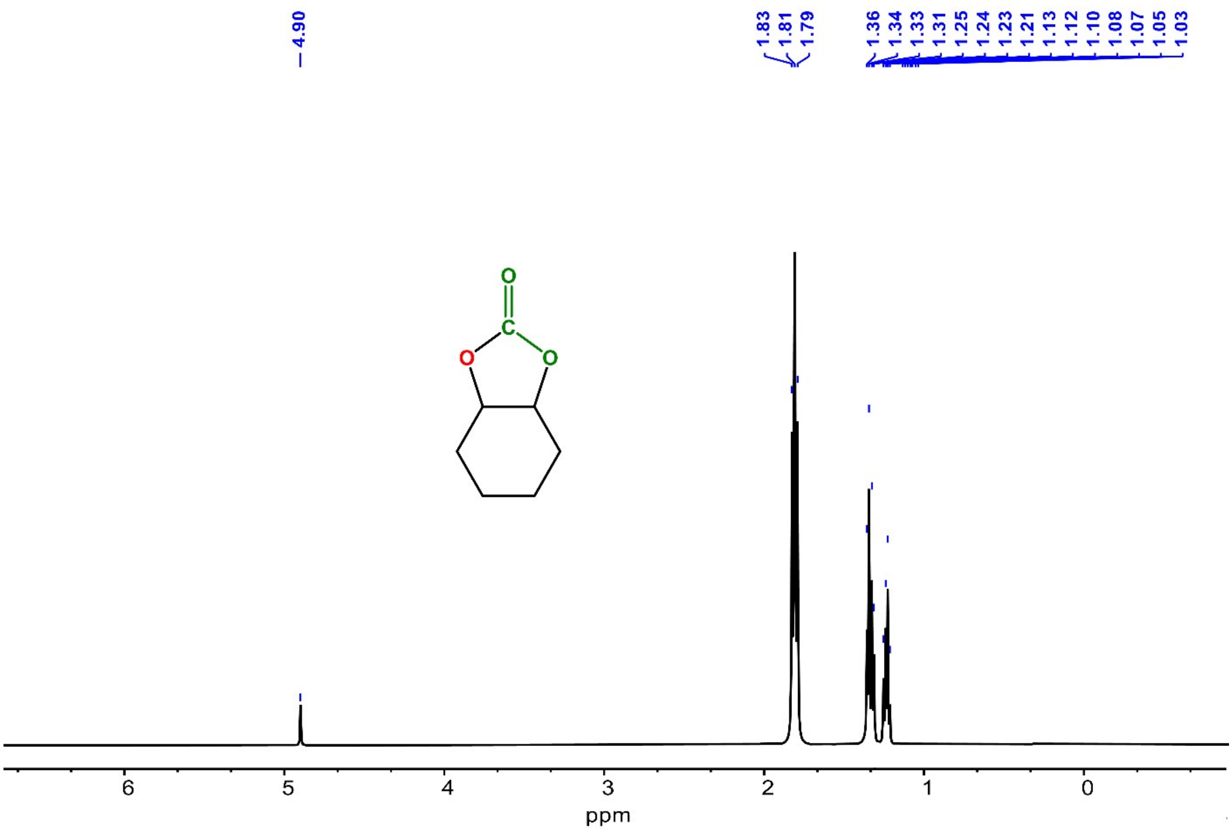


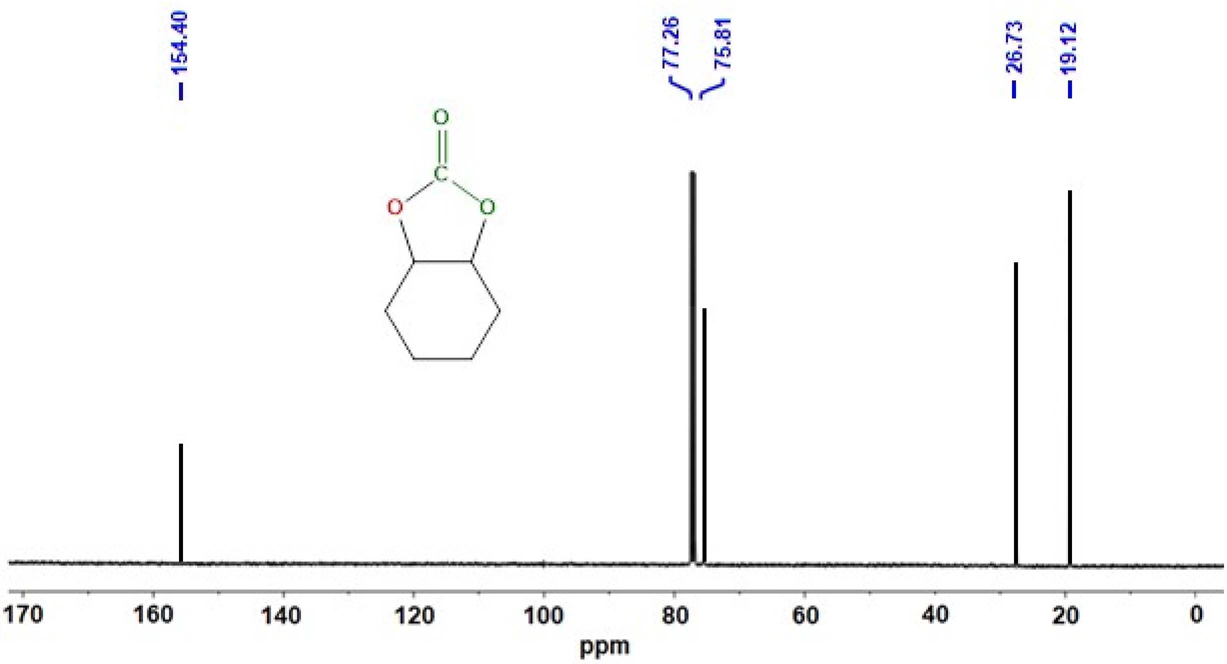
[1]H NMR (400 MHz, $CDCl_3$): δ (ppm) = 4.60-4.54 (m, 1H, -C*<u>H</u>*), 4.39 (t, 1H, *J* = 8.0 Hz, C*<u>H</u>*$_2$), 3.92 (t, *J* = 8.0 Hz, 1H, -C*<u>H</u>*$_2$), 1.67-1.52 (m, 2H, -C*<u>H</u>*$_2$-$CH_2$-$CH_2$-$CH_3$), 1.31-1.22 (m, 4H, -$CH_2$-C*<u>H</u>*$_2$-C*<u>H</u>*$_2$-$CH_3$), and 0.76 (t, 3H, *J* = 6.0 Hz, -$(CH_2)_3$-C*<u>H</u>*$_3$). [13]C NMR (100 MHz, $CDCl_3$) δ (ppm) = 155.60 (*<u>C</u>*=O), 69.50 (-*<u>C</u>*H), 33.70 (-CH-*<u>C</u>*H$_2$), 26.48 (-*<u>C</u>*H$_2$-$CH_2$-$CH_3$), 22.40 ($CH_2$-*<u>C</u>*H$_2$-$CH_3$), and 13.95 (-$CH_2$-$CH_2$-*<u>C</u>*H$_3$).




$^{1}$H NMR (400 MHz, $CDCl_3$): δ (ppm) = 4.09 (s, 2H, -C-C$H_2$) and 1.46 (s, 6H, (-C-C$H_{3})_2$). $^{13}$C NMR (100 MHz, $CDCl_3$) δ (ppm) = 154.48 (C=O), 82.24 (-CH), 75.27 (-CH-C$H_2$), 40.04 (C-C$H_3$), and 25.79 (C-C$H_3$).




$^{1}$H NMR (400 MHz, $CDCl_3$): δ (ppm) = 4.90 (s, 2H, -C$\underline{H}$), 1.81 (t, 4H, $J$ = 8.0 Hz O-CH-C$\underline{H_2}$), 1.36-1.21 (m, 2H, O-CH-$CH_2$-C$\underline{H_2}$), and 1.13-1.03 (m, 2H, O-CH-$CH_2$-C$\underline{H_2}$). $^{13}$C NMR (100 MHz, $CDCl_3$) δ (ppm) = 155.40 ($\underline{C}$=O), 75.81 (O-$\underline{C}$H), 26.73 (O-CH-$\underline{C}H_2$), and 19.12 (O-CH-$CH_2$-$\underline{C}H_2$).