Electronic Supplementary Information for Dalton Transactions

Electronic Supplementary Information for

Facile Alcoholysis of L-Lactide Catalysed by Group 1 and 2 Metal Complexes

Khamphee Phomphrai*, Supathana Pracha, Phenphak Phonjanthuek and Manat Pohmakotr

Department of Chemistry, Faculty of Science, Mahidol University, Rama 6 Road, Bangkok 10400 Thailand. Fax: +662-354-7151; Tel: +662-201-5146; E-mail: sckpp@mahidol.ac.th

Experimental Section

General Details. All operations were carried out under dry argon atmosphere using standard Schlenk techniques. ^{1}H and ^{13}C NMR spectra were recorded on a Bruker DPX-300 spectrometer and referenced to protio impurities of commercial chloroform-d ($CDCl_3$) as internal standards. Mass spectra were obtained on a Thermo Finnigan Polaris Q mass spectrometer. Elemental analyses were performed on a Perkin Elmer Elemental Analyzer 2400 CHN. Specific rotations of the neat enantio-pure products were obtained on JASCO P-1020 Polarimeter. $LiN(SiMe_3)_2$, $NaN(SiMe_3)_2$, and $KN(SiMe_3)_2$ were purchased from Aldrich and used as received. $Ca[N(SiMe_3)_2]_2{\cdot}2THF$ was prepared according to literature procedure.[1] L-lactide was synthesized from L-lactic acid and sublimed three times before use. Methanol, ethanol, isopropanol, n-butanol, benzyl alcohol, and ε-caprolactone were dried over CaH_2 and distilled prior to use.

General procedure

The following procedures were used for the alcoholysis of L-lactide and ε-caprolactone using $LiN(SiMe_3)_2$, $NaN(SiMe_3)_2$, $KN(SiMe_3)_2$, or $Ca[N(SiMe_3)_2]_2{\cdot}2THF$ as catalysts.

a) Using excess alcohol

L-lactide (0.500 g, 3.47 mmol) or ε-caprolactone (0.396 g, 3.47 mmol) and dry methanol (7.0 mL) were added to a Schlenk flask and stirred at desired temperature for 10 min. A freshly prepared solution of metal amide (34.7 μmol) in methanol (1 mL) was added. At desired time, small aliquots (~0.5 mL) were taken, quenched with 2 drops of acetic acid, dried under vacuum, and analyzed by ^{1}H NMR. When the reaction proceeded to greater than 95%, the reaction mixture was quenched with acetic acid (0.5 mL) and dried under vacuum. The product was isolated by distillation under reduced pressure as colorless oil. Typical isolated yields are greater than 80%.

b) Using 2.2 eq alcohol

Dry alcohol (7.63 mmol) was added to a suspension of L-lactide (0.500 g, 3.47 mmol) in toluene (3.5 mL) and stirred at room temperature for 5 min. A freshly prepared solution of $Ca[N(SiMe_3)_2]_2{\cdot}2THF$ (174 μmol) in toluene (0.5 mL) was added. At desired time, small aliquots (~0.5 mL) were taken, quenched with 2 drops of acetic acid, dried under vacuum, and analyzed by ^{1}H NMR. When the reaction proceeded to greater than 95%, the reaction mixture was dried under vacuum. The product was isolated by distillation under reduced pressure as colorless oil. Typical isolated yields are greater than 80%. The exception is isopropyl (*S*)-lactate where only about 50% conversion was observed after 1 h and the product was isolated at 20% yield.

Methyl (*S*,*S*)-lactyllactate. δ_H (300 MHz; $CDCl_3$) 1.46 (3 H, d, *J* 7.0, CH_3), 1.49 (3 H, d, *J* 7.1, CH_3), 3.72 (3 H, s, OCH_3), 4.33 (1 H, q, *J* 6.9, CH), 5.15 (1 H, q, *J* 7.1, CH). δ_C (75 MHz, $CDCl_3$) 16.8, 20.4 (CH_3), 52.5 (OCH_3), 66.7, 69.2 (CH), 170.7, 175.1 (C=O); MS (ESI): *m*/*z* =199.05, $[M\text{-}Na]^+$; $[\alpha]_D^{26}$ −50.8°, neat; Found: C, 46.32; H, 6.79. Calc. for $C_7H_{12}O_5$: C, 47.75; H, 6.82.

Methyl (*S*)-lactate. δ_H (300 MHz; $CDCl_3$) 1.34 (3 H, d, CH_3), 3.70 (3 H, s, OCH_3), 4.24 (1 H, q, CH), 6.18 (1 H, br s, OH); δ_C (75 MHz, $CDCl_3$) 20.9 (CH_3), 52.8 (OCH_3), 67.0 (CH), 176.4 (C=O); $[\alpha]_D^{25}$ −7.7°, neat.

Ethyl (*S*)-lactate. δ_H (300 MHz; $CDCl_3$) 1.24 (3 H, t, OCH_2CH_3), 1.36 (3 H, d, $CHCH_3$), 2.87 (1 H, br, OH), 4.18 (3 H, m, OCH_2CH_3 + $CHCH_3$); δ_C (75 MHz, $CDCl_3$) 14.4 (CH_3), 20.6 ($CHCH_3$), 61.9 (OCH_2), 66.9 (*C*H), 175.9 (C=O); MS (ESI): *m/z* = 141.06, $[M\text{-}Na]^+$; $[\alpha]_D^{26}$ −9.0°, neat.

Isopropyl (*S*)-lactate. δ_H (300 MHz; $CDCl_3$) 1.24 (6 H, 2 d, $CHMe_2$), 1.36 (3 H, d, $CHCH_3$), 2.53 (1 H, br, OH), 4.19 (1 H, q, $CHCH_3$), 5.05 (1 H, m, $CHMe_2$); δ_C (75 MHz, $CDCl_3$) 20.4 ($CHCH_3$), 21.8 ($CHMe_2$), 66.8 ($CHCH_3$), 69.3 ($CHMe_2$), 175.3 (C=O); MS (ESI): *m/z* = 155.07, $[M\text{-}Na]^+$; $[\alpha]_D^{26}$ −10.3°, neat.

Benzyl (*S*)-lactate. δ_H (300 MHz; $CDCl_3$) 1.42 (3 H, d, CH_3), 2.85 (1 H, br, OH), 4.30 (1 H, q, CH), 5.19 (2 H, s, CH_2Ph), 7.34 (5 H, m, Ar-H); δ_C (75 MHz, $CDCl_3$) 20.5 (CH_3), 67.0 (CH), 67.4 (CH_2Ph), 128.4, 128.7, 128.8, 135.4 (Ar-C), 175.7 (C=O); MS (ESI): *m/z* = 203.08, $[M\text{-}Na]^+$; $[\alpha]_D^{26}$ −23.4°, neat; Found C, 66.53; H, 5.48. Calc. for $C_{10}H_{12}O_3$: C, 66.65; H, 6.71.

n-Butyl (*S*)-lactate. δ_H (300 MHz; $CDCl_3$) 0.90 (3 H, t, CH_2CH_3), 1.34 (2 H, m, CH_2CH_3), 1.37 (3 H, d, $CHCH_3$), 1.60 (2 H, m, OCH_2CH_2), 2.67 (1 H, br, OH), 4.14 (2 H, m, OCH_2CH_2), 4.22 (1 H, q, $CHCH_3$); δ_C (75 MHz, $CDCl_3$) 13.8 (CH_2CH_3), 19.2 (CH_2CH_3), 20.5 ($CHCH_3$), 30.7 (OCH_2CH_2), 65.6 (OCH_2CH_2), 66.9 ($CHCH_3$), 176.0 (C=O); MS (ESI): *m/z* = 169.09, $[M\text{-}Na]^+$; $[\alpha]_D^{26}$ −11.1°, neat.

Methyl 6-hydroxyhexanoate. δ_H (300 MHz; $CDCl_3$) 1.30 (2 H, m, *J* 5.0, CH_2), 1.50 (2 H, m, CH_2), 1.57 (2 H, m, CH_2), 2.25 (2 H, t, *J* 7.4, CH_2), 3.56 (2 H, t, *J* 6.7, CH_2), 3.59 (3 H, s, OCH_3); 6.14 (1 H, br s, OH); δ_C (75 MHz, $CDCl_3$) 24.8, 25.4, 32.4, 34.1 (CH_2), 51.7 (OCH_3), 62.6 ($HOCH_2$), 174.5 (C=O).

Reference:

1) M. Westerhausen, *Inorg. Chem.*, 1991, **30**, 96-101.

Data File C:\HPCHEM\1\DATA\A\00001631.D Sample Name: Methyl lactate

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Acq. Operator   : Amporn
Method          : C:\HPCHEM\1\METHODS\PENPUK.M
Last changed    : 20-Nov-07 3:50:40 PM by Amporn
                  (modified after loading)
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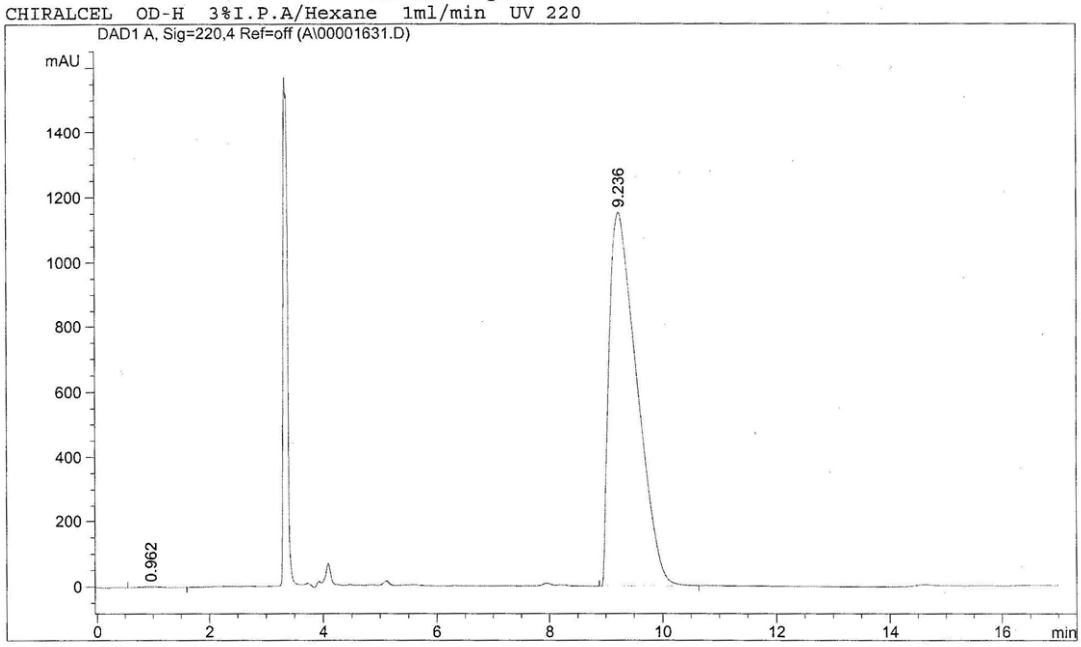


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Dilution              :      1.0000

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   2   9.236 PB    0.5287 3.89725e4  1152.08997  99.7727

Totals :                   3.90613e4  1155.43575

 Results obtained with enhanced integrator!
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Chiral HPLC of methyl (*S*)-lactate.

Instrument 1 20-Nov-07 4:09:07 PM Amporn Page 1 of 1