Supporting Information

Dialkylgallium alkoxides – a tool for facile and stereoselective synthesis of PLA-drug conjugates

Martyna Cybularczyk-Cecotka,[ab] Rafał Zaremba,[ab] Aleksander Hurko,[ac] Andrzej Plichta,[c] Maciej Dranka,[c] and Paweł Horeglad[a]*

[a]*Centre of New Technologies, University of Warsaw, Banacha 2c, 02-097, Warsaw, Poland.*
[b]*Faculty of Chemistry, University of Warsaw, Pasteura 1, 02-093, Warsaw, Poland.*
[c]*Faculty of Chemistry, Warsaw University of Technology, Noakowskiego 3, 00-664, Warsaw, Poland.*

GENERAL REMARKS

All operations were carried out under dry argon using standard Schlenk techniques. Solvents and reagents were purified and dried prior to use. Deuterated solvents were dried over potassium (toluene-d_8), calcium hydride (CD_2Cl_2). All solvents were purified using MBRAUN Solvent Purification Systems (MB-SPS-800). L-Lactide and *rac*-Lactide were purchased from Aldrich and further purified by crystallization from anhydrous toluene and sublimed under vacuum. (*S*)-methyl lactate was purchased from Aldrich, dried over molecular sieves and distilled under argon. 2-metoxyphenol, 2-(methylamino)ethanol and 2-(isopropylamino)ethanol were purchased from Aldrich and dried over molecular sieves. HN(^{i}Pr)$CH_2CH(CH_2OPh)OH$ and Atenolol were purchased from ABCR and used as received. For the synthesis of **3** HN(^{i}Pr)$CH_2CH(CH_2OPh)OH$ was sublimed under vacuum. Me_3Ga was purchased from Strem Chemicals, Inc. and used as received. ^{1}H NMR spectra were recorded on Agilent 400-MR DD2 400 MHz with shifts given in ppm according to deuterated solvent shift. Measurements of molar masses and $Đ_M = M_wM_n^{-1}$ were performed with GPC using Malvern (Viscotek) GPCmax coupled with TDA 305 Triple Detector Array (TDA) equipped with one analytical column by Jordi Labs DVB Mixed Bed and dichloromethane as eluent (flow rate of 1 mL min^{-1}) at 30 C. MALDI-TOF spectra were recorded on a Bruker ultrafleXtreme mass spectrometer. MALDI-TOF spectra (Figure S66 – S68) were recorded on Shimadzu/Kratos, Axima Performance. (*S,S*)-$[Me_2Ga(\mu\text{-}OCH(Me)CO_2Me)]_2$ was synthesized according to the literature.[1] $[Me_2Ga(OArOMe)]_2$ was synthesized, analogously to (*S,S*)-$[Me_2Ga(\mu\text{-}OCH(Me)CO_2Me)]_2$, in the reaction of 2-metoxyphenol with trimethyl gallium – a generally used method for the synthesis of dialkylgallium alkoxides and aryloxides.

Synthesis of **1:**

A stirred solution of Me_3Ga (0.690 g, 6.0 mmol) in methylene chloride (10 mL) was cooled to −78 C, and the solution of $HN(Me)C_2H_4OH$ (0,450 g, 6 mmol) in CH_2Cl_2 (1 ml) was added dropwise. After addition the reaction mixture was allowed to warm to a room temperature and stirred for 2 hours until gas evolution essentially ceased. Then, methylene chloride was removed under vacuum to give a white solid, which was subsequently recrystallized from CH_2Cl_2/hexane solution at −20 °C to give white

crystals, which were washed twice with 3 mL of hexane and dried under vacuum to give **1** (0.854 g, 89%).

Anal. Calcd for $C_5H_{14}GaON$: C, 34.54; H, 8.12; N, 8.06**. Found:** C, 33.34; H, 8.20; N, 6.96.

^{1}H NMR (CD_2Cl_2, 400 MHz): -0.49 (s, 6H, $GaCH_3$), 2.36 (s, 3H, NCH_3), 2.68 (t, ^3J(H,H)= 6.0 Hz, 2H, CH_2), 3.62 (t,^3J(H,H)= 6.0 Hz, 2H, CH_2).

^{13}C NMR (CD_2Cl_2, 100MHz): -7.1, 35.2, 53.7, 59.7.

Synthesis of **2:**

A stirred solution of Me_3Ga (0.197 g, 1.72 mmol) in methylene chloride (5 mL) was cooled to −78 C, and the solution of $HN(^iPr)C_2H_4OH$ (0,177 g, 1.72 mmol) in CH_2Cl_2 (1 ml) was added dropwise. After addition the reaction mixture was allowed to warm to a room temperature and stirred for 2 hours until gas evolution essentially ceased. Then methylene chloride was removed under vacuum to give a white solid, which was subsequently recrystallized from CH_2Cl_2/hexane solution at −20 °C to give white crystals, which were washed twice with 3 mL of hexane and dried under vacuum to give **2** (0.236 g, 68%).

Anal. Calcd for $C_7H_{18}GaON$: C, 41.63; H, 8.98; N, 6.94**. Found:** C, 41.48; H, 9.01; N, 6.76.

^{1}H NMR (CD_2Cl_2, 400 MHz): -0.43 (s, 6H, $GaCH_3$), 1.14 (d, ^3J(H,H)= 6.4 Hz, 6H, C*H*$(CH_3)_2$), 2.69 (br, 2H, CH_2), 2.84-2.88 (m, 1H, CH(C*H*$_3)_2$), 3.68 (br T, 2H, CH_2);

^{13}C NMR (CD_2Cl_2, 100MHz): -5.9, 23.2, 50.1, 50.5, 62.3.

Synthesis of **3:**

A stirred solution of Me_3Ga (0.267 g, 2.3 mmol) in methylene chloride (5 mL) was cooled to −78 C, and the solution of $HN(^iPr)CH_2CH(CH_2OPh)OH$ (0,486 g, 2.3 mmol) in CH_2Cl_2 (1 ml) was added dropwise. After addition the reaction mixture was allowed to warm to a room temperature and stirred for 2 hours until gas evolution essentially ceased. Solvent and volatile residues were then removed under vacuum to give yellow oil, which was subsequently recrystallized from Et_2O/hexane solution at −20 °C to give white crystals, which were washed twice with 3 mL of hexane and dried under vacuum to give **3** (0.461 g, 65%).

Anal. Calcd for $C_{14}H_{24}GaON$: C, 54.58; H, 7.85; N, 4.55**. Found:** C, 53.87; H, 7.80; N, 4.56.

^{1}H NMR (CD_2Cl_2, 400 MHz): -0.33 (s, 6H, $GaCH_3$), 1.19 (br, 6H, CH(C*H*$_3)_2$), 2.23 (br, 1H, NH), 2.72 (br, 1H, CH(C*H*$_3)_2$), 2.93 3.04 (br, 2H, CH_2), 3.92 (m, 1H, CH_2), 4.02 (m, 1H, CH), 4.20 (br, 1H, CHC*H*$_2$), 6.90-6.96 (m, 3H, CH_{Ar}), 7.26-7.30 (m, 2H, CH_{Ar});

^{13}C NMR (CD_2Cl_2, 100MHz): -5.5, 22.93, 50.3, 52.3, 70.5, 73.2, 115.0, 121.3, 130.0, 159.4.

Details of polymerization studies of *rac*-LA. In a typical run, the methylene chloride solution (20 mL) of *rac*-LA (0.9 g, 6.24 mmol) and the catalyst (0.12 mmol, unless different amount was noted) (and an appropriate amount of aminoalcohol and amine, if mentioned) were thermostated for the indicated time. Each polymerization was quenched by the addition of HCl solution (5%, 50 mL). The organic phase was separated, washed twice with water (50 mL), and dried under vacuum to give PLA as a white solid. ^{1}H NMR ($CDCl_3$, 400 MHz): (a) PLA signals, 1.46–1.55 (m, 3H, C*H*CH_3), 5.10–5.23 (m, 1H, CHC*H*$_3$) (b) end groups were in each case indicated on the spectra (see below).

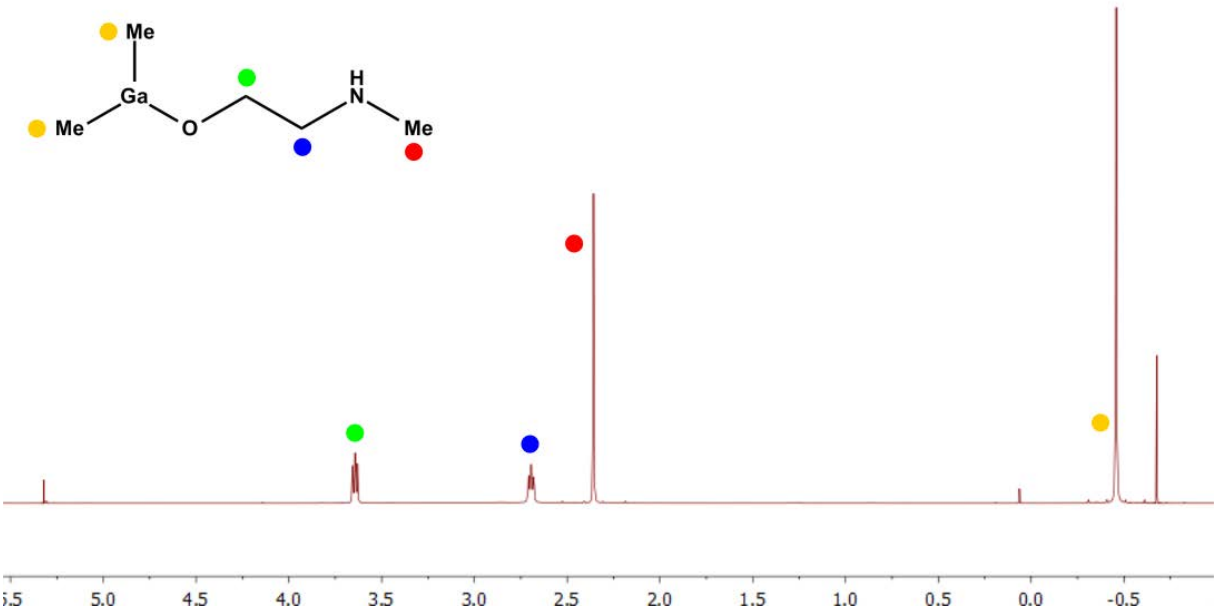


Figure S1. ^{1}H NMR (CD_2Cl_2, 400 MHz) spectrum of **1.**

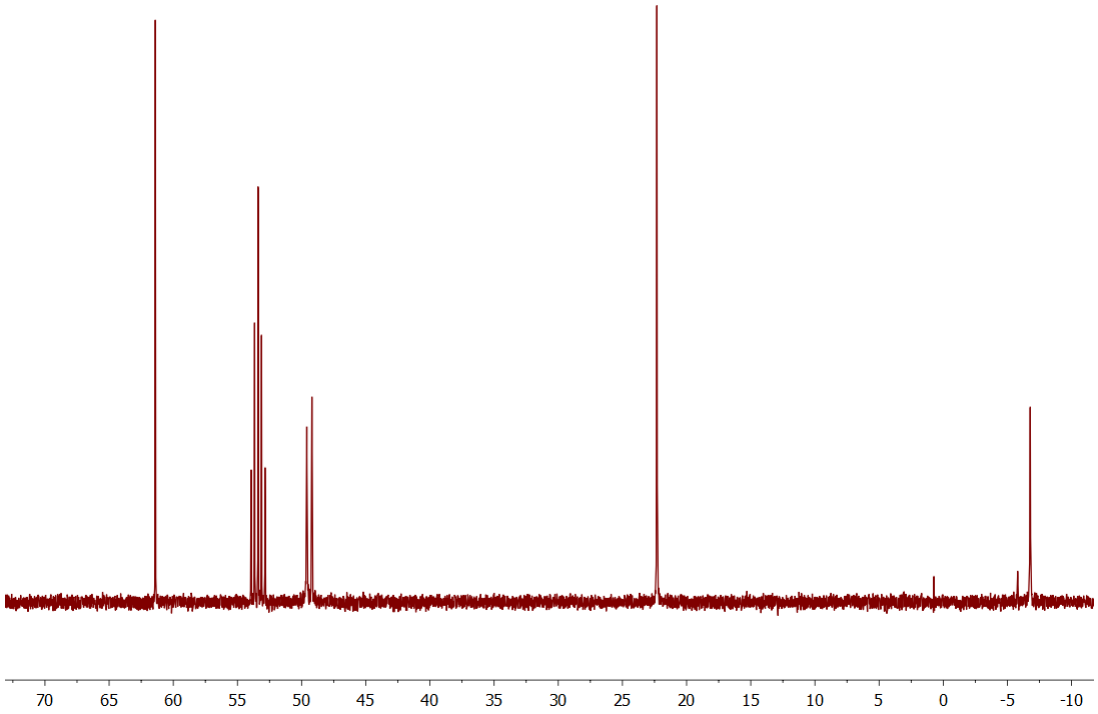


Figure S2. ^{13}C NMR (CD_2Cl_2, 100 MHz) spectrum of **1.**

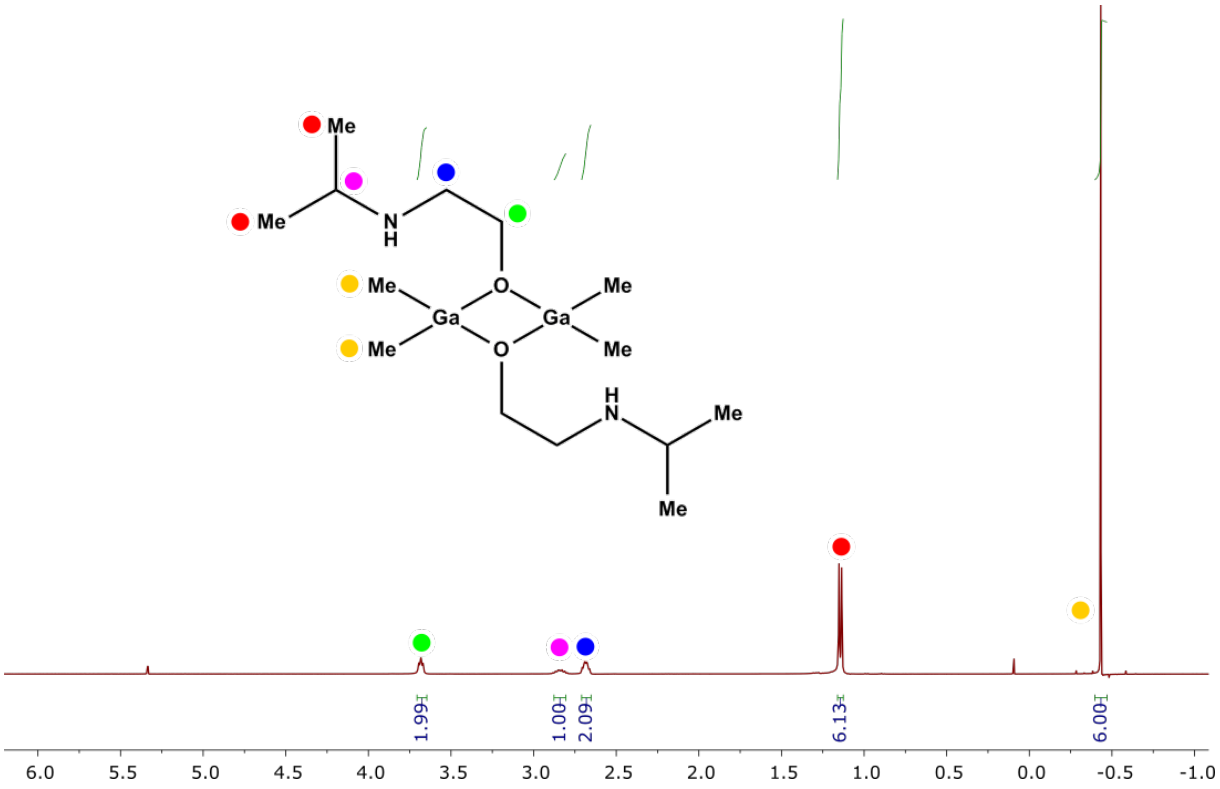


Figure S3. ^{1}H NMR (CD_2Cl_2, 400 MHz) spectrum of **2.**

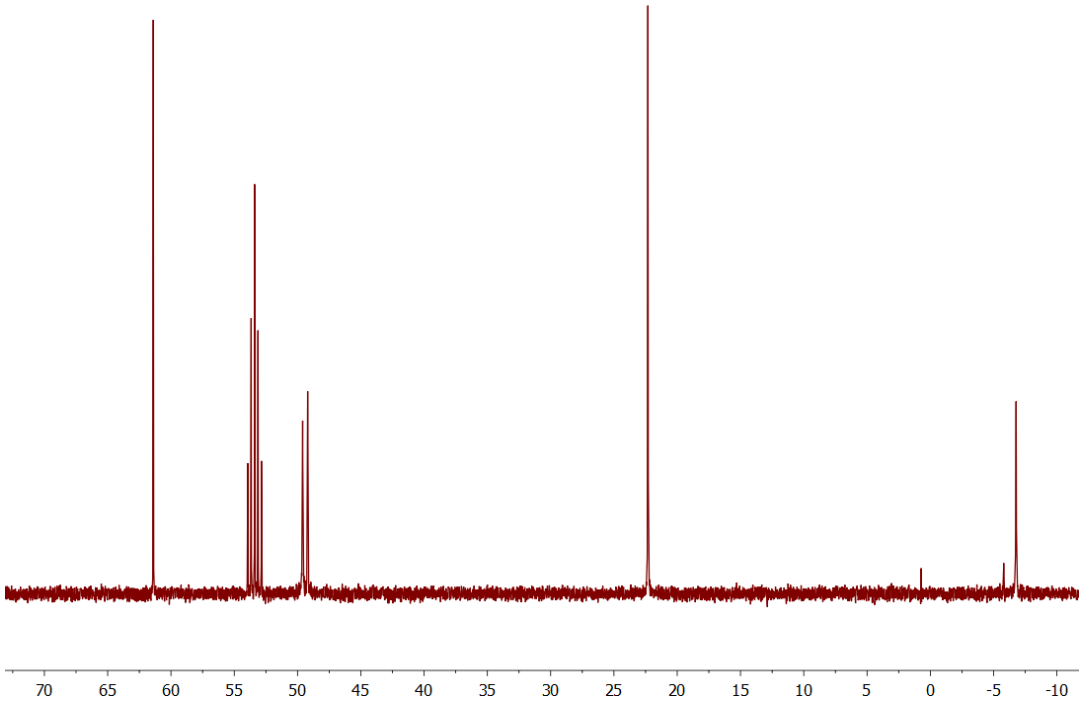


Figure S4. ^{13}C NMR (CD_2Cl_2, 100 MHz) spectrum of **2.**

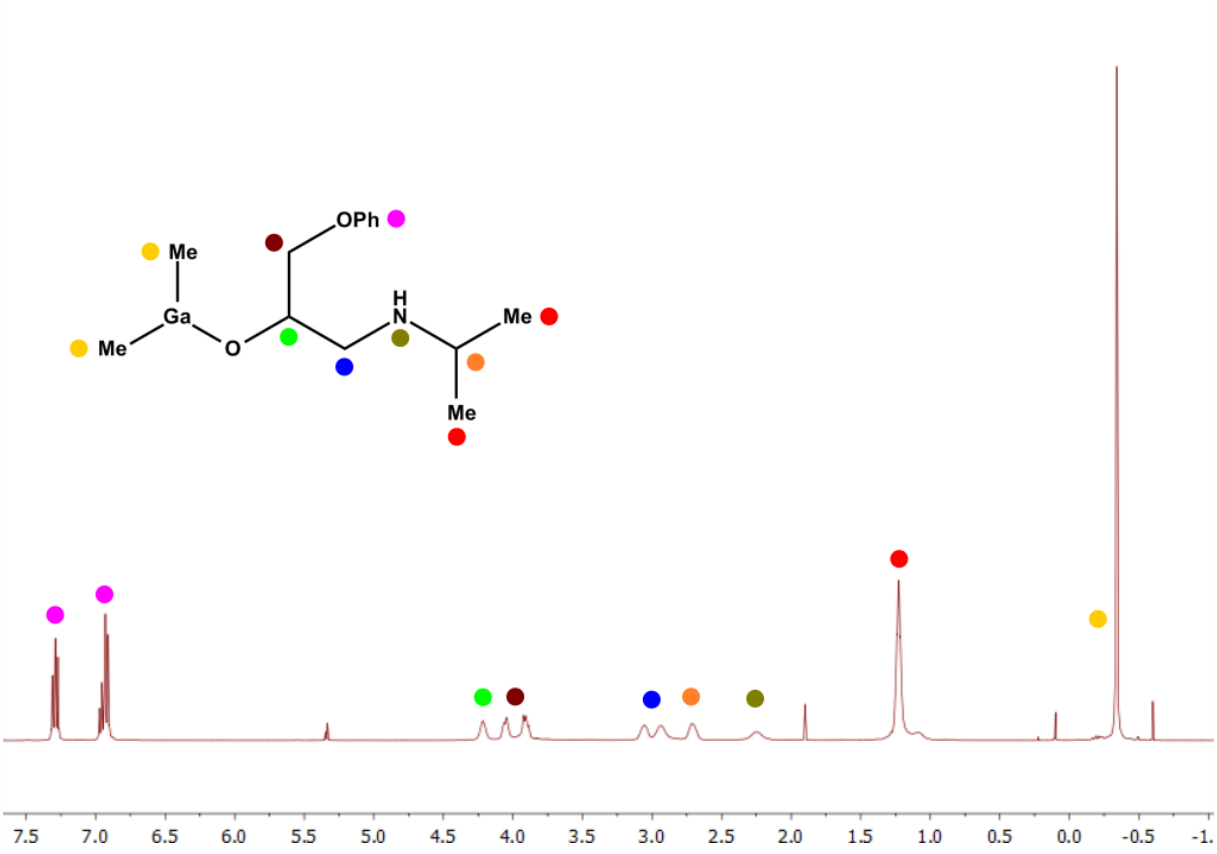


Figure S5. ^{1}H NMR (CD_2Cl_2, 400 MHz) spectrum of **3.**

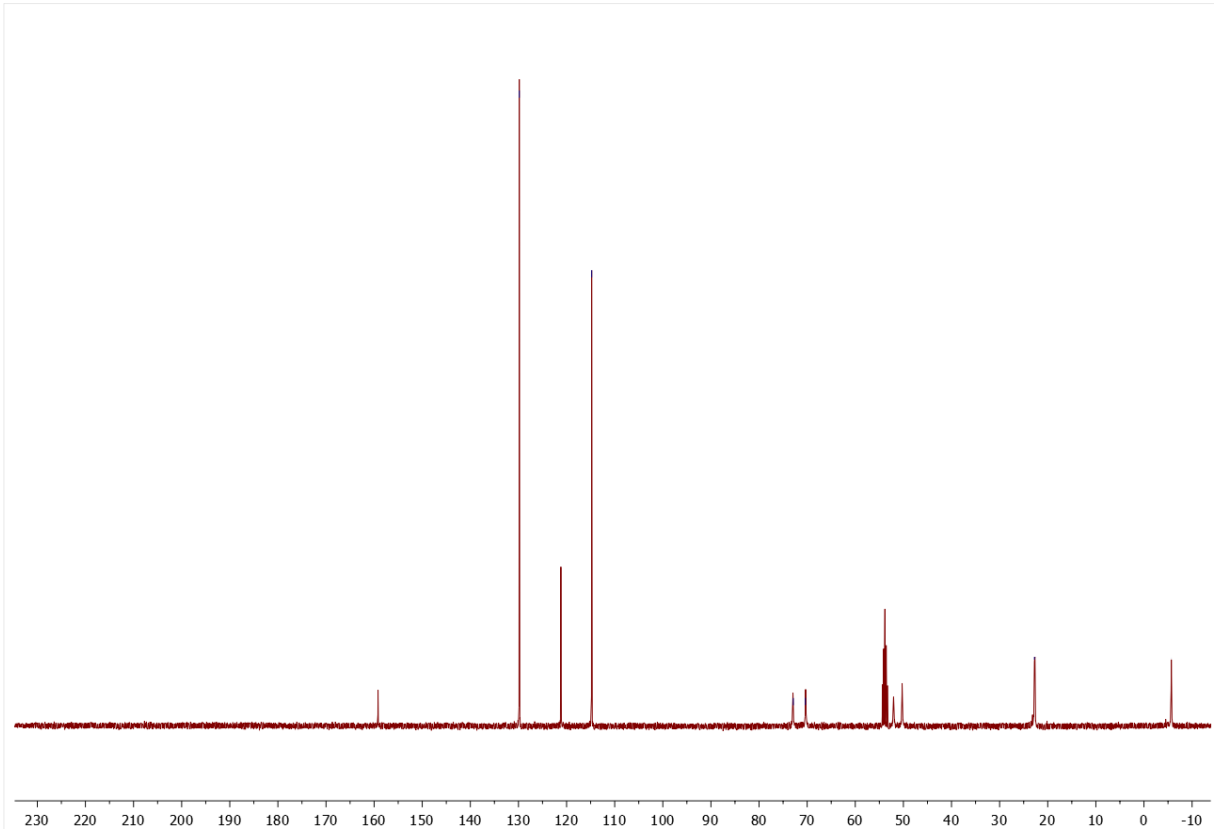


Figure S6. ^{13}C NMR (CD_2Cl_2, 100 MHz) spectrum of **3.**

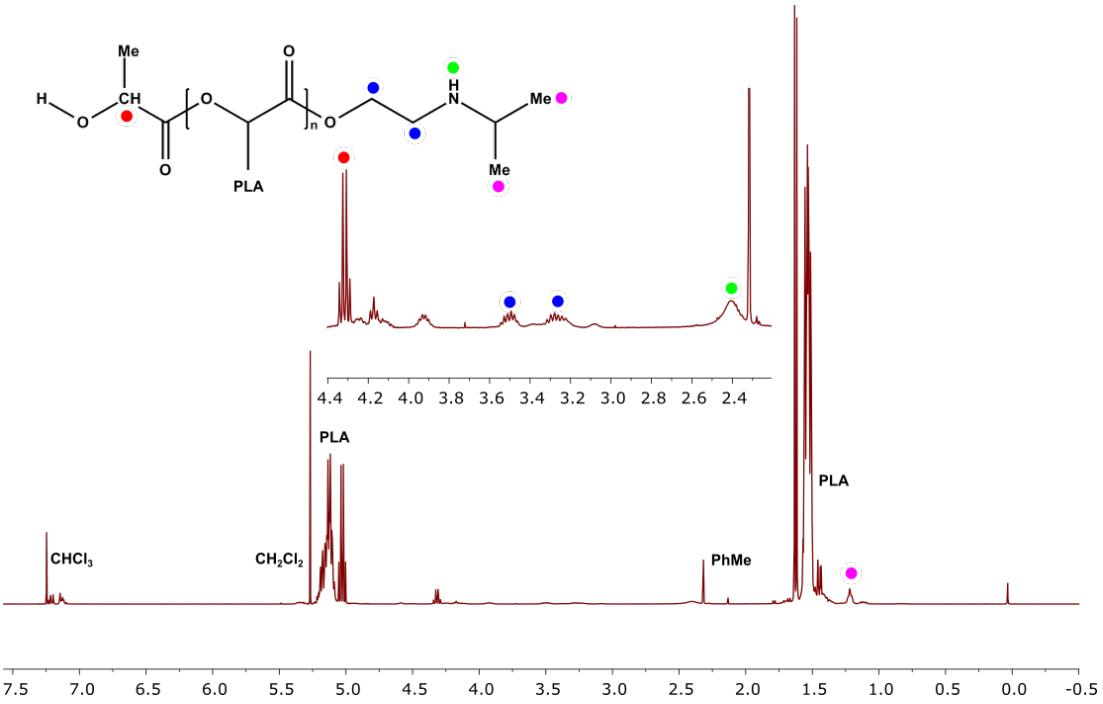


Figure S7. ^{1}H NMR ($CDCl_3$, 400 MHz) spectra of PLA obtained by polymerization of 50 eq of *rac*-LA with **2** as an initiator, in toluene at 70˚C, 24h.

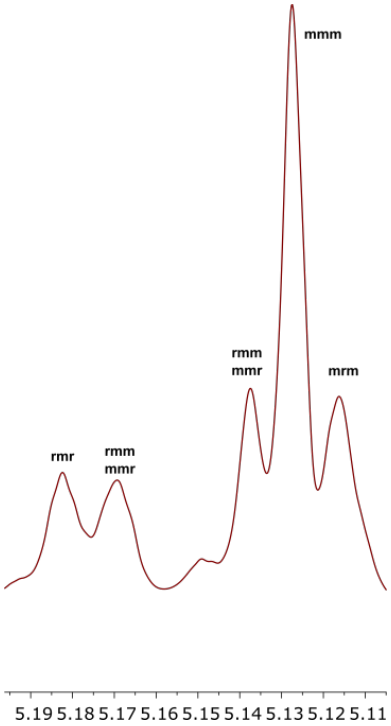


Figure S8. Homonuclear decoupled ^{1}H NMR ($CDCl_3$, 400MHz) spectrum of the methine region of PLA obtained by polymerization of 50 eq of *rac*-LA with **2** as an initiator, in toluene at 70˚C, 24h.

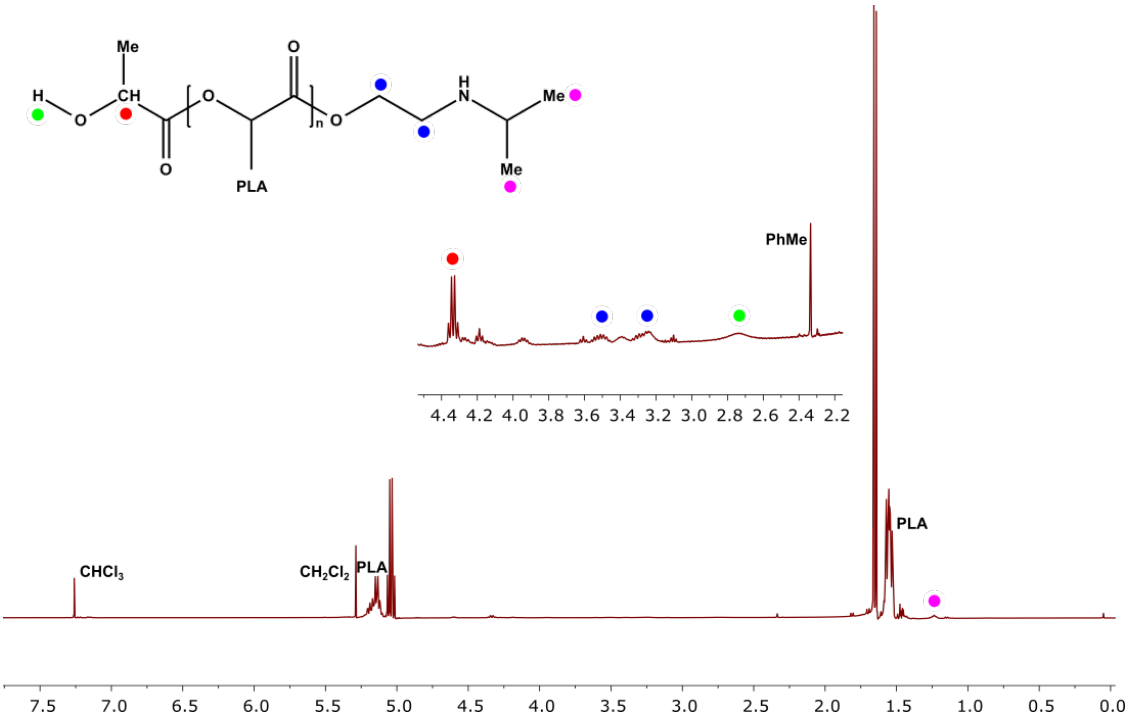


Figure S9. ^{1}H NMR ($CDCl_3$, 400 MHz) spectra of PLA obtained by polymerization of 50 eq of *rac*-LA with **2** as an initiator, in toluene at 40˚C, 144h.

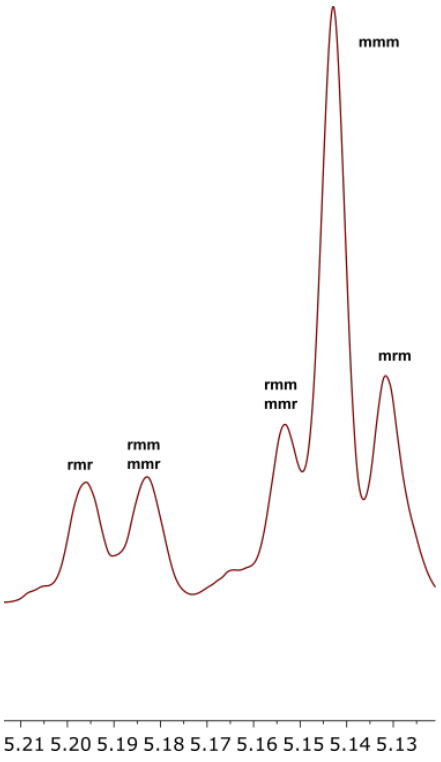


Figure S10. Homonuclear decoupled ^{1}H NMR ($CDCl_3$, 400MHz) spectrum of the methine region of of PLA obtained by polymerization of 50 eq of *rac*-LA with **2** as an initiator, in toluene at 40˚C, 144h.

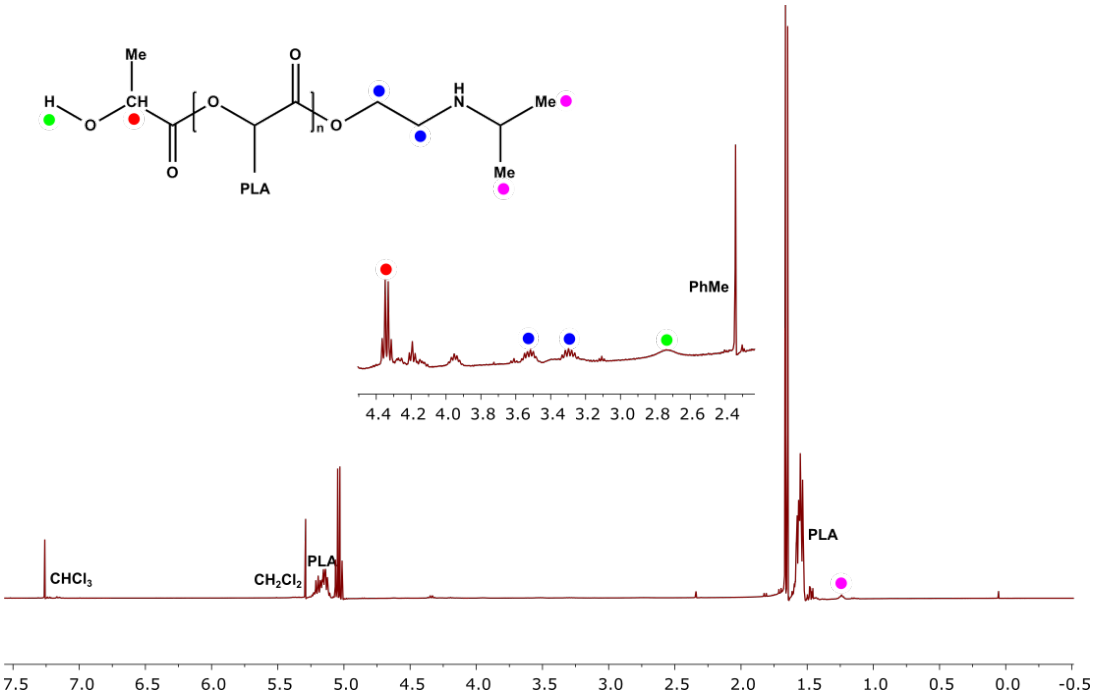


Figure S11. ^{1}H NMR ($CDCl_3$, 400 MHz) spectra of PLA obtained by polymerization of 50 eq of *rac*-LA with **2/piridine 1:6** as an initiator, in toluene at 40˚C, 144h.

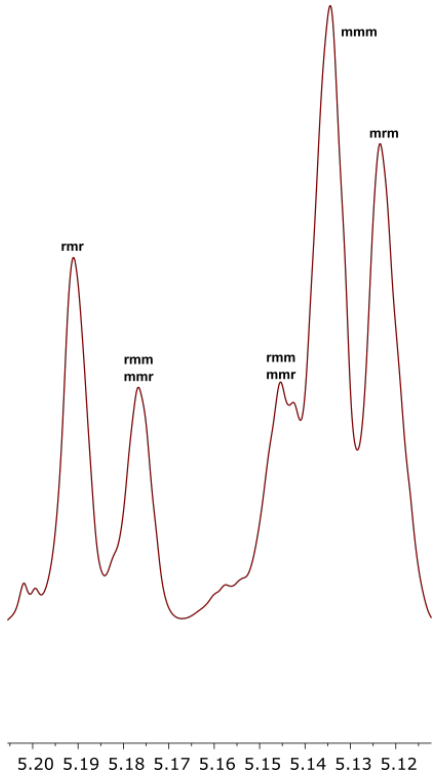


Figure S12. Homonuclear decoupled ^{1}H NMR ($CDCl_3$, 400MHz) spectrum of the methine region of of PLA obtained by polymerization of 50 eq of *rac*-LA with **2/piridine 1:6** as an initiator, in toluene at 40˚C, 144h.

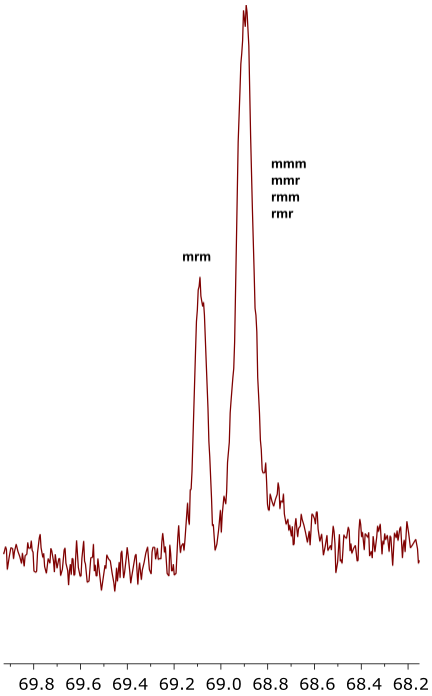


Figure S13. ^{13}C NMR ($CDCl_3$, 100 MHz) spectrum of methine region of PLA obtained by polymerization of 50 eq of *rac*-LA with **2/piridine 1:6** as an initiator, in toluene at 40˚C, 144h.

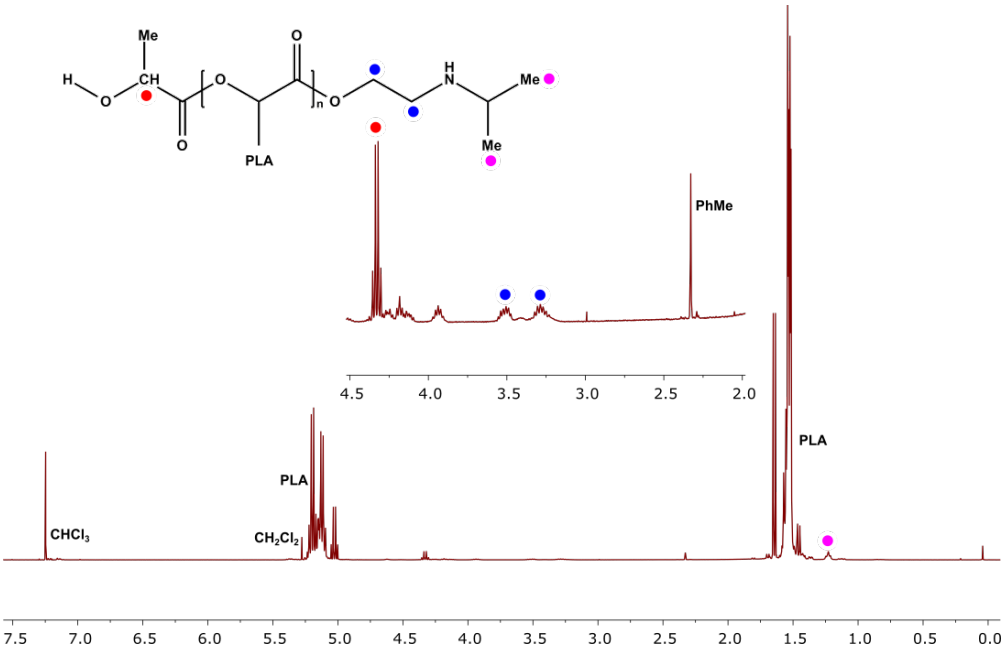


Figure S14. ^{1}H NMR ($CDCl_3$, 400 MHz) spectra of PLA obtained by polymerization of 50 eq of *rac*-LA with **2/DMAP 1:6** as an initiator, in toluene at 40˚C, 120h.

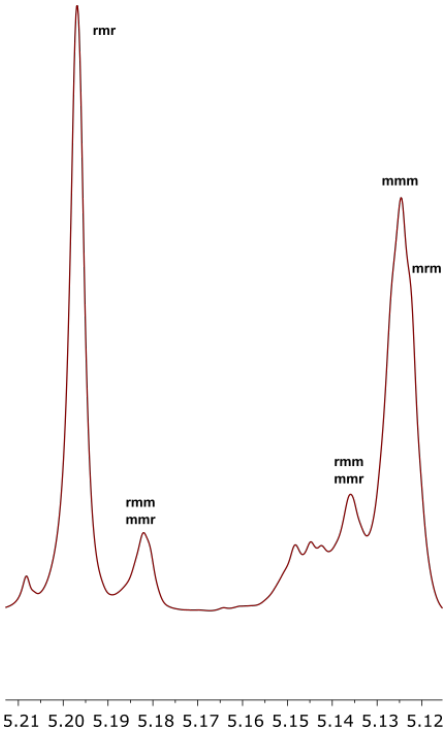


Figure S15. Homonuclear decoupled ^{1}H NMR ($CDCl_3$, 400MHz) spectrum of the methine region of PLA obtained by polymerization of 50 eq of *rac*-LA with **2/DMAP 1:6** as an initiator, in toluene at 40˚C, 120h.

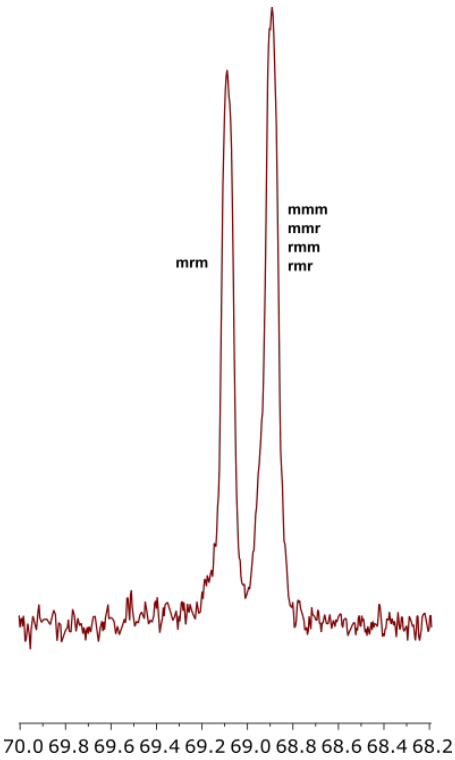


Figure S16. ^{13}C NMR ($CDCl_3$, 100 MHz) spectrum of methine region of PLA obtained by polymerization of 50 eq of *rac*-LA with **2/DMAP 1:6** as an initiator, in toluene at 40˚C, 120h.

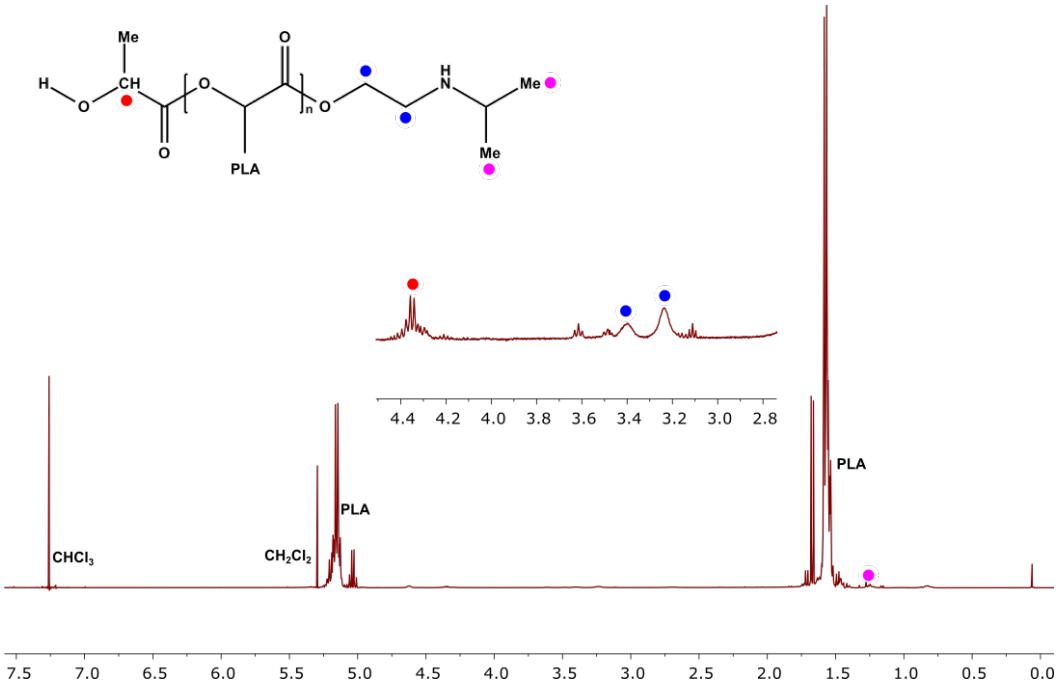


Figure S17. ^{1}H NMR ($CDCl_3$, 400 MHz) spectra of PLA obtained by polymerization of 50 eq of *rac*-LA with **2/DBU 1:2** as an initiator, in methylene chloride at -20˚C, 18h.

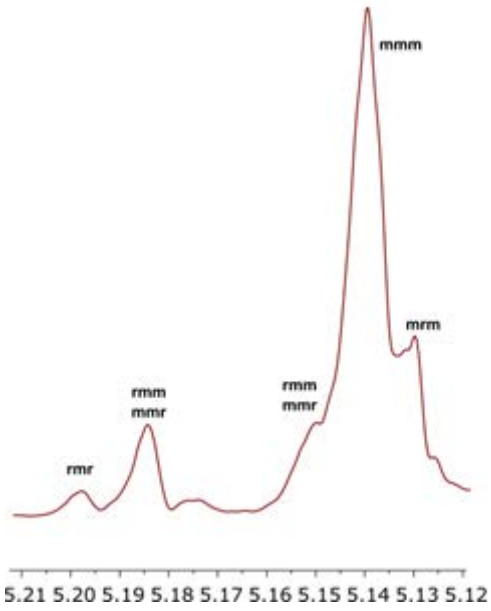


Figure S18. Homonuclear decoupled ^{1}H NMR ($CDCl_3$, 400MHz) spectrum of the methine region of PLA obtained by polymerization of 50 eq of *rac*-LA with **2/DBU 1:2** as an initiator, in methylene chloride at -20˚C, 18h.

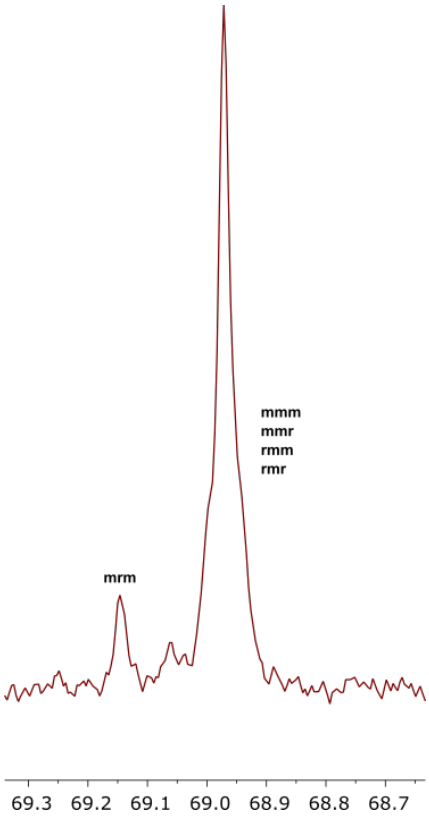


Figure S19. ^{13}C NMR ($CDCl_3$, 100 MHz) spectrum of methine region of PLA obtained by polymerization of 50 eq of *rac*-LA with **2/DBU 1:2** as an initiator, in methylene chloride at -20˚C, 18h.

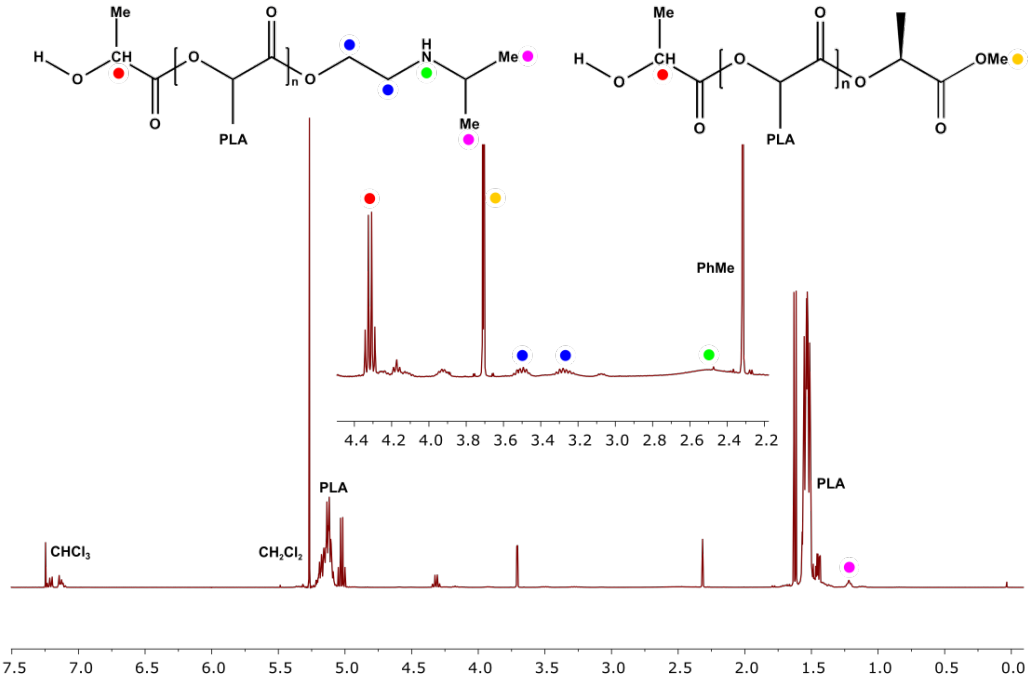


Figure S20. ^{1}H NMR ($CDCl_3$, 400 MHz) spectra of PLA obtained by polymerization of 50 eq of *rac*-LA with **$Me_2Ga(\mu$-$OCH(Me)CO_2Me)]_2$/2** H-**B** as an initiator, in toluene at 70˚C, 24h.

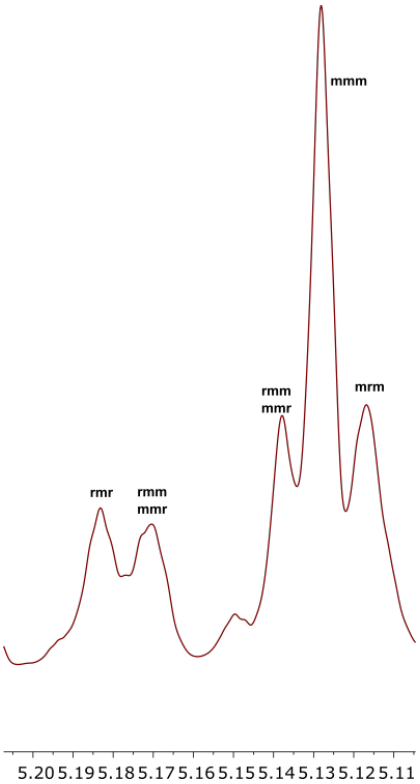


Figure S21. Homonuclear decoupled ^{1}H NMR ($CDCl_3$, 400MHz) spectrum of the methine region of PLA obtained by polymerization of 50 eq of *rac*-LA with **$Me_2Ga(\mu$-$OCH(Me)CO_2Me)]_2$/2** H-**B** as an initiator, in toluene at 70˚C, 24h.

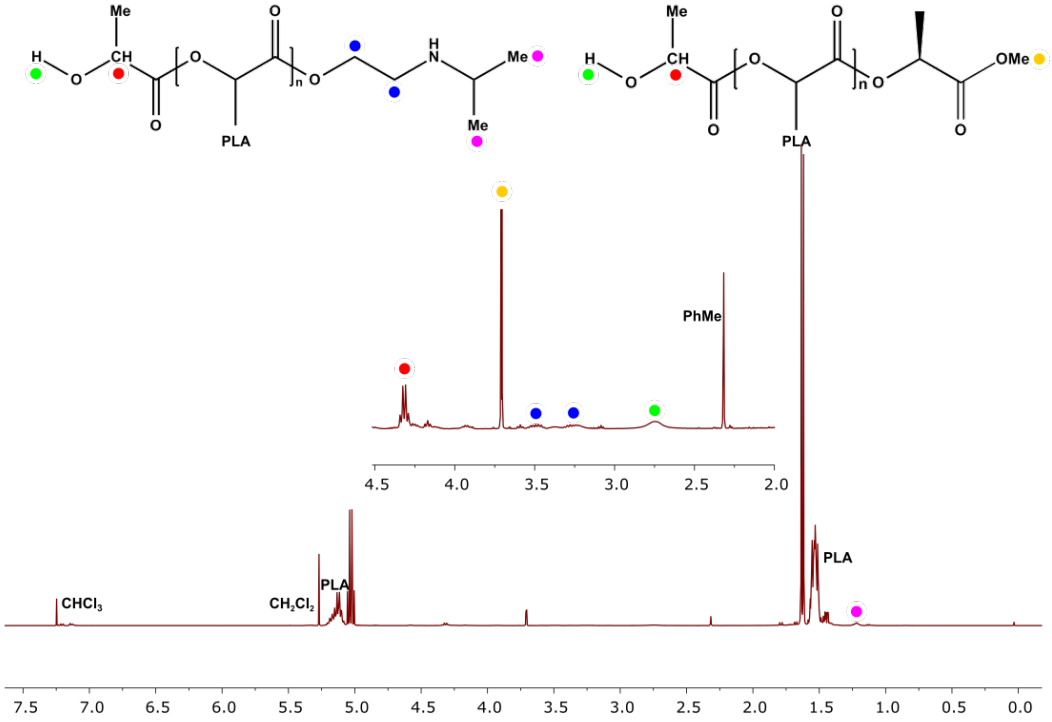


Figure S22. ^{1}H NMR ($CDCl_3$, 400 MHz) spectra of PLA obtained by polymerization of 50 eq of *rac*-LA with **$Me_2Ga(\mu$-$OCH(Me)CO_2Me)]_2$/2** H-**B** as an initiator, in toluene at 40˚C, 144h.

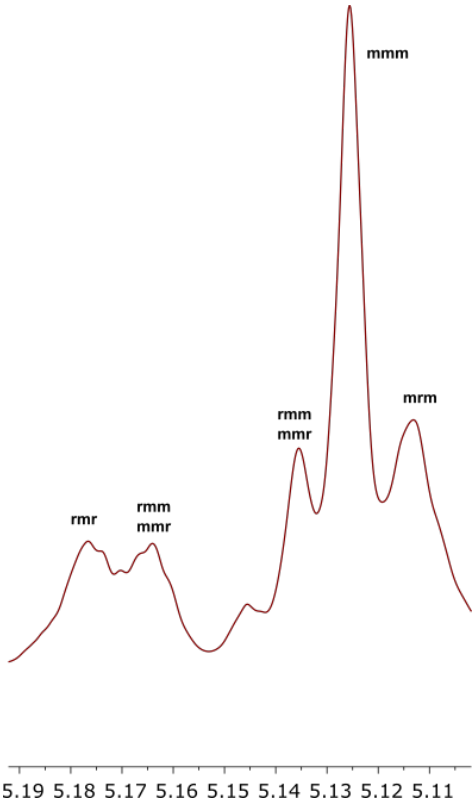


Figure S23. Homonuclear decoupled ^{1}H NMR ($CDCl_3$, 400MHz) spectrum of the methine region of PLA obtained by polymerization of 50 eq of *rac*-LA with **$Me_2Ga(\mu$-$OCH(Me)CO_2Me)]_2$/2** H-**B** as an initiator, in toluene at 40˚C, 144h.

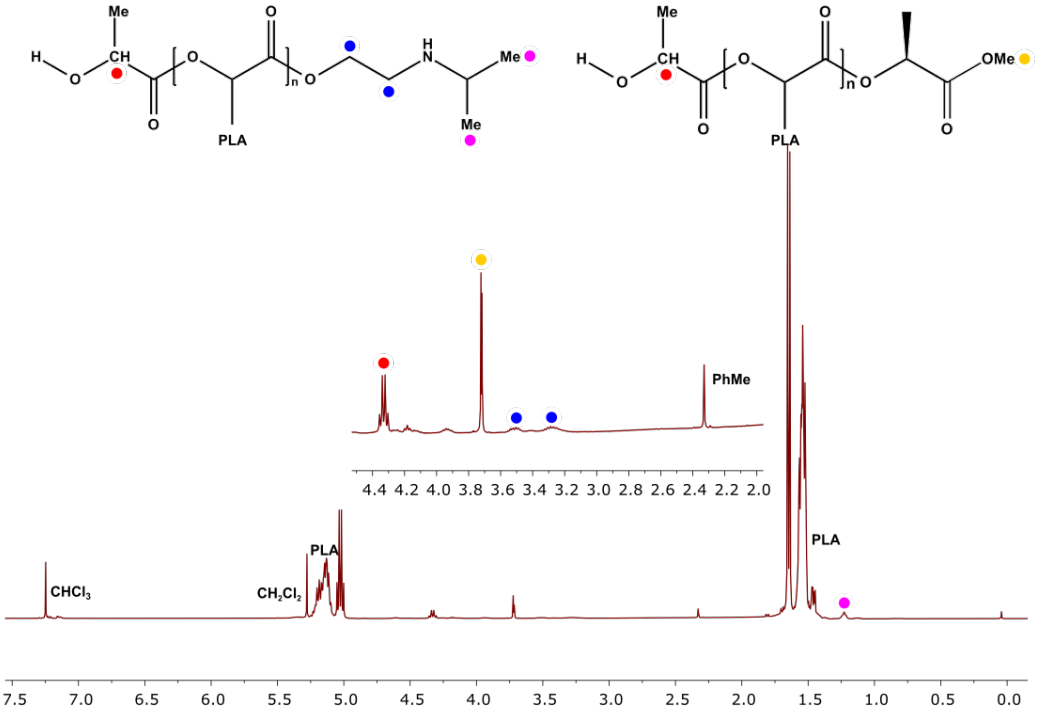


Figure S24. ^{1}H NMR ($CDCl_3$, 400 MHz) spectra of PLA obtained by polymerization of 50 eq of *rac*-LA with **$Me_2Ga(\mu$-OCH(Me)CO_2Me)]$_2$/2** H-**B/piridine 1:6** as an initiator, in toluene at 40˚C, 144h.

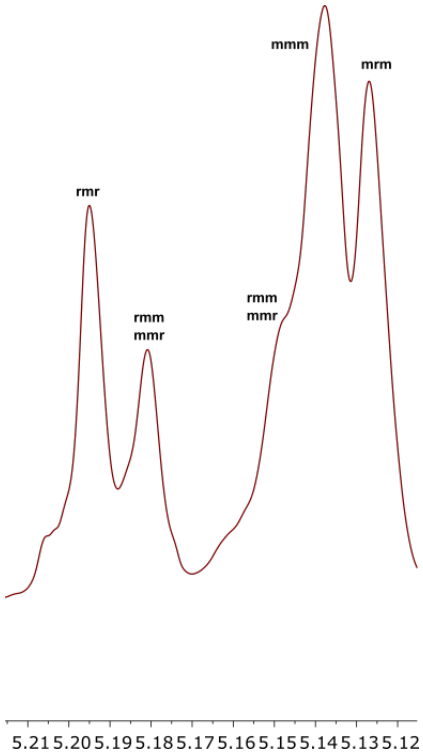


Figure S25. Homonuclear decoupled ^{1}H NMR ($CDCl_3$, 400MHz) spectrum of the methine region of PLA obtained by polymerization of 50 eq of *rac*-LA with **$Me_2Ga(\mu$-OCH(Me)CO_2Me)]$_2$/2** H-**B/piridine 1:6** as an initiator, in toluene at 40˚C, 144h.

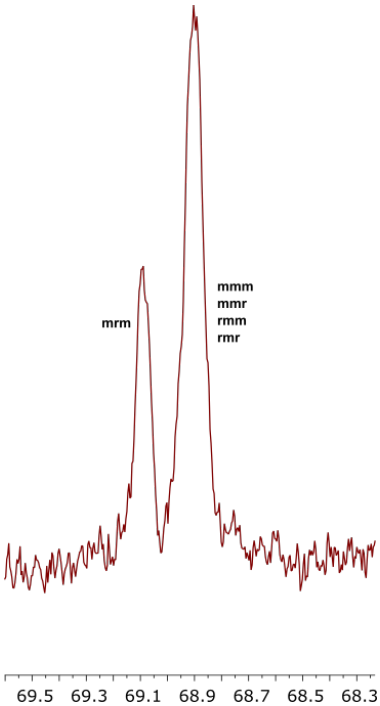


Figure S26. ^{13}C NMR ($CDCl_3$, 100 MHz) spectrum of methine region of PLA obtained by polymerization of 50 eq of *rac*-LA with **$Me_2Ga(\mu$-OCH(Me)CO_2Me)$]_2$/2** H-**B/piridine 1:6** as an initiator, in toluene at 40˚C, 144h.

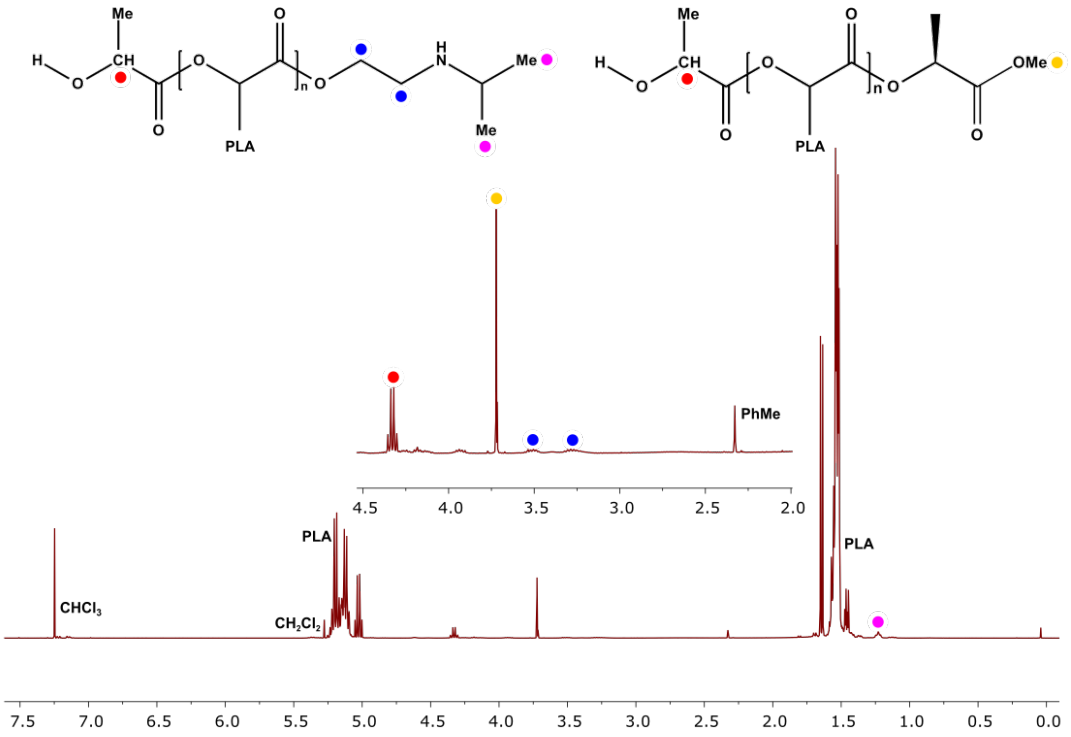


Figure S27. ^1H NMR ($CDCl_3$, 400 MHz) spectra of PLA obtained by polymerization of 50 eq of *rac*-LA with **$Me_2Ga(\mu$-OCH(Me)CO_2Me)$]_2$/2** H-**B/DMAP 1:6** as an initiator, in toluene at 40˚C, 120h.

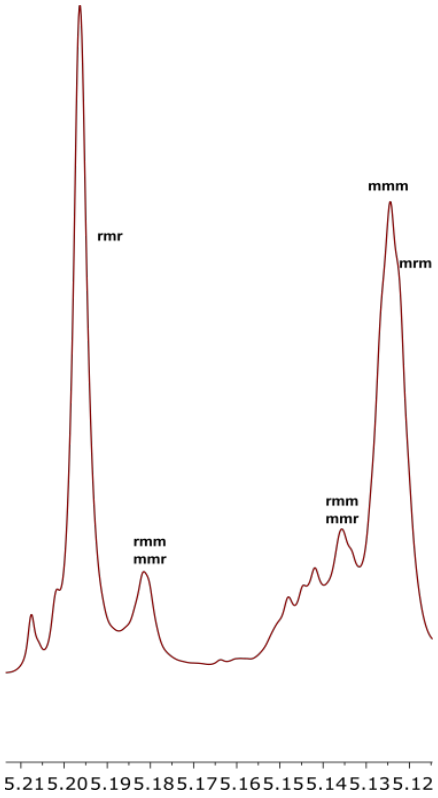


Figure S28. Homonuclear decoupled ^{1}H NMR ($CDCl_3$, 400MHz) spectrum of the methine region of PLA obtained by polymerization of 50 eq of *rac*-LA with **$Me_2Ga(\mu$-$OCH(Me)CO_2Me)]_2$/2** H-**B/DMAP 1:6** as an initiator, in toluene at 40˚C, 120h.

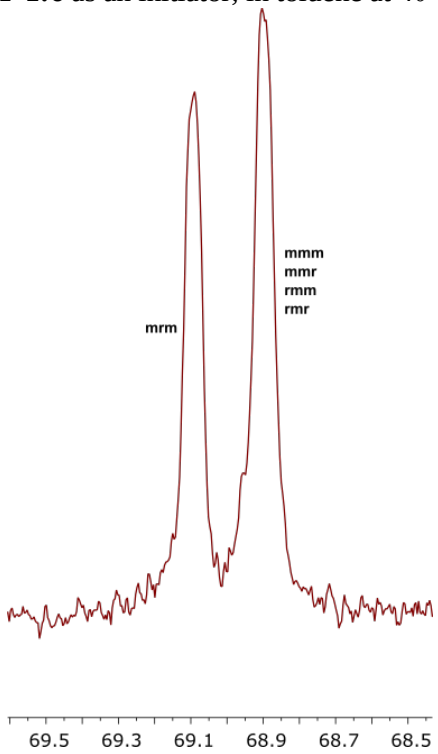


Figure S29. ^{13}C NMR ($CDCl_3$, 100 MHz) spectrum of methine region of PLA obtained by polymerization of 50 eq of *rac*-LA with **$Me_2Ga(\mu$-$OCH(Me)CO_2Me)]_2$/2** H-**B/DMAP 1:6** as an initiator, in toluene at 40˚C, 120h.

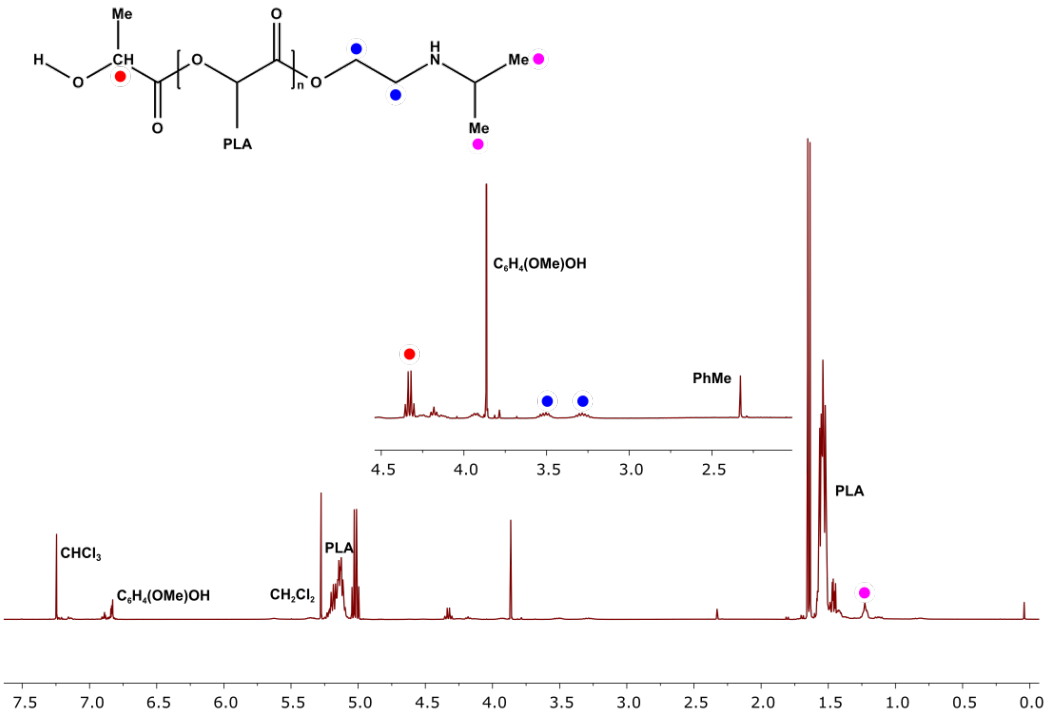


Figure S30. ^{1}H NMR ($CDCl_3$, 400 MHz) spectra of PLA obtained by polymerization of 25 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2** H-**B** as an initiator, in toluene at 70˚C, 24h.

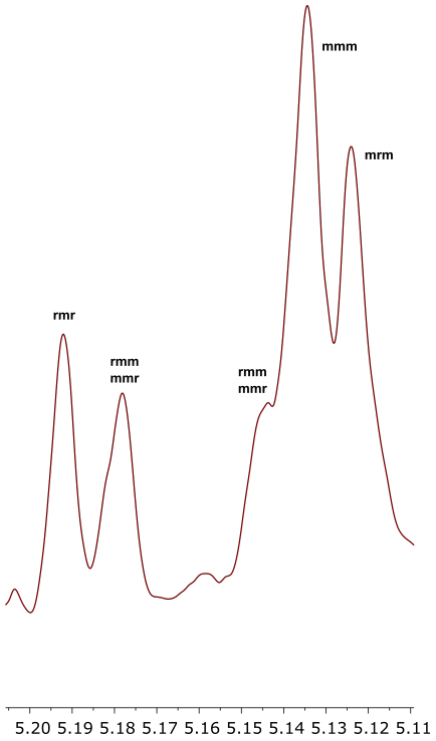


Figure S31. Homonuclear decoupled ^{1}H NMR ($CDCl_3$, 400MHz) spectrum of the methine region of PLA obtained by polymerization of 25 eq of *rac*-LA with **[Me$_2$Ga(μ-OC$_6$H$_4$OMe)]$_2$/2** H-**B** as an initiator, in toluene at 70˚C, 24h

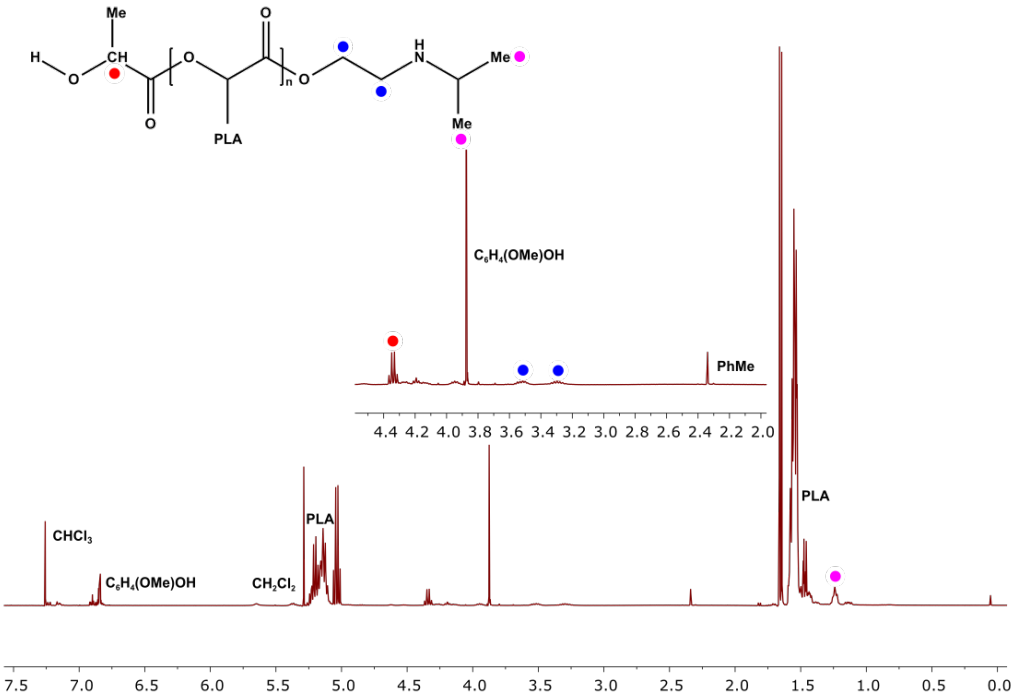


Figure S32. ^{1}H NMR ($CDCl_3$, 400 MHz) spectra of PLA obtained by polymerization of 25 eq of *rac*-LA with **[Me$_2$Ga(μ-OC$_6$H$_4$OMe)]$_2$/2** H-**B**/**γ-picoline 1:6** as an initiator, in toluene at 40˚C, 144h.

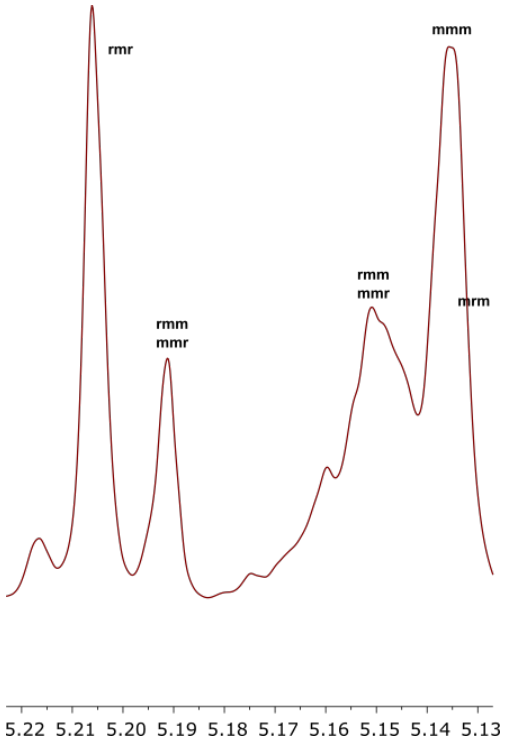


Figure S33. Homonuclear decoupled ^{1}H NMR ($CDCl_3$, 400MHz) spectrum of the methine region of PLA obtained by polymerization of 25 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2** H-**B/γ-picoline 1:6** as an initiator, in toluene at 40˚C, 144h.

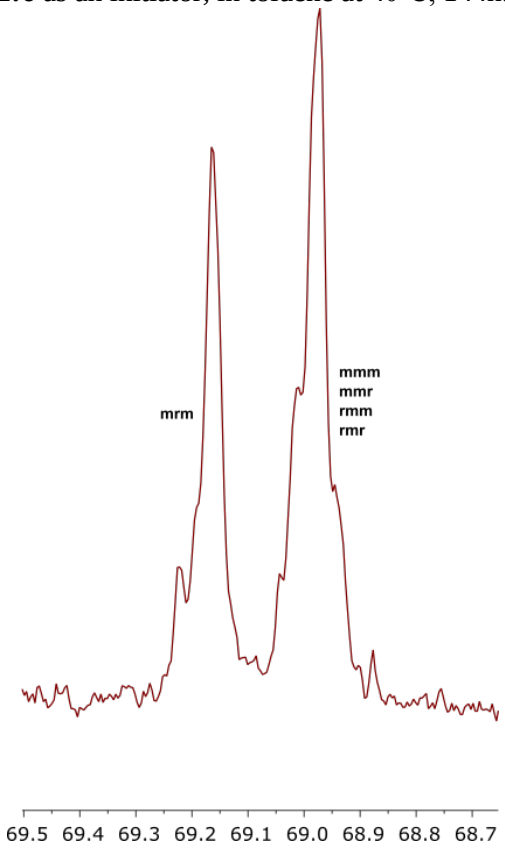


Figure S34. ^{13}C NMR ($CDCl_3$, 100 MHz) spectrum of methine region of PLA obtained by polymerization of 25 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2** H-**B/γ-picoline 1:6** as an initiator, in toluene at 40˚C, 144h.

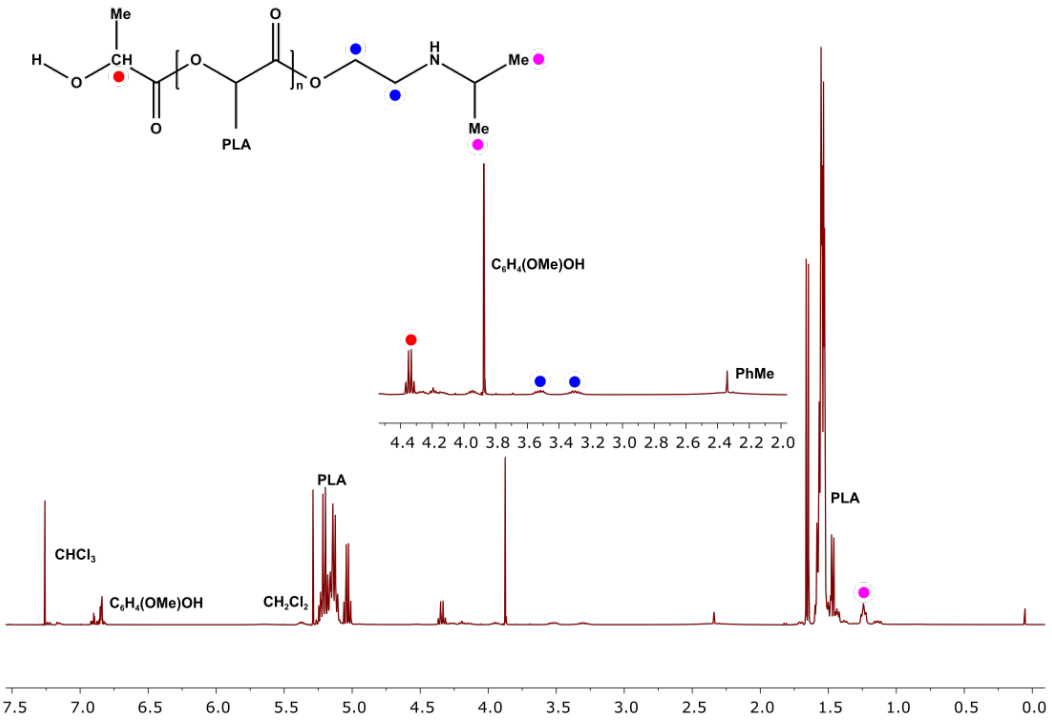


Figure S35. ^{1}H NMR ($CDCl_3$, 400 MHz) spectra of PLA obtained by polymerization of 25 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2** H-**B/γ-picoline 1:60** as an initiator, in toluene at 40˚C, 144h.

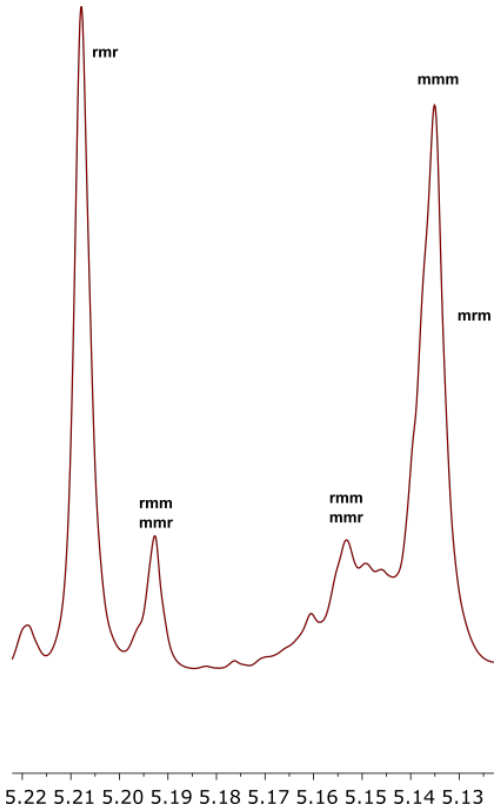


Figure S36. Homonuclear decoupled ^{1}H NMR ($CDCl_3$, 400MHz) spectrum of the methine region of PLA obtained by polymerization of 25 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2** H-**B/γ-picoline 1:60** as an initiator, in toluene at 40˚C, 144h.

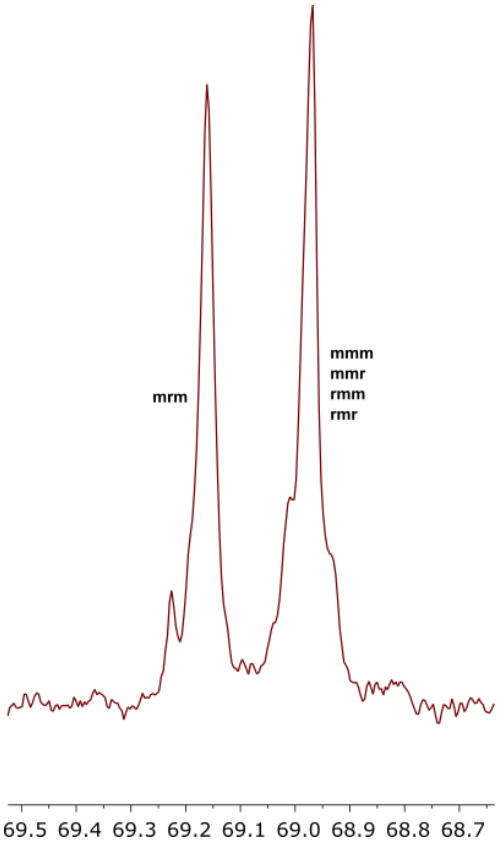


Figure S37. ^{13}C NMR ($CDCl_3$, 100 MHz) spectrum of methine region of PLA obtained by polymerization of 25 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2** H-**B/γ-picoline 1:60** as an initiator, in toluene at 40˚C, 144h.

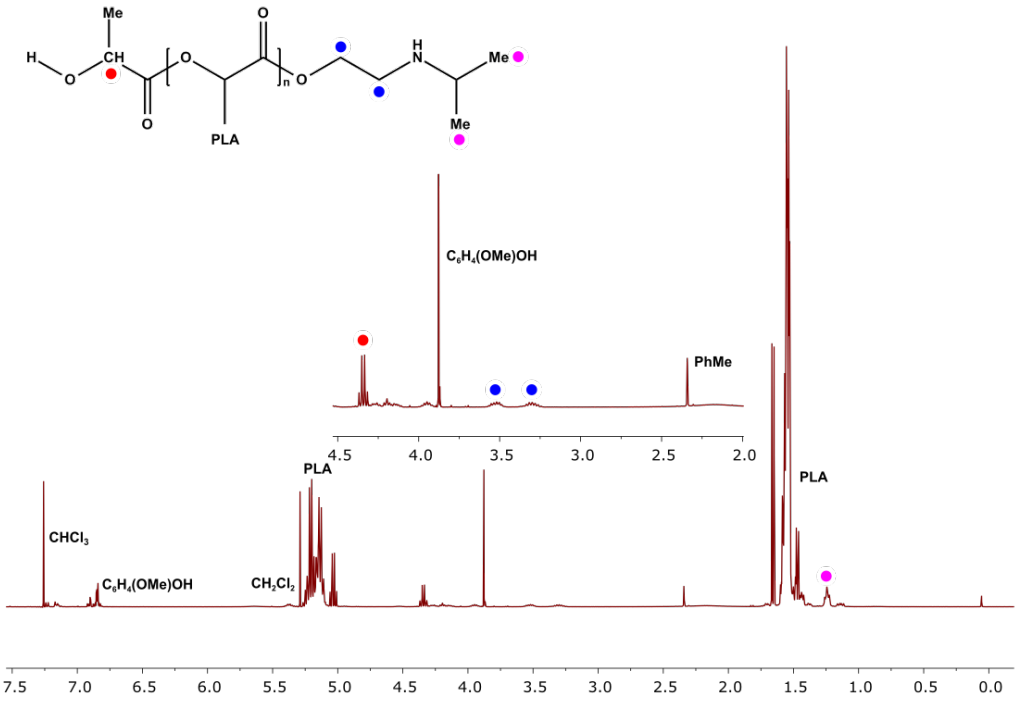


Figure S38. ^{1}H NMR ($CDCl_3$, 400 MHz) spectra of PLA obtained by polymerization of 25 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2** H-**B/piridine 1:60** as an initiator, in toluene at 40˚C, 144h.

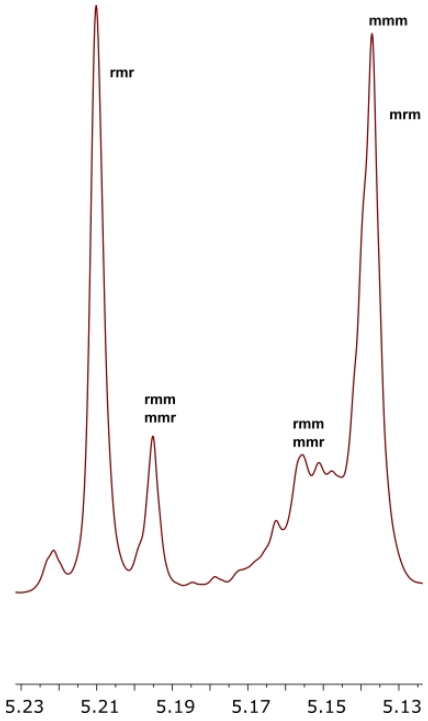


Figure S39. Homonuclear decoupled ^{1}H NMR ($CDCl_3$, 400MHz) spectrum of the methine region of PLA obtained by polymerization of 25 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2** H-**B/piridine 1:60** as an initiator, in toluene at 40˚C, 144h.

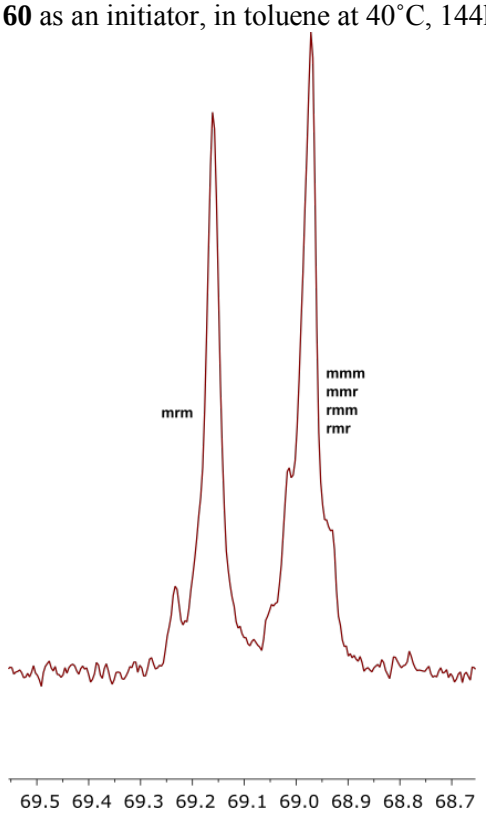


Figure S40. ^{13}C NMR ($CDCl_3$, 100 MHz) spectrum of methine region of PLA obtained by polymerization of 25 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2 H-B/piridine 1:60** as an initiator, in toluene at 40˚C, 144h.

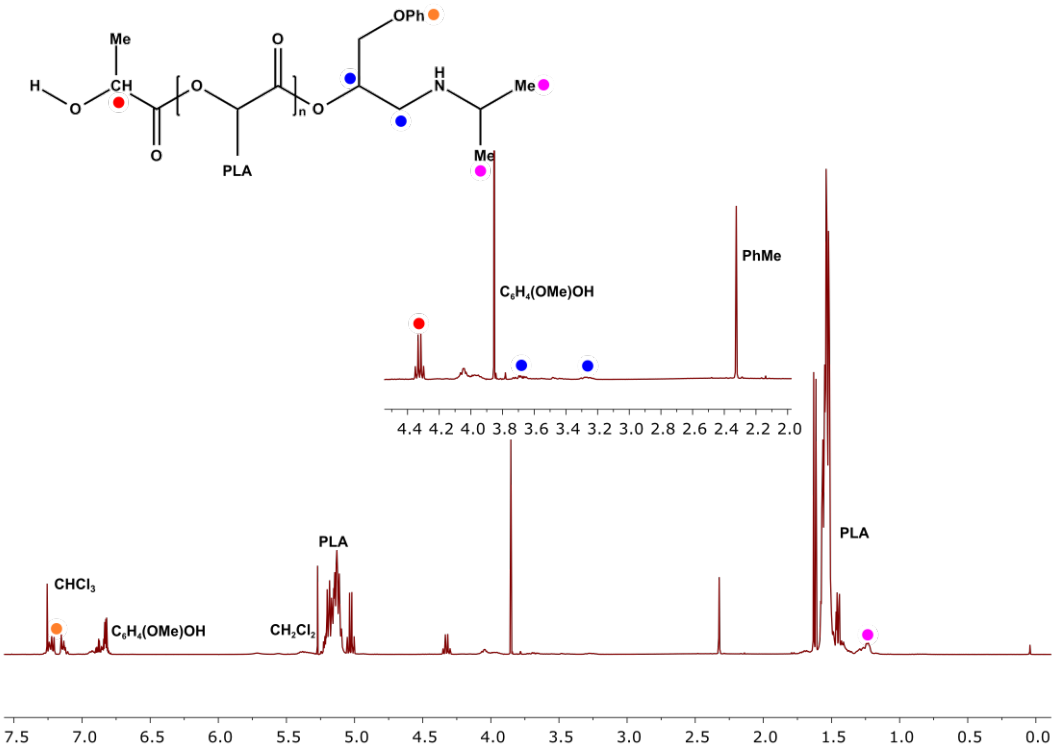


Figure S41. ^{1}H NMR ($CDCl_3$, 400 MHz) spectra of PLA obtained by polymerization of 25 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2** H-**C** as an initiator, in toluene at 40˚C, 240h.

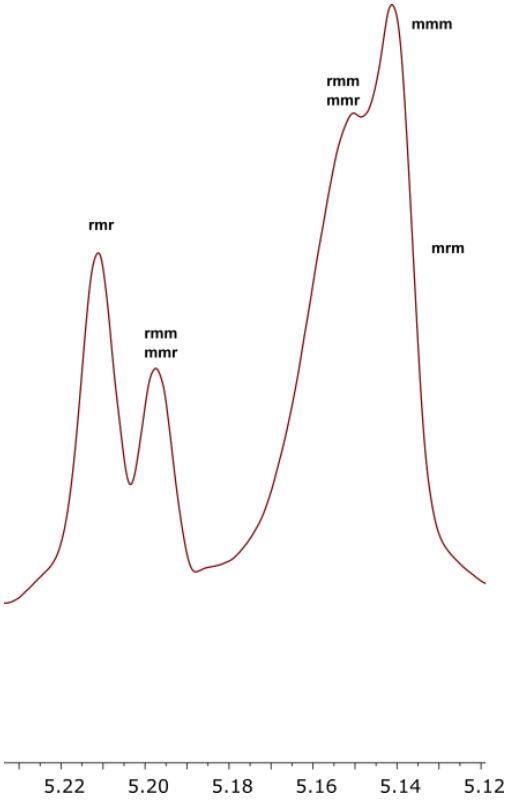


Figure S42. Homonuclear decoupled ^{1}H NMR ($CDCl_3$, 400MHz) spectrum of the methine region of PLA obtained by polymerization of 25 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2** H-**C** as an initiator, in toluene at 40˚C, 240h.

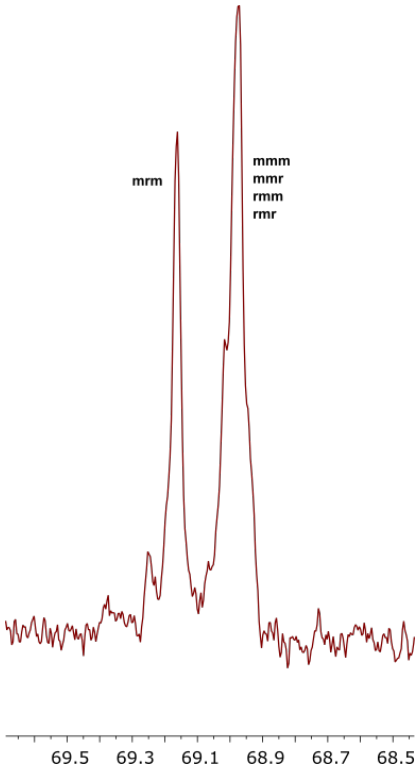


Figure S43. ^{13}C NMR ($CDCl_3$, 100 MHz) spectrum of methine region of PLA obtained by polymerization of 25 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2** H-**C** as an initiator, in toluene at 40˚C, 240h.

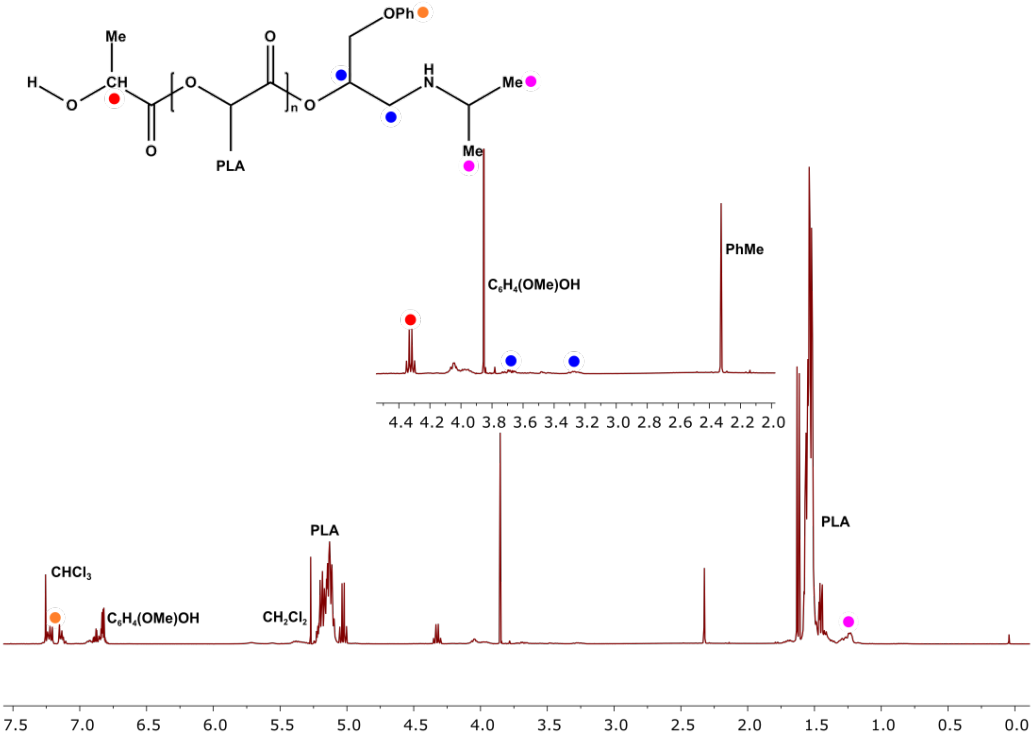


Figure S44. ^{1}H NMR ($CDCl_3$, 400 MHz) spectra of PLA obtained by polymerization of 25 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2** H-**C/piridine 1:6** as an initiator, in toluene at 40˚C, 240h.

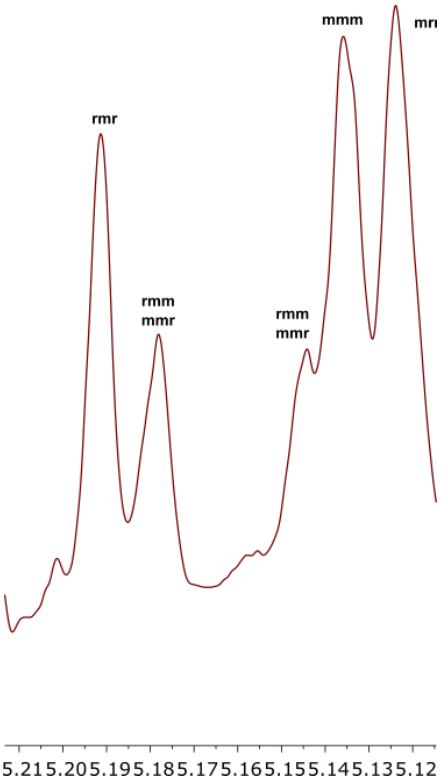


Figure S45. Homonuclear decoupled ^{1}H NMR ($CDCl_3$, 400MHz) spectrum of the methine region of PLA obtained by polymerization of 25 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2** H-**C/piridine 1:6** as an initiator, in toluene at 40˚C, 240h.

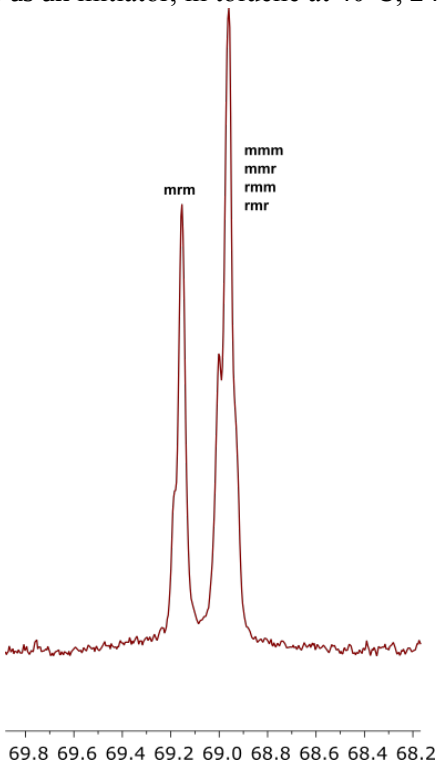


Figure S46. ^{13}C NMR ($CDCl_3$, 100 MHz) spectrum of methine region of PLA obtained by polymerization of 25 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2** H-**C/piridine 1:6** as an initiator, in toluene at 40˚C, 240h.

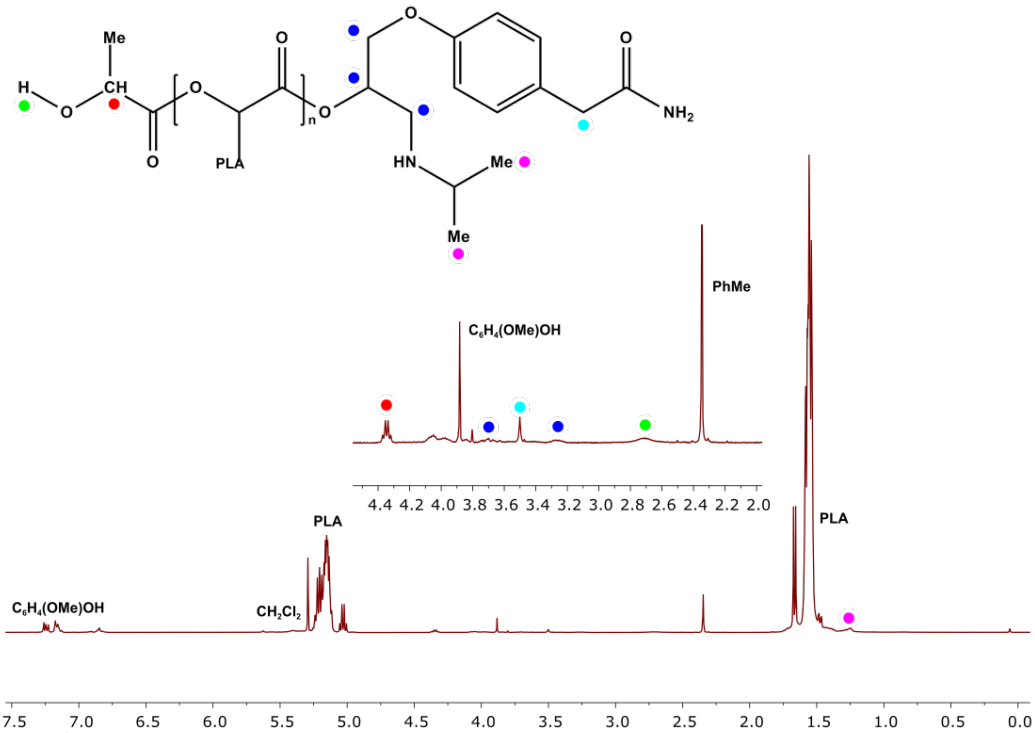


Figure S47. ^{1}H NMR ($CDCl_3$, 400 MHz) spectra of PLA obtained by polymerization of 100 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2 atenolol** as an initiator, in toluene at 40˚C, 720h.

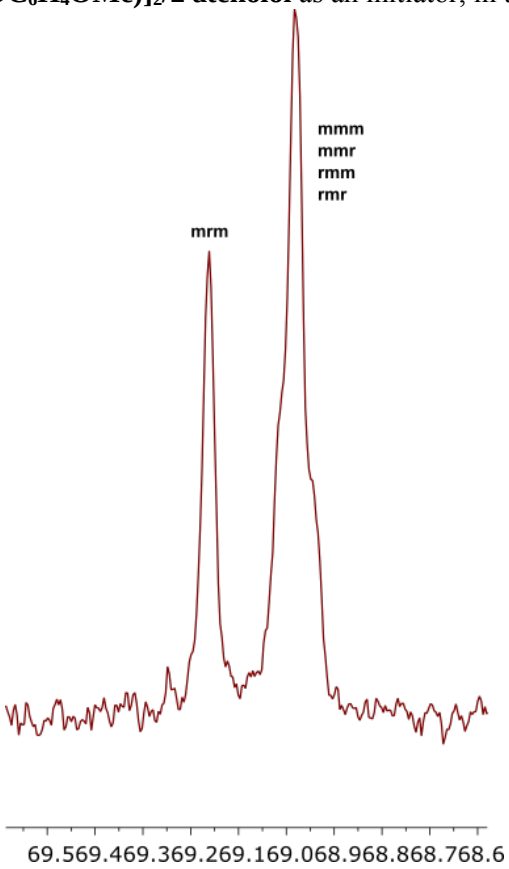


Figure S48. ^{13}C NMR ($CDCl_3$, 100 MHz) spectrum of methine region of PLA obtained by polymerization of 100 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2 atenolol** as an initiator, in toluene at 40˚C, 720h.

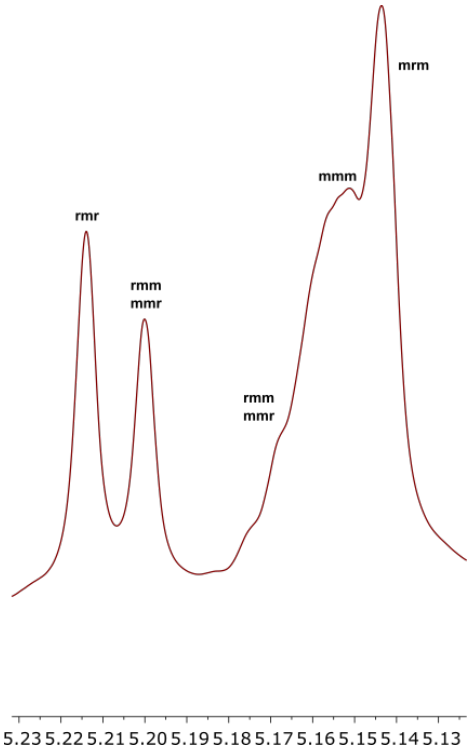


Figure S49. Homonuclear decoupled ^{1}H NMR ($CDCl_3$, 400MHz) spectrum of the methine region of PLA obtained by polymerization of 100 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2 atenolol** as an initiator, in toluene at 40˚C, 720h.

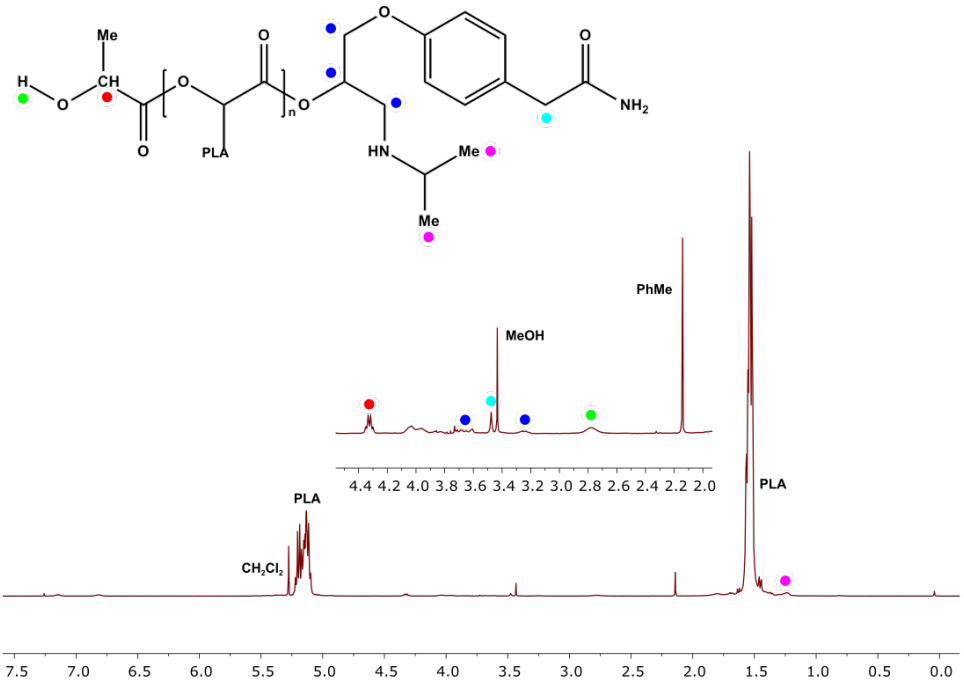


Figure S50. ^{1}H NMR ($CDCl_3$, 400 MHz) spectra of PLA (after precipitation with methanol) obtained by polymerization of 20 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2 atenolol** as an initiator, in toluene at 70˚C, 24h; and after that the temperature was reduced to 40˚C, **6 eq of DMAP** and 80 eq of *rac*-LA was added and reaction was carried out for additional 288h.

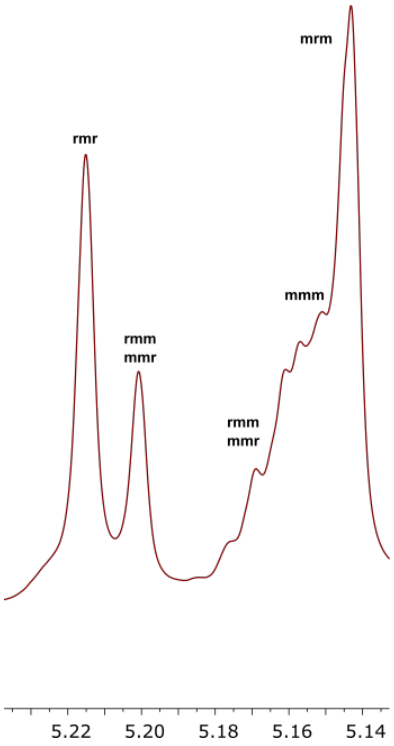


Figure S51. Homonuclear decoupled ^{1}H NMR ($CDCl_3$, 400MHz) spectrum of the methine region of PLA (after precipitation with methanol) obtained by polymerization of 20 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2 atenolol** as an initiator, in toluene at 70˚C, 24h; and after that the temperature was reduced to 40˚C, **6 eq of DMAP** and 80 eq of *rac*-LA was added and reaction was carried out for additional 288h.

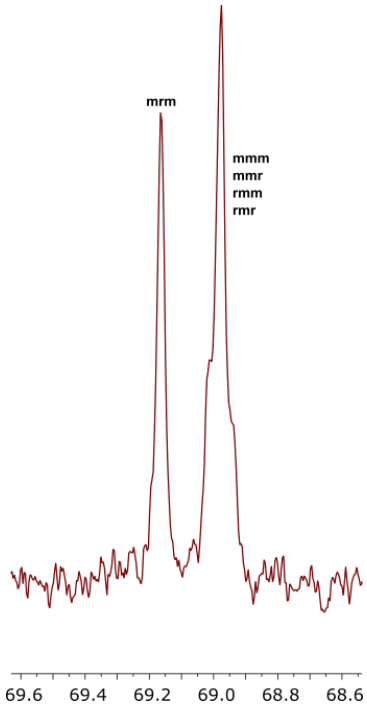
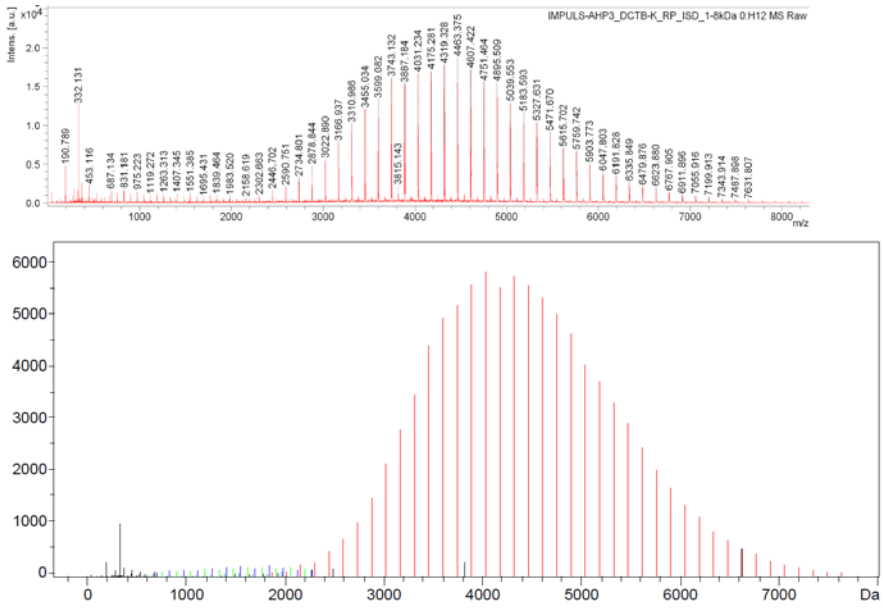
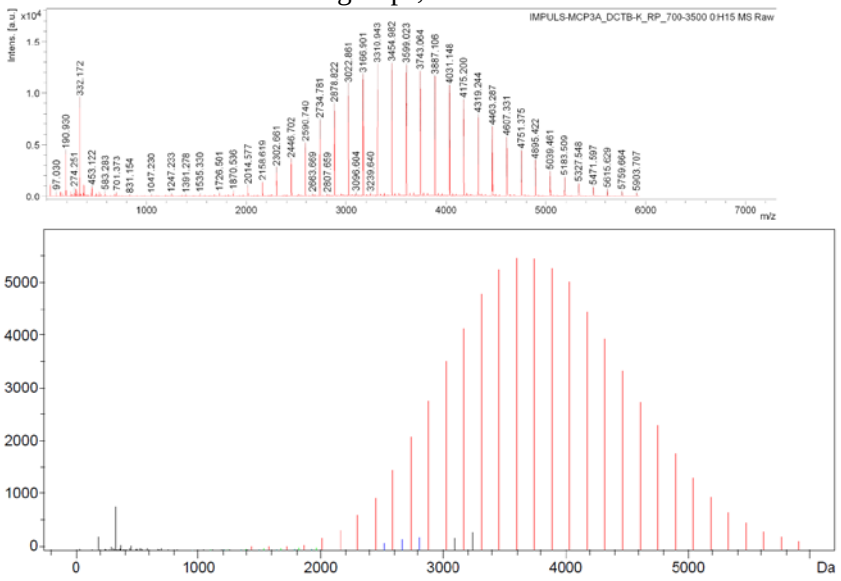


Figure S52. ^{13}C NMR ($CDCl_3$, 100 MHz) spectrum of methine region of PLA (after precipitation with methanol) obtained by polymerization of 20 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2 atenolol** as an initiator, in toluene at 70˚C, 24h; and after that the temperature was reduced to 40˚C, **6 eq of DMAP** and 80 eq of *rac*-LA was added and reaction was carried out for additional 288h.



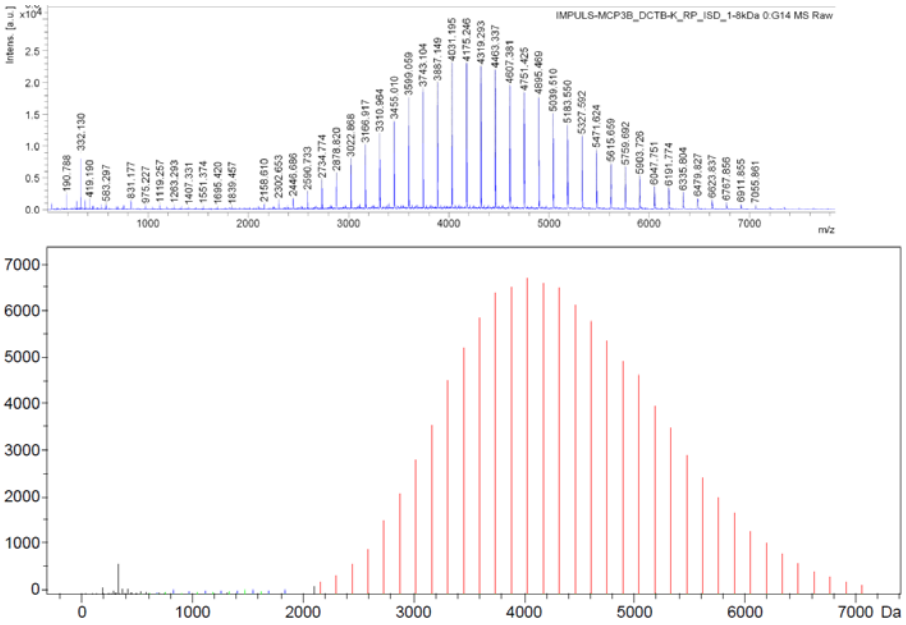
n	ser.	rep.unit	resid.	end1	end2	cation	Mn	Mw	pd	DP	% I.	cnt
1	1	144.042	103.081			38.9637	4380.98	4591.31	1.04801	30.4147	92	41
2	2	144.042	72.1606			38.9637	1488.78	1631.05	1.09556	10.3358	1.8	13
3	3	144.042	-0.01501			38.9637	1485.11	1624.26	1.09370	10.3103	1.6	12
4	4	144.042	55.9513			38.9637	1525.99	1597.35	1.04676	10.5941	0.4	9

Figure S53. MALDI–TOF spectrum of PLA (2-(4'-Hydroxybenzeneazo)benzoic acid -HABA was used as a matrix) obtained by polymerization of 50 eq of *rac*-LA with **2** as an initiator (Table 1, entry 1), in toluene at 70˚C, 24h. The main distribution refer to PLA with OH and $CH_2CH_2NH^iPr$ end groups, with K^+.



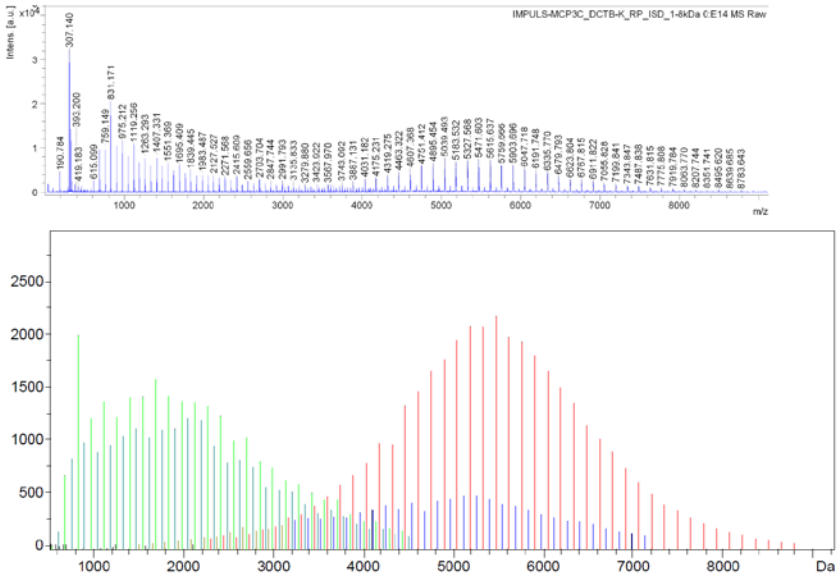
n	ser.	rep.unit	resid.	end1	end2	cation	Mn	Mw	pd	DP	% I.	cnt
1	1	144.039	103.132			38.9637	3749.48	3893.13	1.03831	26.0310	94.7	32
2	2	144.039	32.0031			38.9637	2650.22	2655.03	1.00181	18.3993	0.7	3
3	3	144.039	55.9660			38.9637	1552.19	1606.21	1.03480	10.7762	0.3	8
4	4	144.039	18.0123			38.9637	1591.68	1627.38	1.02243	11.0503	0.1	6

Figure S54. MALDI–TOF spectrum of PLA (2-(4'-Hydroxybenzeneazo)benzoic acid -HABA was used as a matrix) obtained by polymerization of 50 eq of *rac*-LA with **2** as an initiator, in toluene at 40˚C, 144h (Table 1, entry 2). The main distribution refer to PLA with OH and $CH_2CH_2NH^iPr$ end groups, with K^+.



n	ser.	rep.unit	resid.	end1	end2	cation	Mn	Mw	pd	DP	% I.	cnt
1	1	144.038	103.195			38.9637	4287.08	4484.19	1.04598	29.7636	97	35
2	2	144.038	72.0012			38.9637	1261.32	1366.32	1.08324	8.75690	0.6	10
3	3	144.038	0.00769			38.9637	1184.04	1259.51	1.06374	8.22037	0.3	8

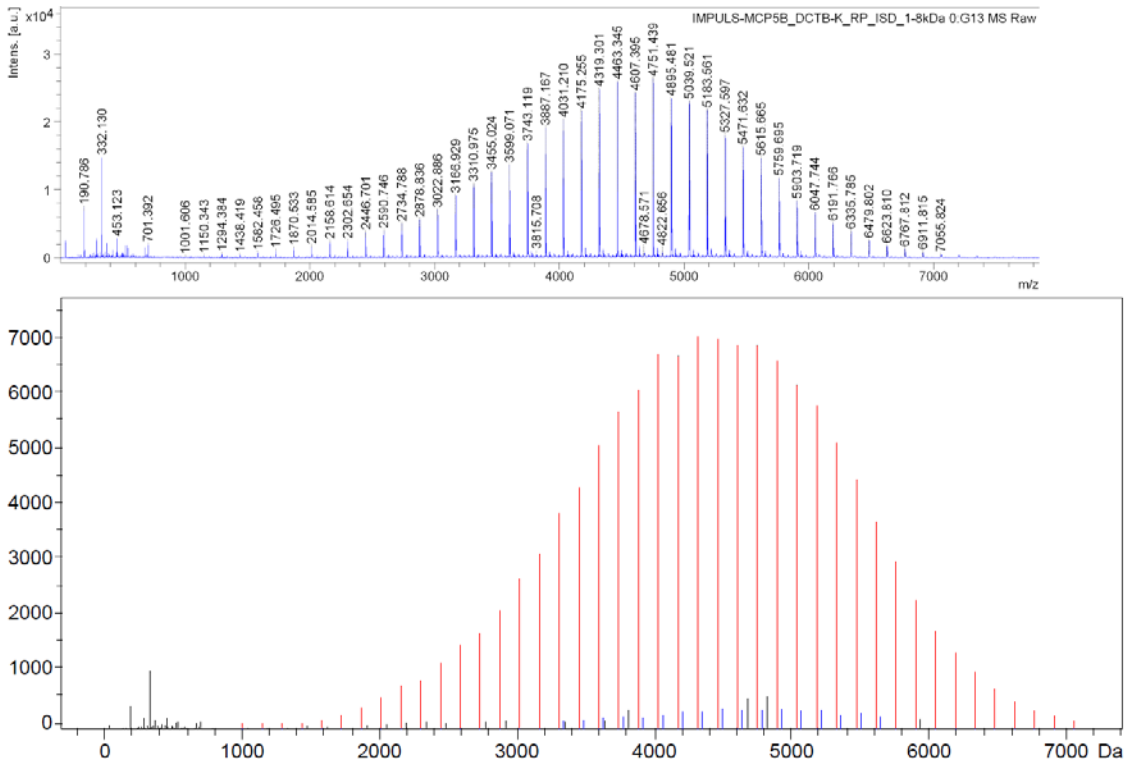
Figure S55. MALDI–TOF spectrum of PLA (2-(4'-Hydroxybenzeneazo)benzoic acid -HABA was used as a matrix) obtained by polymerization of 50 eq of *rac*-LA with **2/piridine 1:6** as an initiator, in toluene at 40˚C, 144h (Table 1, entry 3). The main distribution refer to PLA with OH and $CH_2CH_2NH^iPr$ end groups, with K^+.



n	ser.	rep.unit	resid.	end1	end2	cation	Mn	Mw	pd	DP	% I.	cnt
1	1	144.035	103.184			38.9637	5392.98	5633.13	1.04453	37.4423	38	46
2	2	144.035	31.3235			38.9637	5001.92	5205.74	1.04075	34.7272	9.3	28
3	3	144.035	72.1155			38.9637	2013.24	2430.86	1.20743	13.9775	25	28
4	4	144.035	0.06818			38.9637	2067.31	2467.28	1.19347	14.3529	18.9	28

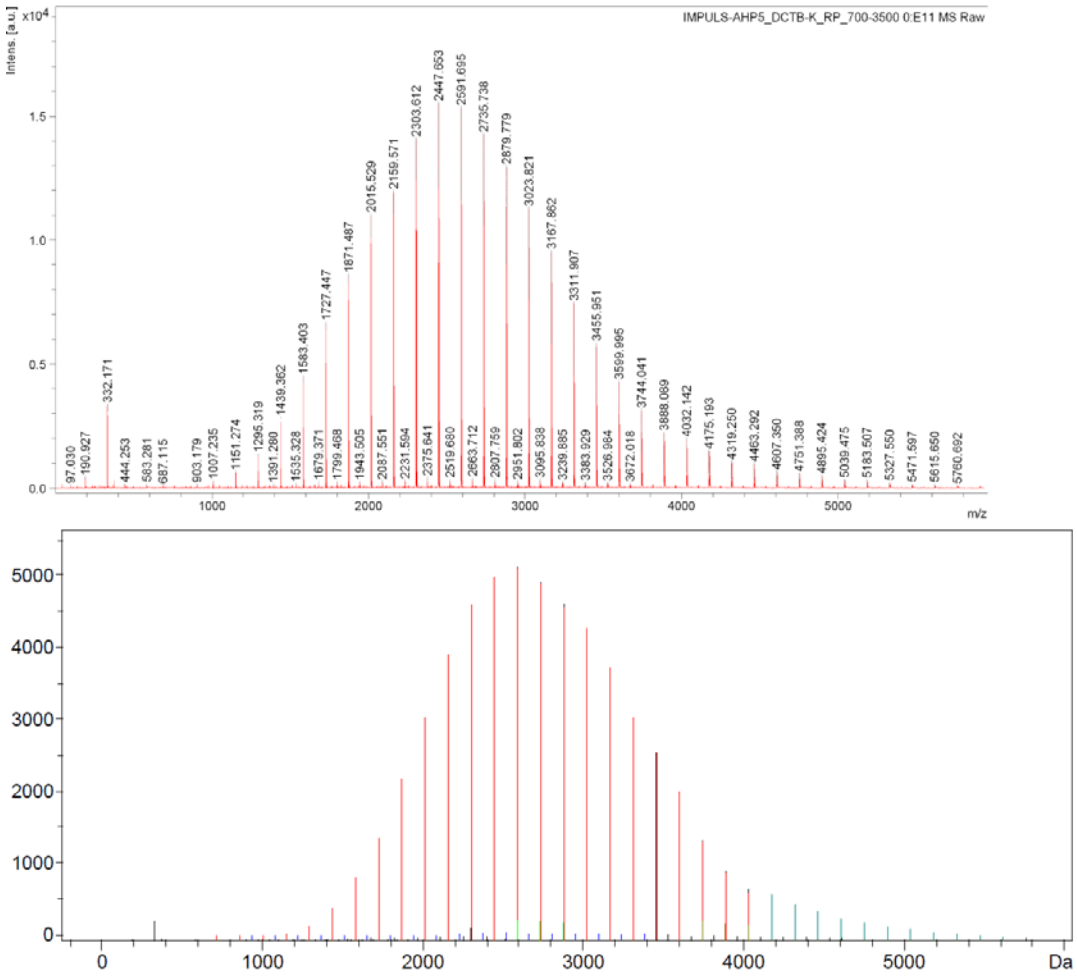
Figure S56. MALDI–TOF spectrum of PLA (2-(4'-Hydroxybenzeneazo)benzoic acid -HABA was used as a matrix) obtained by polymerization of 50 eq of *rac*-LA with **2/DMAP 1:6** as an initiator

(Table 1, entry 4), in toluene at 40˚C, 120h. The distributions refer to PLA with OH and $CH_2CH_2NH^iPr$ end groups and cyclic PLA, with K^+.



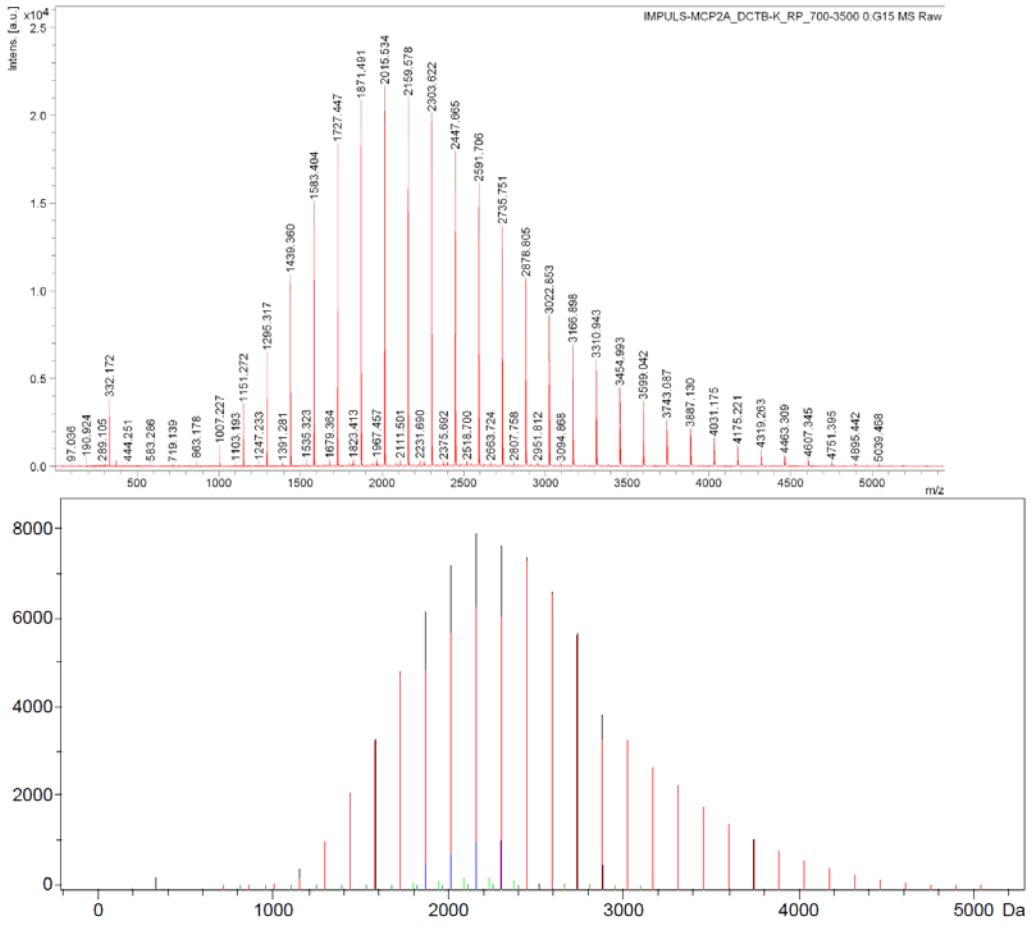
n	ser.	rep.unit	resid.	end1	end2	cation	Mn	Mw	pd	DP	% I.	cnt
1	1	144.039	103.143			38.9637	4353.95	4577.95	1.05145	30.2275	91.6	43
2	2	144.039	135.291			38.9637	4554.36	4642.98	1.01946	31.6189	3.3	17

Figure S57. MALDI–TOF spectrum of PLA (2-(4'-Hydroxybenzeneazo)benzoic acid -HABA was used as a matrix) obtained by polymerization of 50 eq of *rac*-LA with **2/DBU 1:2** as an initiator (Table 1, entry 5), in methylene chloride at -20˚C, 18h. The main distribution refer to PLA with OH and $CH_2CH_2NH^iPr$ end groups, with K^+.



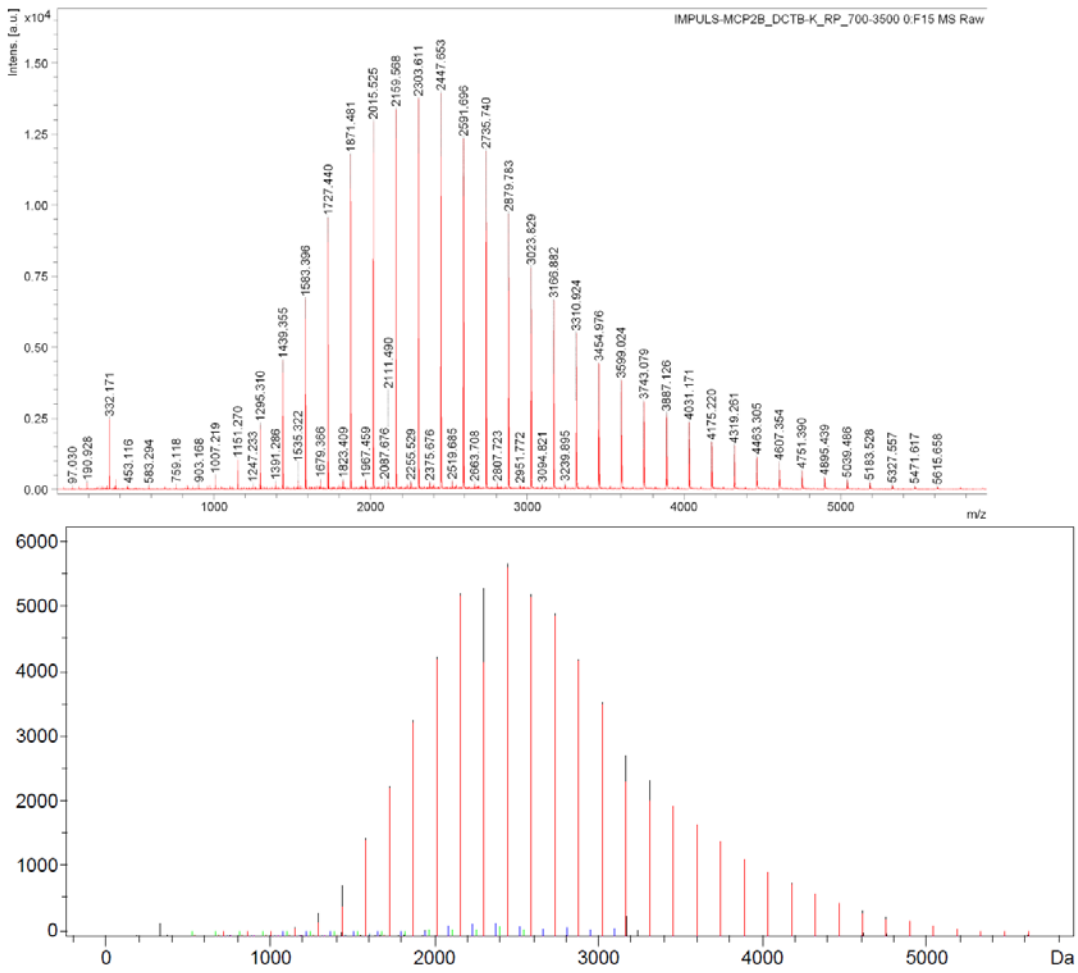
n	ser.	rep.unit	resid.	end1	end2	cation	Mn	Mw	pd	DP	% I.	cnt
1	1	144.039	104.066			38.9637	2665.29	2793.37	1.04806	18.5039	88.2	24
2	2	144.039	32.0397			38.9637	2512.75	2637.20	1.04953	17.4449	1.7	18
3	1	144.039	103.170			38.9637	2694.50	2699.55	1.00187	18.7067	1.2	3
4	3	144.043	103.033			38.9637	4537.01	4568.95	1.00704	31.4975	4.3	11
5	4	144.043	102.050			38.9637	3836.26	3839.84	1.00093	26.6327	1.1	3

Figure S58. MALDI–TOF spectrum of PLA (2-(4'-Hydroxybenzeneazo)benzoic acid -HABA was used as a matrix) PLA obtained by polymerization of 50 eq of *rac*-LA with **[Me$_2$Ga(*μ*-OCH(Me)CO$_2$Me)]$_2$/2** H-**B** as an initiator, in toluene at 70˚C, 24h (Table 2, entry 1). The main distribution refer to PLA with OH, $CH_2CH_2NH^iPr$ and CH(Me)C(O)OMe end groups, with K^+.



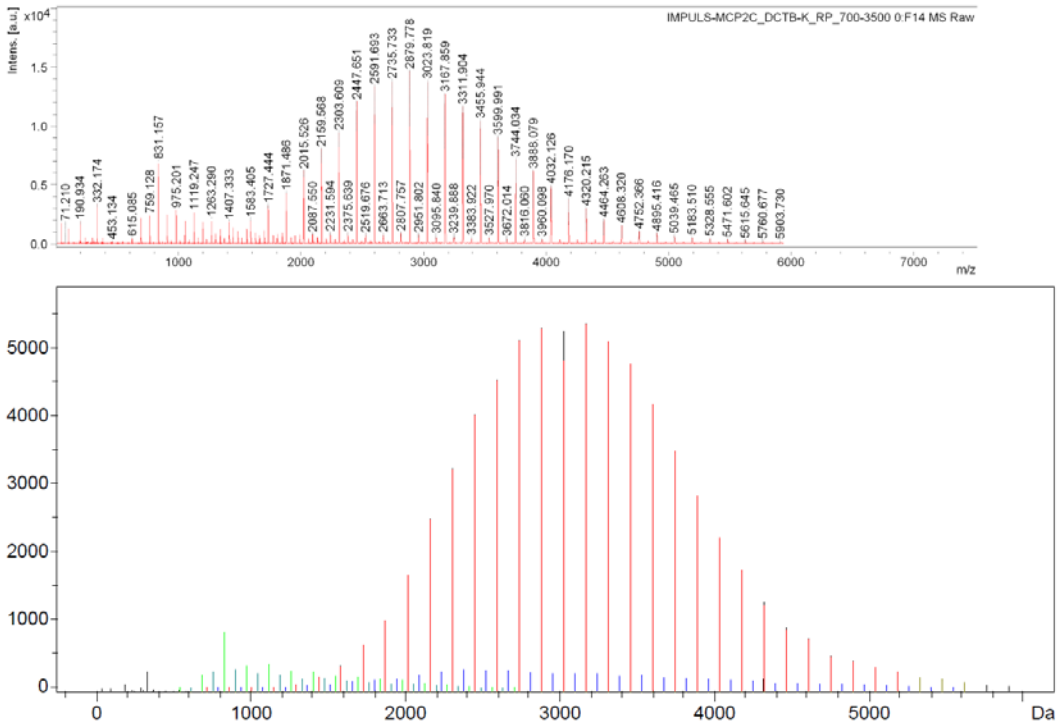
n	ser.	rep.unit	resid.	end1	end2	cation	Mn	Mw	pd	DP	% I.	cnt
1	1	144.037	103.631			38.9637	2401.59	2579.26	1.07398	16.6735	92.1	31
2	2	144.037	102.141			38.9637	2087.18	2098.29	1.00532	14.4906	3.9	4
3	3	144.037	32.2805			38.9637	2075.54	2092.76	1.00830	14.4098	1.1	5
4	4	144.037	55.9930			38.9637	1893.18	1968.89	1.03999	13.1438	0.8	12
5	5	144.037	31.8605			38.9637	2782.88	2791.02	1.00292	19.3207	0.3	4

Figure S59. MALDI–TOF spectrum of PLA (2-(4'-Hydroxybenzeneazo)benzoic acid -HABA was used as a matrix) obtained by polymerization of 50 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OCH(Me)CO_2Me)]_2$/2** H-**B** as an initiator, in toluene at 40˚C, 144h (Table 2, entry 2). The main distribution refer to PLA with OH, $CH_2CH_2NH^iPr$ and CH(Me)C(O)OMe end groups, with K^+.



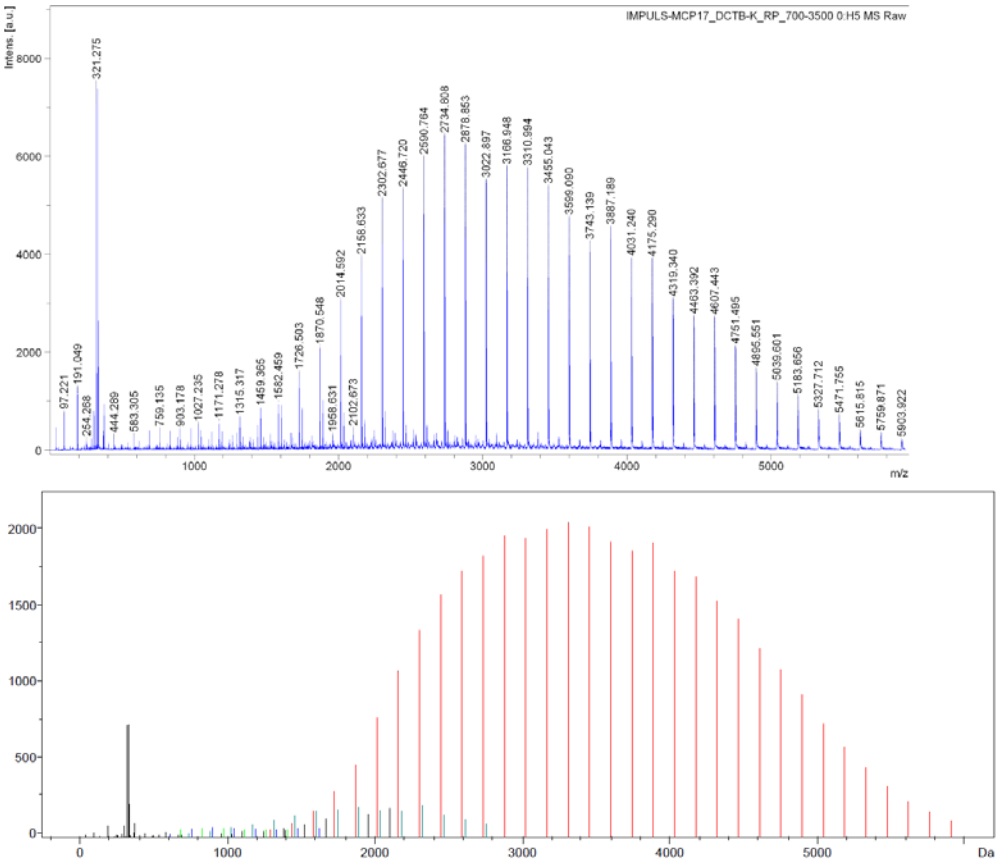
n	ser.	rep.unit	resid.	end1	end2	cation	Mn	Mw	pd	DP	% I.	cnt
1	1	144.037	103.629			38.9637	2659.82	2868.02	1.07827	18.4662	92.7	35
2	2	144.037	32.0976			38.9637	2355.27	2431.29	1.03228	16.3518	2	15
3	3	144.037	55.9364			38.9637	1973.96	2062.43	1.04482	13.7045	1.2	15
4	4	143.880	129.094			38.9637	1225.15	1285.91	1.04960	8.51507	0.1	7
5	5	143.880	73.1390			38.9637	1143.48	1236.10	1.08099	7.94747	0.1	9
6	6	143.880	1.08613			38.9637	1002.85	1043.63	1.04066	6.97001	0	5

Figure S60. MALDI–TOF spectrum of PLA (2-(4'-Hydroxybenzeneazo)benzoic acid -HABA was used as a matrix) obtained by polymerization of 50 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OCH(Me)CO_2Me)]_2$/2** H-**B/piridine 1:6** as an initiator, in toluene at 40˚C, 144h (Table 2, entry 3). The main distribution refer to PLA with OH, $CH_2CH_2NH^iPr$ and CH(Me)C(O)OMe end groups, with K^+.



n	ser.	rep.unit	resid.	end1	end2	cation	Mn	Mw	pd	DP	% I.	cnt
1	1	144.041	103.956			38.9637	3089.37	3256.87	1.05422	21.4479	82.6	32
2	2	144.041	32.0287			38.9637	3075.10	3451.65	1.12245	21.3488	6.9	34
3	3	144.041	71.9979			38.9637	1285.00	1498.84	1.16642	8.92106	4.5	16
4	4	144.041	-0.02182			38.9637	1354.38	1560.94	1.15251	9.40272	2.9	15
5	5	143.986	105.499			38.9637	5413.23	5415.61	1.00044	37.5956	0.6	3

Figure S61. MALDI–TOF spectrum of PLA (2-(4'-Hydroxybenzeneazo)benzoic acid -HABA was used as a matrix) obtained by polymerization of 50 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OCH(Me)CO_2Me)]_2$/2** H-**B/DMAP 1:6** as an initiator, in toluene at 40˚C, 120h (Table 2, entry 4). The main distribution refer to PLA with OH, $CH_2CH_2NH^iPr$ and CH(Me)C(O)OMe end groups, with K^+.



n	ser.	rep.unit	resid.	end1	end2	cation	Mn	Mw	pd	DP	% I.	cnt
1	1	144.045	103.063			38.9637	3481.06	3731.30	1.07188	24.1665	86.3	33
2	2	144.045	-0.06050			38.9637	1124.92	1209.17	1.07489	7.80949	0.9	8
3	3	144.045	71.9644			38.9637	1000.22	1058.17	1.05793	6.94382	0.7	6
4	4	144.045	123.987			38.9637	1865.13	1998.81	1.07167	12.9482	4.3	15

Figure S62. MALDI–TOF spectrum of PLA (2-(4'-Hydroxybenzeneazo)benzoic acid -HABA was used as a matrix) obtained by polymerization of 25 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OC_6H_4OMe)]_2$/2** H-**B** as an initiator, in toluene at 70˚C, 24h (Table 2, entry 5). The main distribution refer to PLA with OH and $CH_2CH_2NH^iPr$ end groups, with K^+.

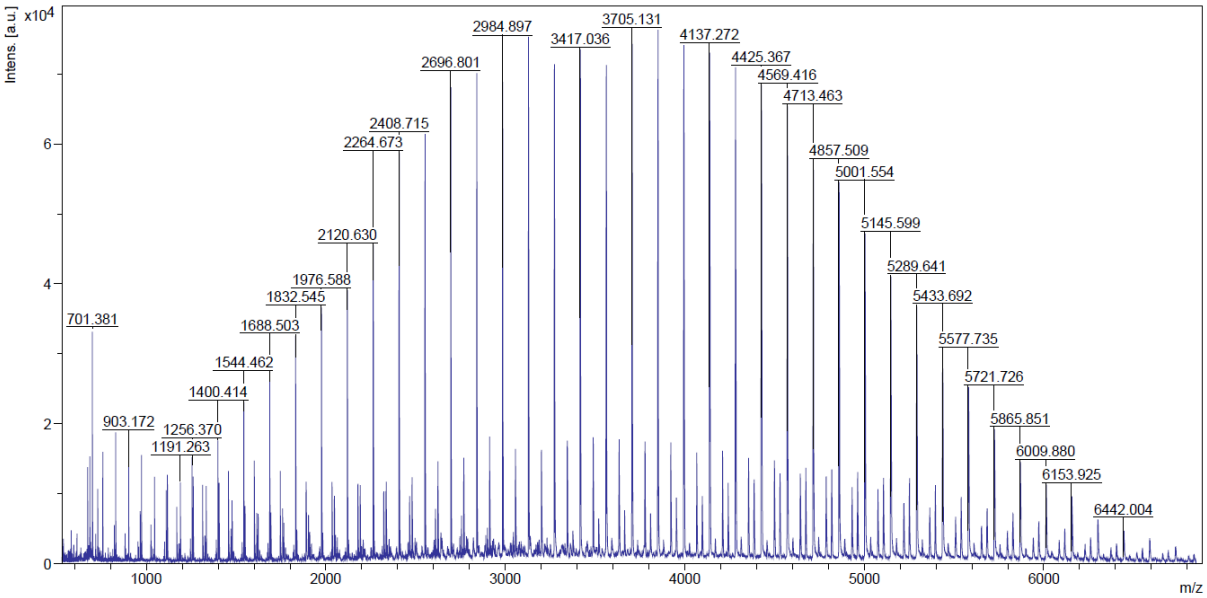


Figure S63. MALDI–TOF spectrum of PLA (2-(4'-Hydroxybenzeneazo)benzoic acid -HABA was used as a matrix) obtained by polymerization of 25 eq of *rac*-LA with **[Me$_2$Ga(μ-OC$_6$H$_4$OMe)]$_2$/2 H-C** as an initiator, in toluene at 40˚C, 240h (Table 2, entry 9). The main distribution refer to PLA with OH and CH(CH$_2$OPh)CH$_2$NH^{i}Pr end groups, with K$^+$.

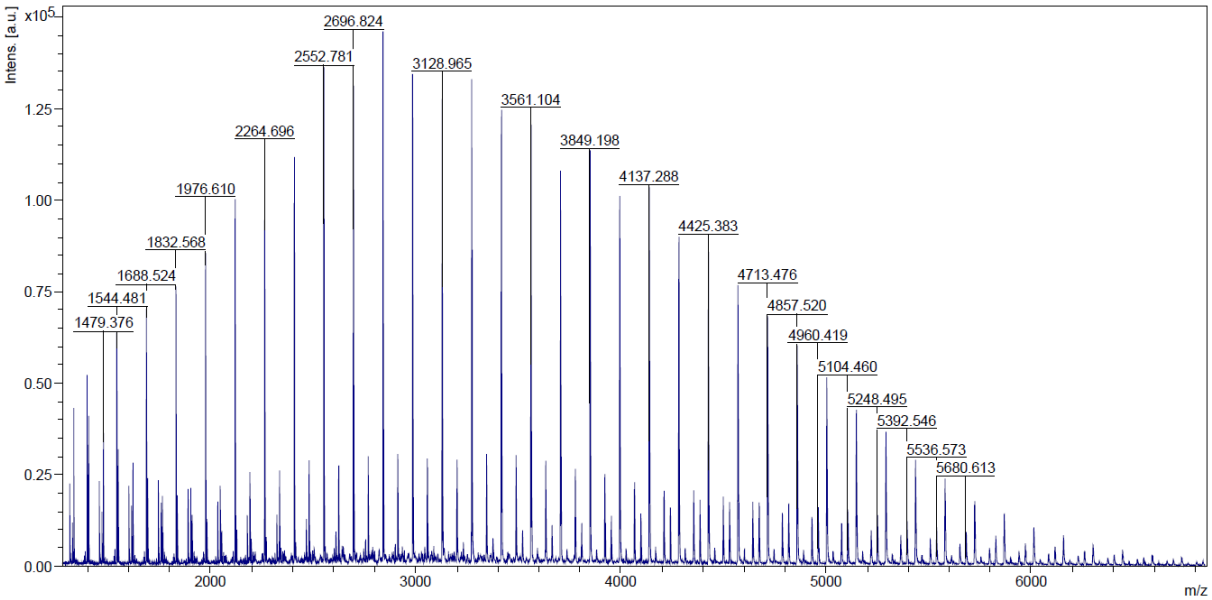


Figure S64. MALDI–TOF spectrum of PLA (2-(4'-Hydroxybenzeneazo)benzoic acid -HABA was used as a matrix) obtained by polymerization of 25 eq of *rac*-LA with **[Me$_2$Ga(μ-OC$_6$H$_4$OMe)]$_2$/2 H-C/piridine 1:6** as an initiator, in toluene at 40˚C, 240h (Table 2, entry 10). The main distribution refer to PLA with OH and CH(CH$_2$OPh)CH$_2$NH^{i}Pr end groups, with K$^+$.

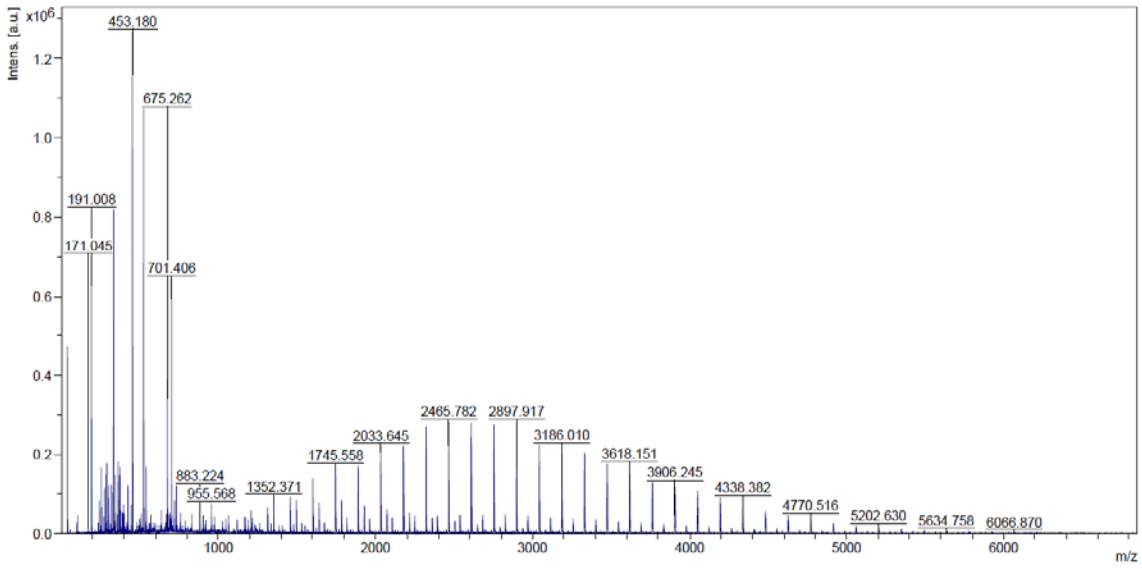


Figure S65. MALDI–TOF spectrum of PLA (2-(4'-Hydroxybenzeneazo)benzoic acid -HABA was used as a matrix) obtained by polymerization of 25 eq of *rac*-LA with **[Me$_2$Ga(μ-OC$_6$H$_4$OMe)]$_2$/atenolol** as an initiator, in toluene at 70˚C, 24h (Table 2, entry 11). The main distribution refer to PLA with OH and atenolol end groups, with K^+.

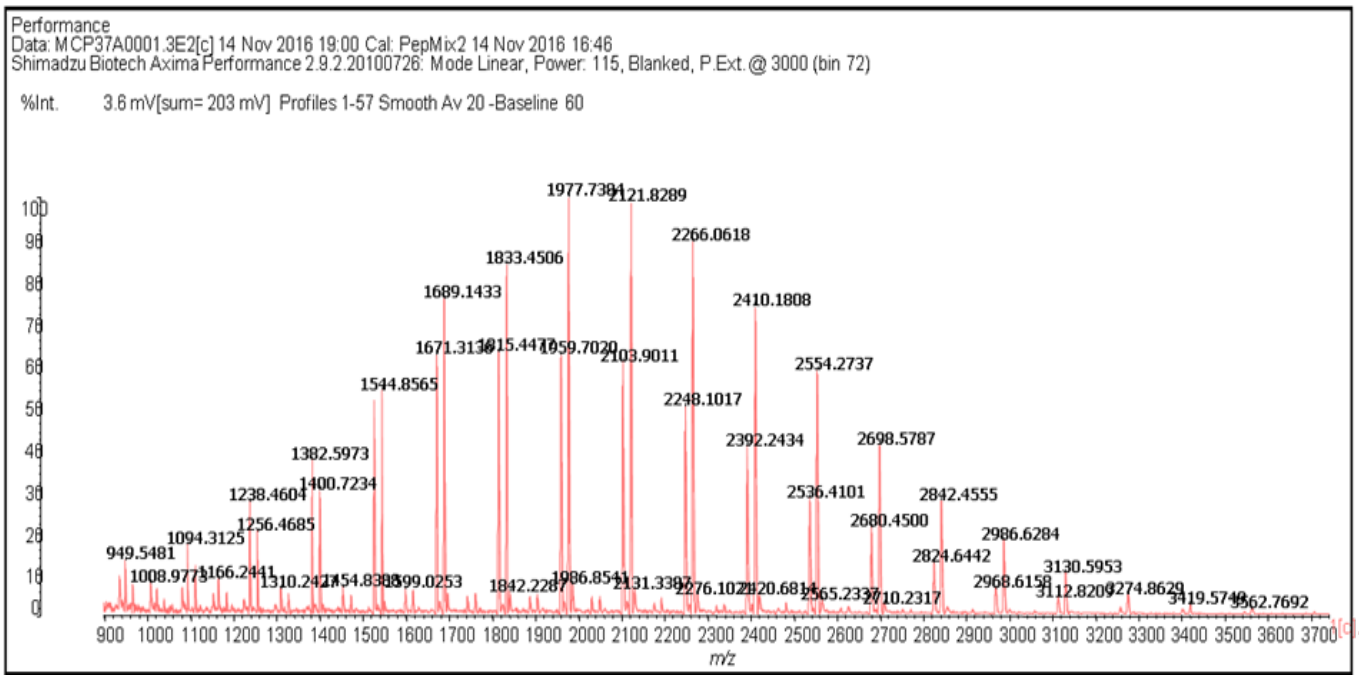


Figure S66 MALDI–TOF spectrum of PLA obtained by polymerization of 25 eq of *rac*-LA with **[Me$_2$Ga((μ-OC$_6$H$_4$OMe)]$_2$/2** H-**B/γ-picoline 1:6** as an initiator, in toluene at 40˚C, 144h (Table 2, entry 7). The main distribution refer to PLA with OH and $CH_2CH_2NH_2$ end groups (due to, most probably side reaction with matrix), with K^+. PDI = 1.53 (based on GPC analysis).

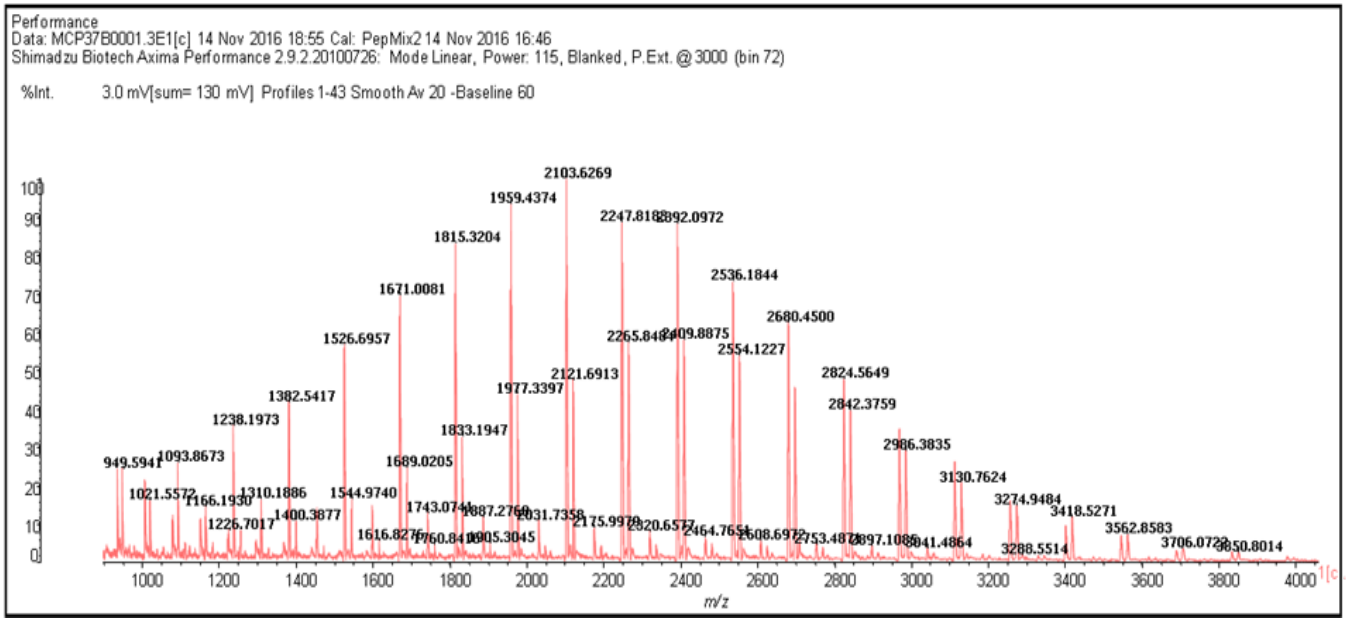


Figure S67 MALDI–TOF spectrum of PLA obtained by polymerization of 25 eq of *rac*-LA with **[$Me_2Ga((\mu\text{-}OC_6H_4OMe)]_2$/2** H-**B/γ-picoline 1:60** as an initiator, in toluene at 40˚C, 144h (Table 2, entry 8). The main distribution refer to PLA with OH and $CH_2CH_2NH_2$ end groups (due to, most probably side reaction with matrix), with K^+. PDI = 1.46 (based on GPC analysis).

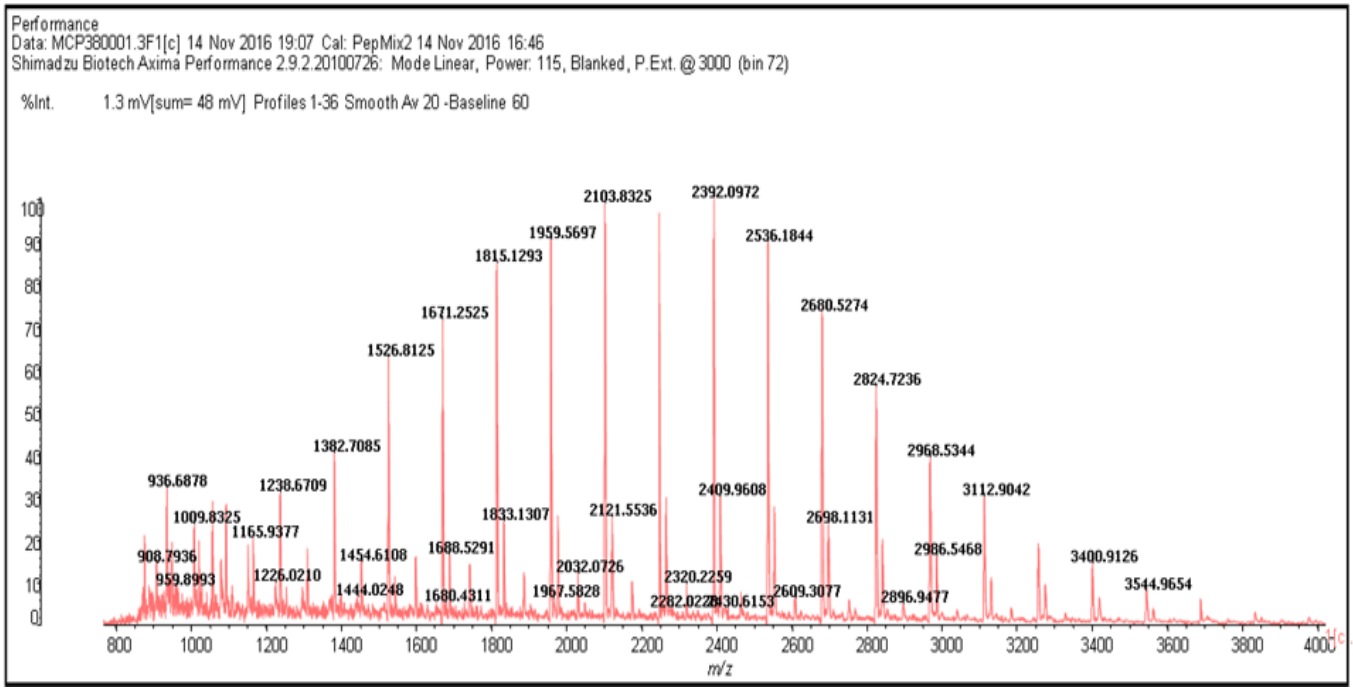


Figure S68 MALDI–TOF spectrum of PLA obtained by polymerization of 25 eq of *rac*-LA with **[$Me_2Ga((\mu\text{-}OC_6H_4OMe)]_2$/2** H-**B/γ-pyridine 1:60** as an initiator, in toluene at 40˚C, 144h (Table 2, entry 6). The main distribution refer to PLA with OH and $CH_2CH_2NH_2$ end groups (due to, most probably side reaction with matrix), with K^+. PDI = 1.43 (based on GPC analysis).

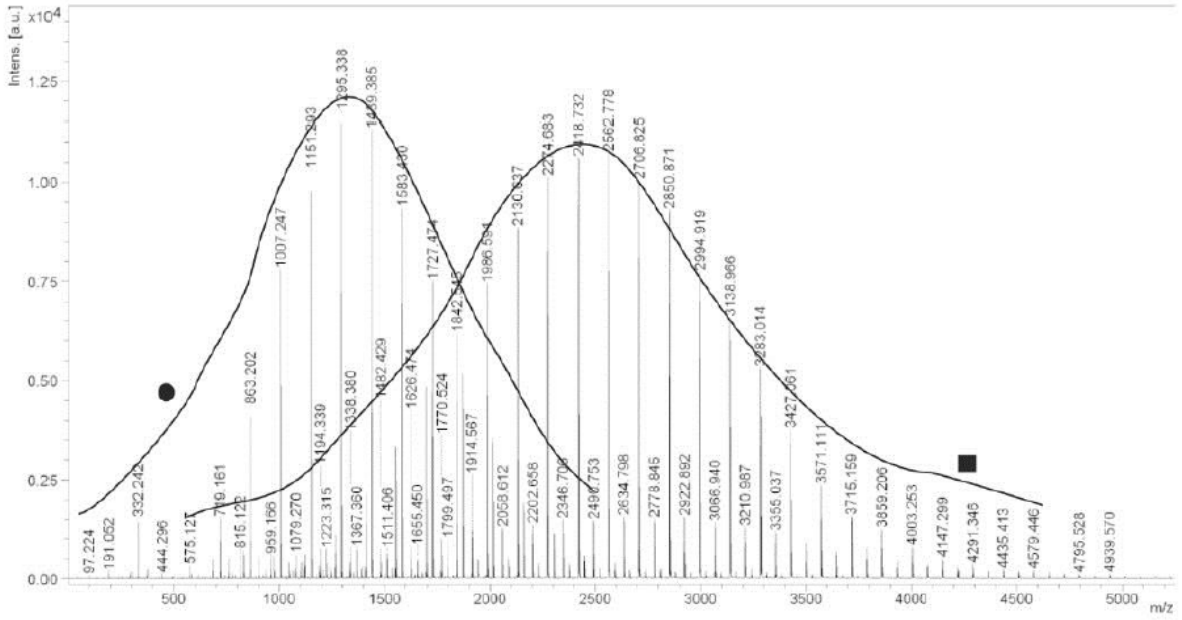


Figure S69. MALDI–TOF spectrum of PLA (2-(4'-Hydroxybenzeneazo)benzoic acid -HABA was used as a matrix) obtained by polymerization of 25 eq of *rac*-LA with **[Me$_2$Ga(*μ*-OCH(Me)CO$_2$Me)]$_2$/2** H-**A** as an initiator, in toluene at 70˚C, 22h. The main distribution refer to PLA with OH, CH_2CH_2NHMe and CH(Me)C(O)OMe end groups, with K^+. PDI = 1.37 (based on GPC analysis).

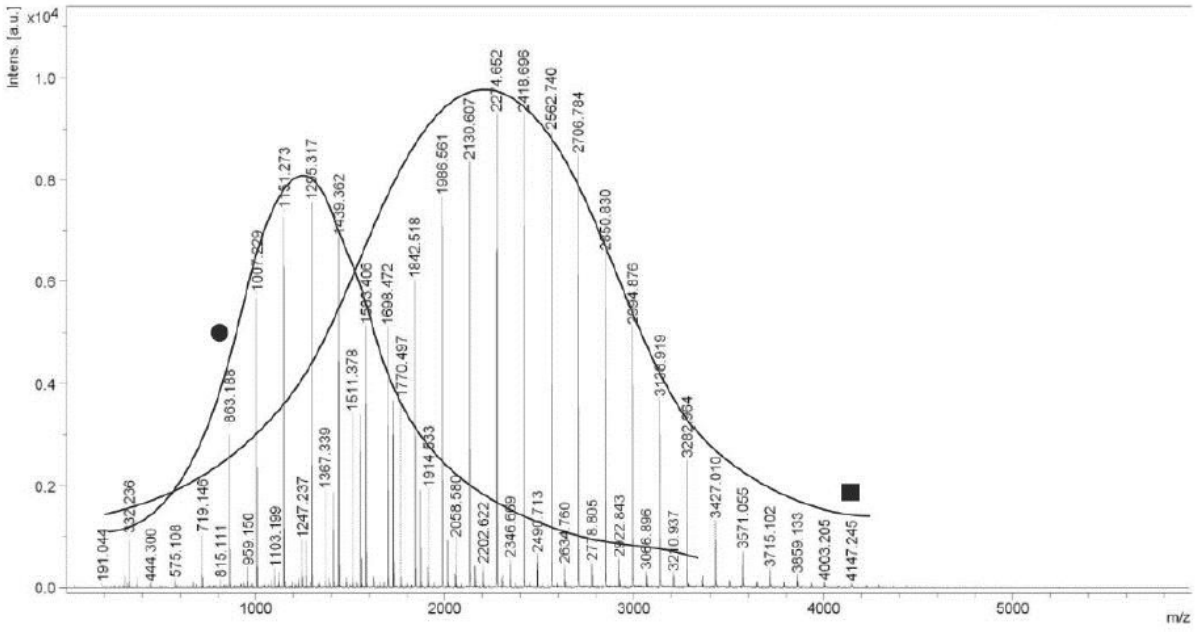
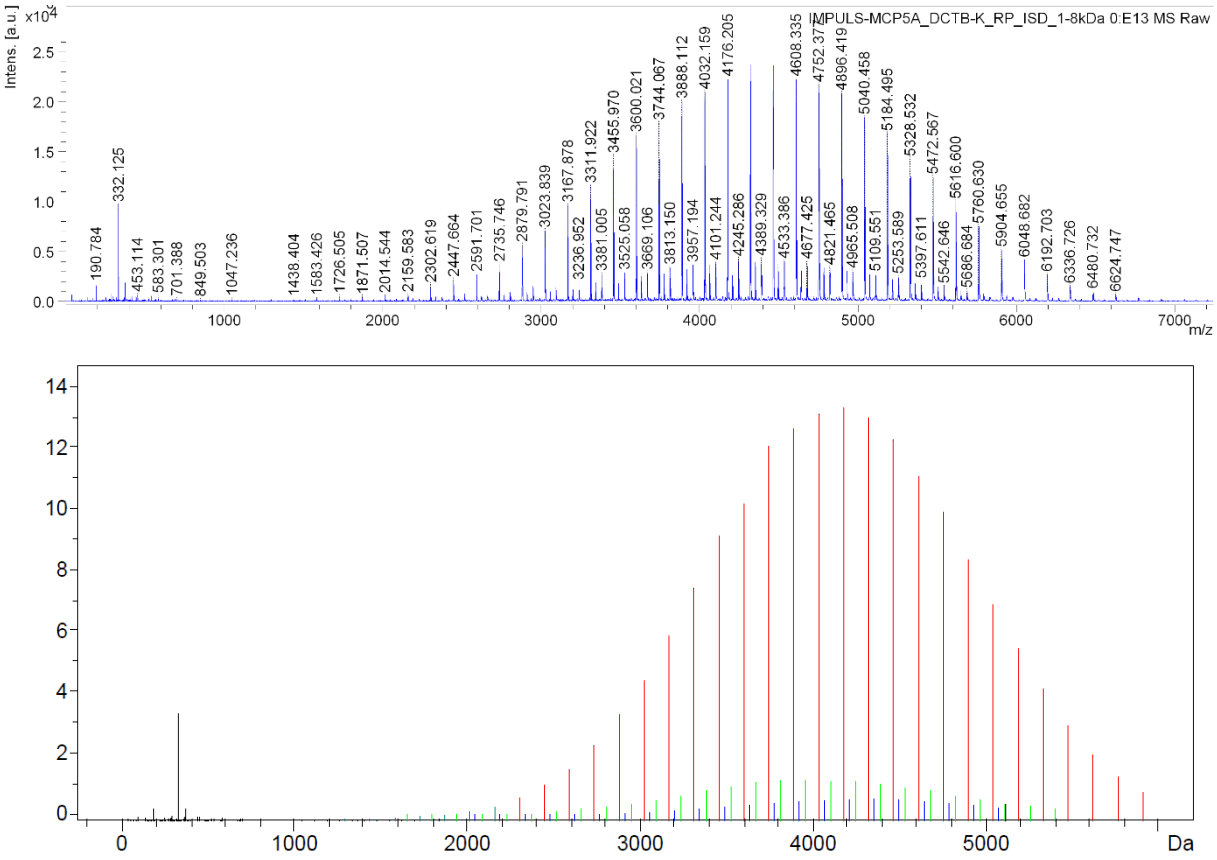
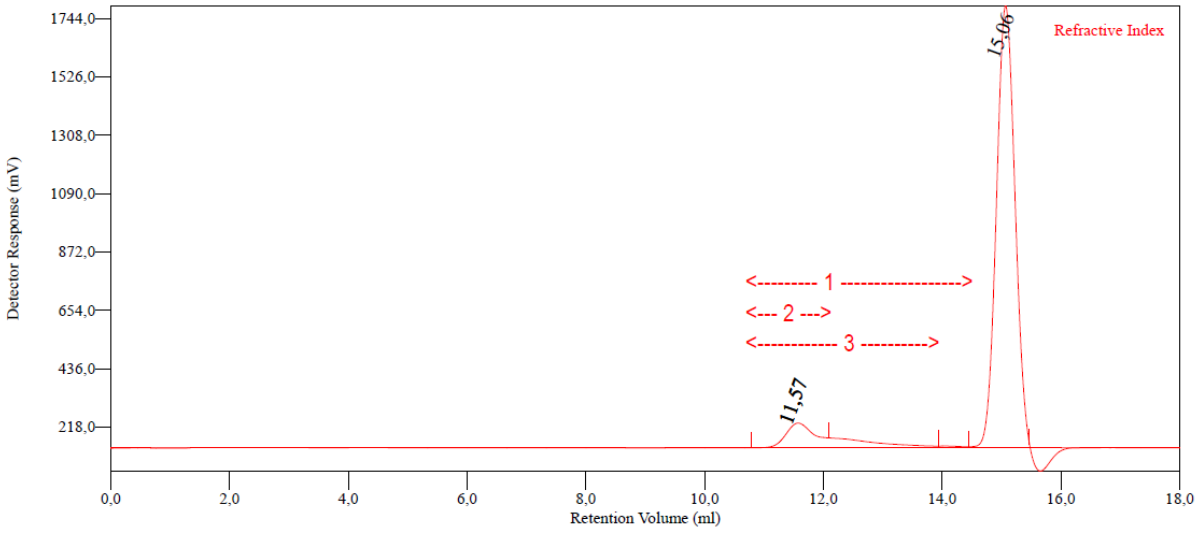


Figure S70. MALDI–TOF spectrum of PLA (2-(4'-Hydroxybenzeneazo)benzoic acid -HABA was used as a matrix) obtained by polymerization of 25 eq of *rac*-LA with **[Me$_2$Ga(*μ*-OCH(Me)CO$_2$Me)]$_2$/2** H-**A** as an initiator, in toluene at 40˚C, 168h. The main distribution refer to PLA with OH, CH_2CH_2NHMe and CH(Me)C(O)OMe end groups, with K^+. PDI = 1.33 (based on GPC analysis).



n	ser.	rep.unit	resid.	end1	end2	cation	Mn	Mw	pd	DP	% I.	cnt
1	1	144.043	104.027			38.9637	4105.23	4234.18	1.03141	28.5001	83.5	27
2	2	144.043	135.166			38.9637	3943.59	4072.64	1.03272	27.3779	4	22
3	3	144.043	29.2344			38.9637	3889.23	4042.45	1.03940	27.0005	8.3	27
4	4	144.043	103.038			38.9637	1894.15	1925.55	1.01658	13.1499	0.5	7

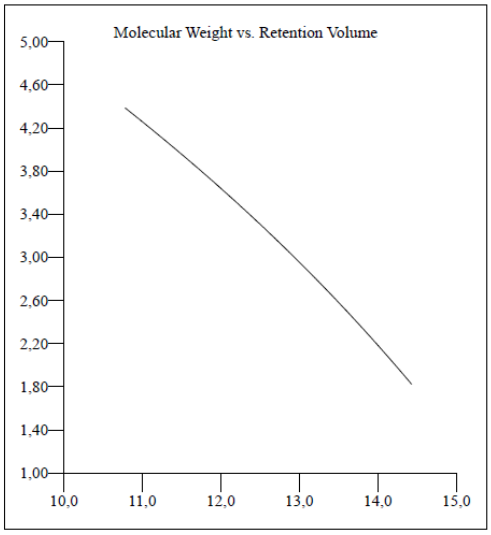
Figure S71. MALDI–TOF spectrum of PLA (2-(4'-Hydroxybenzeneazo)benzoic acid -HABA was used as a matrix) obtained by polymerization of 50 eq of *rac*-LA with **[$Me_2Ga(\mu$-$OCH(Me)CO_2Me)]_2$/2** H-**B/2 DBU** as an initiator, in methylene chloride at -20˚C, 6h. The main distribution refer to PLA (P_r = with OH, $CH_2CH_2NH^iPr$ and CH(Me)C(O)OMe end groups, with K^+.



Conventional Calibration - Homopolymers : Results

	<1>	<2>	<3>	
Peak RV - (ml)	11,567	11,567	11,570	15,057
Mn - (Daltons)	1 302	7 175	1 986	0
Mw - (Daltons)	5 274	7 926	5 420	0
Mz - (Daltons)	7 878	8 724	7 853	0
Mp - (Daltons)	8 196	8 188	8 168	0
Mw / Mn	4,048	1,105	2,728	0,000
Percent Above Mw: 0	100,000	100,000	100,000	0,000
Percent Below Mw: 0	0,000	0,000	0,000	0,000
Mw 10.0% Low	296	4 305	471	0
Mw 10.0% High	11 913	12 846	11 910	0
Wt Fr (Peak)	0,393	0,226	0,381	0,000
RI Area - (mvml)	88,92	51,13	86,18	597,88
UV Area - (mvml)	0,00	0,00	0,00	0,00

Annotation	
Method File	CC_PS_RI_frm_2016-01-0003.vcm
Limits File	
Date Acquired	Jan 22, 2016 - 12:17:58
Solvent	Chlorek metylenu
Acquisition Operator	admin : Administrator
Calculation Operator	ap : Andrzej Plichta (5632)
Column Set	Jordi DVB G+MB
System	TDA G+MB
Flow Rate - (ml/min)	1,000
Inj Volume - (ul)	65,0
Volume Increment - (ml)	0,00333
Detector Temp. - (deg C)	30,0
Column Temp. - (deg C)	30,0
OmniSEC Build Number	406



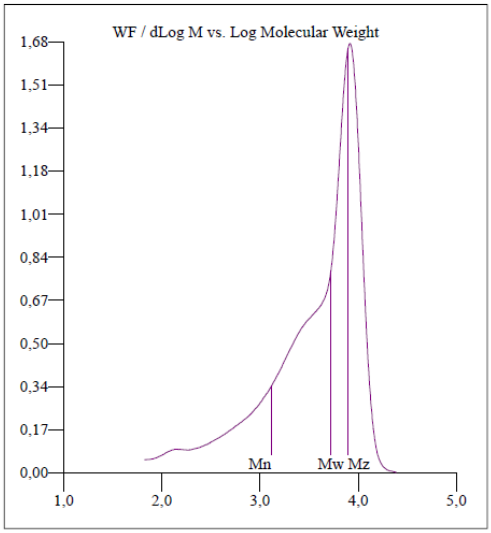


Figure S72. GPC data for PLA obtained by polymerization of 50 eq of *rac*-LA with **[Me$_2$Ga(μ-OCH(Me)CO$_2$Me)]$_2$/2** H-**B/2 DBU** as an initiator, in methylene chloride at -20˚C, 6h.

Crystal structure determination

Single crystals suitable for X-ray diffraction studies were selected under a polarizing microscope, mounted in inert oil and transferred to the Oxford Diffraction κ-CCD Gemini A Ultra diffractometer. Cell refinement and data collection as well as data reduction and analysis were performed with the CRYSALIS^{PRO} software.[2]. Using Olex2 [3], the structures were solved with ShelXT[4] structure solution program and refined with the ShelXL−2014[5] refinement package using Least Squares minimization. The crystal data and experimental parameters are summarized in Table S1, Supporting information. CCDC1569393-CCDC1569395 contain the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif.

Table S1 Crystal data and structure refinement details

Compound	**1**	**2**	**3**
Chemical formula	$C_{10}H_{28}Ga_2N_2O_2$	$C_{14}H_{36}Ga_2N_2O_2$	$C_{28}H_{48}Ga_2N_2O_4$
Formula Mass	347.78	403.89	616.12
Crystal system	monoclinic	monoclinic	monoclinic
a/Å	6.6946(3)	6.4969(2)	21.4049(7)
b/ Å	10.7516(5)	13.5023(4)	8.2553(3)
c/ Å	11.4183(5)	11.1683(4)	18.0932(5)
α/°	90	90	90
β/°	95.446(4)	95.288(3)	100.559(3)
γ/°	90	90	90
Unit cell volume/ Å^3	818.15(6)	975.55(5)	3143.00(18)
Temperature/K	120.0(1)	120.0(1)	293(1)
Space group	*P*21/*n*	*P*21/*n*	*C*2/*c*
No. of formula units per unit cell, *Z*	2	2	4
Radiation type	MoKα	MoKα	MoKα
Absorption coefficient, μ/mm^{-1}	3.285	2.765	1.746
No. of reflections measured	6987	15974	16888
No. of independent reflections	1672	2331	3096
R_{int}	0.0564	0.0438	0.0222
Final R_1 values ($I > 2\sigma(I)$)	0.0356	0.0206	0.0221

Final $wR(F^2)$ values ($I > 2\sigma(I)$)	0.0912	0.0508	0.0584
Final R_1 values (all data)	0.0419	0.0244	0.0269
Final $wR(F^2)$ values (all data)	0.0984	0.0526	0.0620
Goodness of fit on F^2	1.147	1.071	1.063
CCD number	CCDC1569393	CCDC1569394	CCDC1569395

[1] P. Horeglad, P. Kruk and J. Pécaut, *Organometallics*, 2010, **29**, 3729.
[2] CRYSALIS^{PRO} Software system, Rigaku, Oxford, UK, 2016
[3] O. V. Dolomanov, L. J. Bourhis, R. J. Gildea, J. A. K. Howard, H. Puschmann, *J. Appl. Cryst.*, 2009, **42**, 339-341
[4] G. M. Sheldrick, *Acta Cryst.*. 2015, **A71**, 3-8
[5] Sheldrick, G.M. *Acta Cryst.*, 2015, **C71**, 3-8