Preparation of Polypeptide via Living Polymerization of *Z*-Lys-NCA Initiated by Platinum Complexes

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Received November 20, 2007; Revised Manuscript Received February 22, 2008

ABSTRACT: Two novel platinum complexes, [bis(diphenylphosphino)ethane][*N*-((1*S*,2*R*)-2-hydroxo-1,2-diphenylethyl)-4-methyl-benzenesulfonamidato]platinum(II) [(dppe)Pt(MBS−O), **2a]** and [bis(diphenylphosphino)-ethane][*N*-((1*S*,2*R*)-2-amido-1,2-diphenylethyl)-4-methylbenzenesulfonamidato]platinum [(dppe)Pt(MBS−NH), **2b**] were synthesized and structurally characterized. Experimental results show that compound **2b** is an efficient initiator toward ring opening polymerization of amino acid *N*-carboxyanhydride (NCA) yielding polypeptides with narrow PDIs (1.07−1.19). By comparing the activity of complex **2a** with that of **2b**, the mechanism for polymerization of NCA initiated by an amido−sulfonamidate is proposed.

Introduction

Due to their tremendously outstanding properties such as self-assembly and formation of liquid crystals, as well as biodegradability and biocompatibility, polypeptides and their copolymers are highly useful materials.[1] Their applications such as bionics, nanotech and drug delivery of polypeptide materials have been published.[2] Although a new route to polypeptide without amino acid *N*-carboxyanhydride (NCA) monomers has been reported,[3] most synthesized polypeptides are obtained via ring-opening polymerization (ROP) of NCAs initiated by suitable initiators.[4] Among these initiators, the first efficient one for the living polymerization of NCA is neutral [Ni(cod)$_2$] reported by T. J. Deming in 1997.[5] Recently, Co, Fe, Pd, Pt, Ru, Ir, and Al complexes have also been shown to be active initiators for NCA polymerization.[6–8] Even though [Pd(cod)$_2$] and [Pt(cod)$_2$] are active toward NCA polymerization, they are inefficient in living polymerization of NCA, making the molecular weight of polypeptide difficult to control.[7] Since no successful Pt complex for living ROP reaction of NCA has been reported, developing an effective Pt complex for the living NCA polymerization has drawn our attention. Most recently, Deming and his co-workers have reported two Ru and Ir complexes coordinated by amido−sulfonamidate ligand and these complexes have been demonstrated as efficient initiators for living ROP of NCA.[8] We report herein the syntheses and characterization of two platinum complexes **2a** and **2b**; investigation of their activities of two complexes toward ring-opening polymerization of N_ξ-carbobenzyloxy-L-lysine *N*-carboxylic anhydride (*Z*-Lys-NCA). Also, we propose a mechanism for the ROP reaction of *Z*-Lys-NCA initiated by the Pt complexes.

Experimental Section

General Data. All manipulations were carried out under a dry nitrogen atmosphere. Solvents and deuterated solvents were purified prior to use. (1*R*,2*S*)-2-Aminodiphenylethanol (99%), sodium azide (NaN_3, 99.5%), lithium diisopropyl amide (LDA, 2.0 M, dissolved in tetrahydrofuran (THF)), potassium platinum(II) tetrachloride, bis(diphenylphosphino)ethane (dppe, 97%), silver carbonate (Ag_2CO_3, 99%), and tribromophosphine (PBr_3, 99%) were purchased from Aldrich Co. and used without further purification. *p*-Toluenesulfonyl chloride (TsCl, 99%) and methane sulfonyl chloride (MsCl, 99.5%) were obtained from Acros Co. and purified by recrystallization from a toluene solution before using. N_ξ-carbobenzyloxy-*L*-lysine (*Z*-Lys, 98%) was bought from Fluka Co. and used without purification. Poly *Z*-Lys standard[5], N_ξ-carbobenzyloxy-*L*-lysine *N*-carboxyanhydride[9] (*Z*-Lys-NCA) monomer, *N*-((1*S*,2*R*)-2-hydroxy-1,2-diphenylethyl)-4-methylbenzenesulfonamide (MBS−OH, **1a**),[10] *N*-((1*S*,2*R*)-2-amino-1,2-diphenylethyl)-4-methylbenzenesulfonamide (MBS−NH$_2$, **1b**),[10] Bis(diphenylphosphino)ethane platinum chloride [(dppe)Pt(Cl$_2$)],[11] and bis(diphenylphosphino)ethane platinum carbonate [(dppe)Pt(CO$_3$)][12] were prepared according to their respective literature methods. ^{1}H (400 MHz) and ^{13}C (100 MHz) NMR spectra were recorded on a Varian Mercury-400 spectrometer with chemical shifts given in ppm from the internal tetramethylsilane (TMS) standard. ^{31}P (162 MHz) spectra were recorded on a Varian Mercury-400 spectrometer with 85% H_3PO_4 as an external reference. Elemental analyses were performed using a Heraeus CHN-ORAPID instrument. Infrared spectra were obtained from a Bruker Equinox 55 spectrometer. The gel permeation chromatography (GPC) measurements were performed on a Postnova PN1122 system equipped with a differential Viscotech Model 200 RI detector using dimethylforamide (DMF) (HPLC grade) as an eluent (flow rate: 1 mL·min^{-1}) and working temperature at 30 °C. The chromatographic column was Phenomenex Phenogel 5 μ 103 Å, Serial No. 228275-1 with weight average molecular weight (M_w) in the range 1000−75000 and a column size of 300 × 7.8 mm. Molecular weight and molecular weight distributions were calculated using poly(*Z*-lysine) as a standard.

Synthesis of (dppe)Pt[N(SO$_2$-*p*-MeC$_6$H$_4$)C(H)(Ph)C(H)(Ph)O] [(dppe)Pt(MBS−O), 2a]. A CH_2Cl_2 (20 mL) solution of (dppe)Pt-(CO_3) (326.5 mg, 0.5 mmol) was added to a suspension of compound **1a** (183.7 mg, 0.5 mmol) in CH_2Cl_2 (20 mL). The mixture was stirred at room temperature for 28 h under a nitrogen gas flow system to allow the removing of CO_2. The volatile materials were then removed under vacuum yielding white solid. The residue was then purified by recrystallization from a mixture of CH_2Cl_2/Et_2O giving **2a**. Yield: 388.4 mg (81%). ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.29 (m, 2H, *p*-toluenesulfonyl, H2), 8.09 (m, 2H, *p*-toluenesulfonyl, H3), 7.98 (m, 2H, P(*Ph*)$_2$), 7.88 (m, 2H, P(*Ph*)$_2$), 7.46 (m, 6H, P(*Ph*)$_2$), 7.32 (m, 6H, P(*Ph*)$_2$), 7.10 (m, 2H, P(*Ph*)$_2$), 7.05 (m, 2H, P(*Ph*)$_2$), 6.99 (m, 2H, HC(*Ph*)NTs), 6.86 (m, 2H, HC(*Ph*)O), 6.81 (m, 3H, HC(*Ph*)O), 6.69 (m, 2H, HC(*Ph*)NTs), 6.62 (m, 1H, HC(*Ph*)NTs), 5.80 (d, J_{Pt-H} = 45.6 Hz, 1H, *H*C(Ph)NTs), 4.26 (d, J_{Pt-H} = 45.6 Hz, 1H, *H*C(Ph)O), 2.62 (m, 1H, (Ph$_2$P)C*H*H′CH$_2$(PPh$_2$)), 2.54 (m, 1H, (Ph$_2$P)CH*H*′CH$_2$-(PPh$_2$)), 2.11 (s, 3H, CH$_3$), 1.72 (m, 1H, (Ph$_2$P)CH$_2$C*H*H′(PPh$_2$)), 1.43 (m, 1H, (Ph$_2$P)CH$_2$CH*H*′(PPh$_2$)). ^{13}C NMR (100 MHz, $CDCl_3$): δ 139.9 (*p*-toluenesulfonyl, C4), 139.5 (*p*-toluenesulfonyl, C1), 135.2

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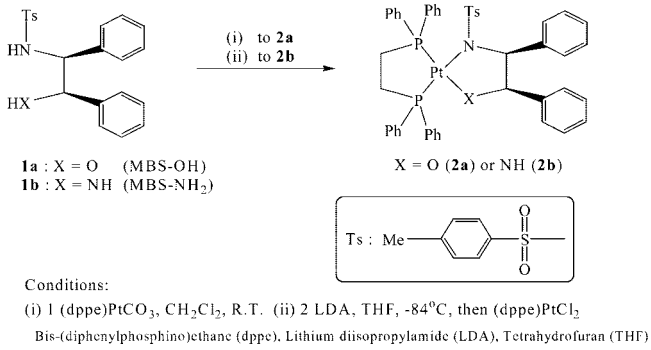
10.1021/ma7025836 CCC: $40.75
Published on Web 04/26/2008

Scheme 1. Preparation of Complexes 2a and 2b



(HC(*Ph*)NTs), 135.1 (HC(*Ph*)O), 133.4 (HC(*Ph*)O), 133.3 (HC(*Ph*)-NTs), 133.2 (HC(*Ph*)O), 132.8 (HC(*Ph*)NTs), 132.7 (HC(*Ph*)O), 131.3 (HC(*Ph*)NTs), 131.2 (P(*Ph*$_2$), 130.3 (*p*-toluenesulfonyl, C3), 129.1 (P(*Ph*$_2$), 128.9 (P(*Ph*$_2$), 128.8 (P(*Ph*$_2$), 128.7 (P(*Ph*$_2$), 128.6 (P(*Ph*$_2$), 128.2 (P(*Ph*$_2$), 128.1 (P(*Ph*$_2$), 128.0 (P(*Ph*$_2$), 127.9 (P(*Ph*$_2$), 127.7 (P(*Ph*$_2$), 127.1 (P(*Ph*$_2$), 126.8 (P(*Ph*$_2$), 125.7 (P(*Ph*$_2$), 125.0 (*p*-toluenesulfonyl, C2), 90.4 (H*C*(Ph)NTs), 71.7 (H*C*(Ph)O), 65.9 (CH_3), 21.0 ((Ph$_2$P)*C*H$_2$CH$_2$(PPh$_2$)), 15.2 ((Ph$_2$P)CH$_2$*C*H$_2$(PPh$_2$)). ^{31}P NMR (162 MHz, $CDCl_3$): δ34.9 (d, J_{P-P} = 12.21 Hz, J_{Pt-P} = 3499 Hz), 33.8 (d, J_{P-P} = 12.21 Hz, J_{Pt-P} = 3321 Hz). Anal. Calcd for $C_{47}H_{44}N_2O_2P_2PtS\cdot CH_2Cl_2$: C, 55.23; H, 4.35; N, 1.34. Found: C, 55.25; H, 4.20; N, 1.32. Mp: 231−233 °C dec.

Synthesis of (dppe)Pt[N(SO$_2$-4-CH$_3$C$_6$H$_4$)C(H)(Ph)C(H)(Ph)-NH], [(dppe)Pt(MBS−NH)] (2b). A solution of compound **1b** (366.5 mg, 1.00 mmol) in THF (50 mL) was cooled to −84 °C, and lithium diisopropylamide (LDA) (1.1 mL, 2.2 mmol) was added. The mixture was stirred at this temperature for 1 h and then warmed up to room temperature slowly and was then stirred for another 2 h. All volatile materials were removed under vacuum, giving a white powder. The resulting powder was then mixed with (dppe)$PtCl_2$ (664.4 mg, 1.00 mmol), and THF (30 mL) was added to the previous mixture. The resulting solution was stirred at room temperature under an atmosphere N_2 gas for 48 h. All volatile substances were evaporated to dryness *in vacuo*, yielding a white solid. The solid was then washed with Et_2O (30 mL) three times and was then dried under vacuum. The resulting residue was recrystallized from a mixed solvent of THF/Et_2O/CH_2Cl_2 at room temperature. Yield: 402.3 mg (42%). ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.30 (m, 2H, *p*-toluenesulfonyl, H2), 8.11 (m, 2H, *p*-toluenesulfonyl, H3), 8.01 (m, 2H, P(*Ph*$_2$), 7.88 (m, 2H, P(*Ph*$_2$), 7.51 (m, 6H, P(*Ph*$_2$), 7.38 (m, 6H, P(*Ph*$_2$), 7.13 (m, 2H, P(*Ph*$_2$), 7.10 (m, 2H, P(*Ph*$_2$), 7.02 (m, 2H, HC(*Ph*)NTs), 6.90 (m, 2H, HC(*Ph*)O), 6.87 (m, 3H, HC(*Ph*)O), 6.71 (m, 2H, HC(*Ph*)NTs), 6.68 (m, 1H, HC(*Ph*)NTs), 5.82 (d, J_{Pt-H} = 45.2 Hz, 1H, HCNTs), 4.31 (d, J_{Pt-H} = 45.2 Hz, 1H, CH), 2.70 (m, 1H, C(Ph$_2$P)-C*H*H′CH$_2$(PPh$_2$)), 2.61 (m, 1H, C(Ph$_2$P)CH*H*′CH$_2$(PPh$_2$)), 2.16 (s, 3H, CH_3), 1.78 (m, 1H, (Ph$_2$P)CH$_2$C*H*H′(PPh$_2$)), 1.43 (m, 1H, C(Ph$_2$P)CH$_2$CH*H*′(PPh$_2$)). ^{13}C NMR (100 MHz, $CDCl_3$): δ140.8 (*p*-toluenesulfonyl, C4), 140.6 (*p*-toluenesulfonyl, C1), 136.7 (HC(*Ph*)NTs), 136.4 (HC(*Ph*)NH), 135.6 (HC(*Ph*)NH), 135.4 (HC-(*Ph*)NTs), 135.1 (HC(*Ph*)NH), 134.7 (HC(*Ph*)NTs), 134.4 (HC(*Ph*)-NH), 133.1 (HC(*Ph*)NTs), 133.0 (P(*Ph*$_2$), 131.4 (P(*Ph*$_2$), 130.4 (*p*-toluenesulfonyl, C3), 129.9 (P(*Ph*$_2$), 129.8 (P(*Ph*$_2$), 129.7 (P-(*Ph*$_2$), 129.5 (P(*Ph*$_2$), 129.3 (P(*Ph*$_2$), 129.2 (P(*Ph*$_2$), 129.0 (P(*Ph*$_2$), 128.7 (P(*Ph*$_2$), 128.6 (P(*Ph*$_2$), 128.0 (P(*Ph*$_2$), 127.6 (P(*Ph*$_2$), 126.6 (P(*Ph*$_2$), 126.1 (*p*-toluenesulfonyl, C2), 90.7 (H*C*(Ph)NTs), 71.9 (H*C*(Ph)NH), 66.2 (CH_3), 21.2 ((Ph$_2$P)-*C*H$_2$CH$_2$(PPh$_2$)), 16.1 ((Ph$_2$P)CH$_2$*C*H$_2$(PPh$_2$)). ^{31}P NMR (162 MHz, $CDCl_3$): δ 35.1 (d, J_{P-P} = 12.15 Hz, J_{Pt-P} = 3515 Hz), 34.0 (d, J_{P-P} = 12.15 Hz, J_{Pt-P} = 3337 Hz). Anal. Calcd for $C_{47}H_{43}NO_3P_2PtS\cdot CH_2Cl_2$: C, 55.28; H, 4.45; N, 2.69. Found: C, 55.30; H, 4.51; N, 2.71. Mp: 234−236 °C dec.

Polymerization of *Z*-Lys-NCA. A typical polymerization procedure was exemplified by the synthesis of P(*Z*-Lys)-20 (the number 20 indicates the designed [M]/[**2b**]) using **2b** as an initiator. A DMF (2 mL) solution of complex **2b** (47.9 mg, 0.05 mmol) was added to a rapidly stirred solution of *Z*-Lys-NCA (306.3 mg, 1.00 mmol) in DMF (8 mL) at 28 °C. After the previous mixture was stirred for 48 h, ^{1}H NMR and IR spectra showed that all of the monomer had been consumed. The resulting mixture was then poured into a mixed solution of Et_2O (80 mL) and concentrated HCl (1 mL) yielding white powder. The white powder was washed with Et_2O (20 mL) and then dried under vacuum. Yield: 244.1 mg (87.1%). M_n = 4700 g·mol^{-1}; PDI = 1.07.

X-ray Crystallographic Studies. Suitable crystals of **2a** and **2b** were sealed in capillary and were mounted on a Bruker AXS SMART 1000 diffractometer. Intensity data were collected in 1350 frames with increasing ω (width of 0.3° per frame). The absorption correction was based on the symmetry equivalent reflections using SADABS program. The space group determination was based on a check of the Laue symmetry and systematic absences, and was confirmed using the structure solution. The structure was solved by direct methods using a SHELXTL package. All non-H atoms were located from successive Fourier maps and hydrogen atoms were refined using a riding model. Anisotropic thermal parameters were used for all non-H atoms, and fixed isotropic parameters were used for H atoms.

Results and Discussion

Preparation and Characterization. These two platinum complexes (dppe)Pt(MBS−O) (**2a**) and (dppe)Pt(MBS−NH) (**2b**) were prepared by a procedure similar to that described in

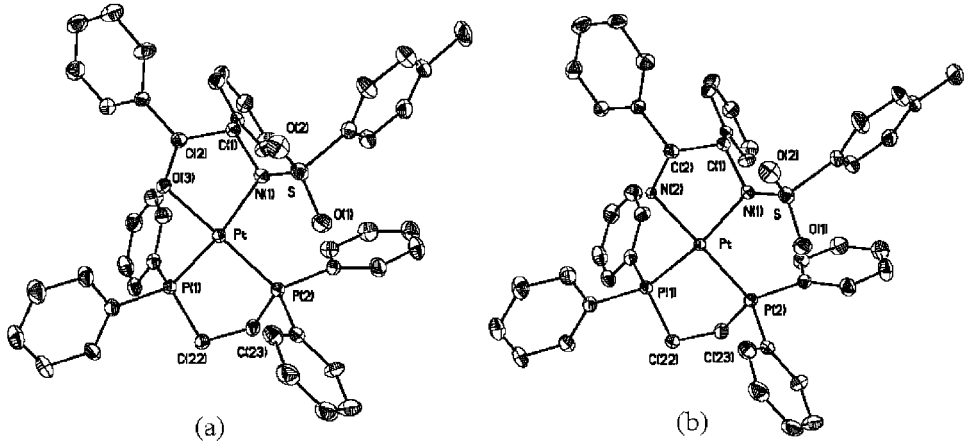
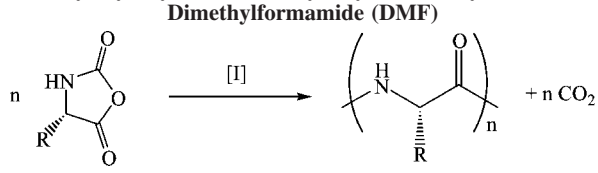


Figure 1. (a) Molecular structure of **2a** as 20% ellipsoids (all of the hydrogen atoms are omitted for clarity). Selected bond lengths (Å): Pt−O(3), 2.033(3); Pt−N(1), 2.074(4); Pt−P(1), 2.2299(12); Pt−P(2), 2.2354(13). (b) Molecular structure of **2b** as 20% ellipsoids (all of the hydrogen atoms are omitted for clarity). Selected bond lengths (Å): Pt−N(1), 2.077(6); Pt−N(2); 2.026(5); Pt−P(1), 2.230(3); Pt−P(2), 2.2337(18).

Table 1. Polymerization of N_{ξ}-Carbobenzyloxy-L-lysine-*N*-carboxyanhydride (*Z*-Lys-NCA) Initiated by Compounds 2a and 2b in Dimethylformamide (DMF)



entry	[I]	[M]:[I]	*t* (h)	*T* (°C)	M_n (calcd)[a]	M_n (GPC)	PDI[b]	yield (%)
1	**2a**	20:1	48	28	-	-	-	0
2	**2a**	20:1	144	28	-	-	-	0
3	**2a**	20:1	24	60	5600	1700	2.58	9.3
4[c]	-	-	144	28	-	-	-	0
5[c]	-	-	24	60	-	2000	2.72	10.8
6	**2b**	20:1	48	28	5600	4700 (4800)[d]	1.07	87.1
7	**2b**	25:1	48	28	6900	6000	1.05	90.2
8	**2b**	30:1	50	28	8200	7400	1.09	92.1
9	**2b**	40:1	54	28	10800	9700	1.12	91.7
10	**2b**	70:1	72	28	18700	17600	1.12	93.6
11	**2b**	80:1	98	28	21300	20500	1.13	90.8
12[e]	**2b**	40 (40):1	54 (54)	28	21300	20300	1.19	91.1

[a] Theoretical value of number average molecular weight (M_n) equals [M]/[I] value times the formula weight of the repeat unit plus the molecular weight of MBS−NH_2. [b] Polydispersity index (PDI = M_w/M_n) was obtained from gel permeation chromatography (GPC) analysis. [c] The blank test was performed by the polymerization of *Z*-Lys-NCA in the absence of platinum complex. [d] The value in parentheses is obtained from ^{1}H NMR analysis. [e] Prepolymerization of *Z*-Lys-NCA with **2b** for 54 h, followed by the addition of another portion of *Z*-Lys-NCA.

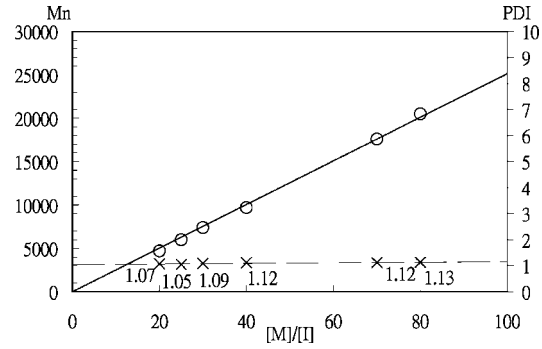


Figure 2. Polymerization of N_{ξ}-carbobenzyloxy-*L*-lysine-*N*-carboxyanhydride (*Z*-Lys-NCA) initiated by complex **2b** in dimethylformamide (DMF) at 28 °C. The relationship between M_n (○) (M_w/M_n (×)) of the polymer and the initial mole ratio [M]/[I] is shown.

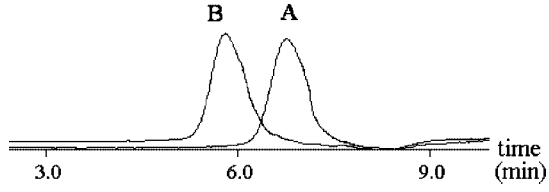


Figure 3. Gel permeation chromatography (GPC) profiles of polymerization resumption experiment: (peak A) after prepolymerization of N_{ξ}-carbobenzyloxy- *L*-lysine-*N*-carboxyanhydride (*Z*-Lys-NCA) (40 equiv to **2b**, 54 h), M_n = 9700 (Polydispersity index, PDI = 1.12); (peak B) after polymerization of 40 equiv more *Z*-Lys-NCA (54 h), M_n = 20 300 (PDI = 1.19).

the literature.[13] Complex **2a** was prepared by mixing (dppe)Pt-(CO_3) with a stoichiometric amount of MBS−OH (**1a**) in CH_2Cl_2 at room temperature for 28 h. However, complex **2b** was obtained from the reaction of (dppe)$PtCl_2$ with Li_2(MBS−NH), which was synthesized *in situ* by the addition of two molar equivalent of LDA to a THF solution of MBS−NH_2. (Scheme 1) Complexes **2a** and **2b** have been fully characterized by NMR spectroscopic studies as well as single crystal structure studies. All chemical shifts of ^{1}H NMR spectra of complexes **2a** and **2b** are situated in normal range, indicating diamagnetic properties. This phenomenon suggests square planar structures of these two complexes, which have been further verified by X-ray structure studies.

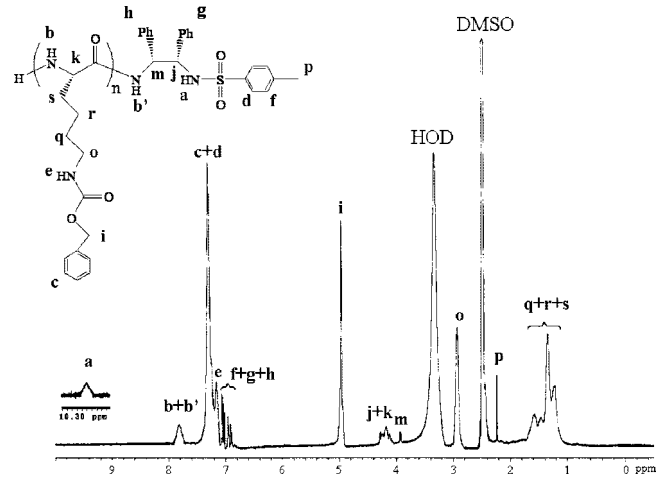
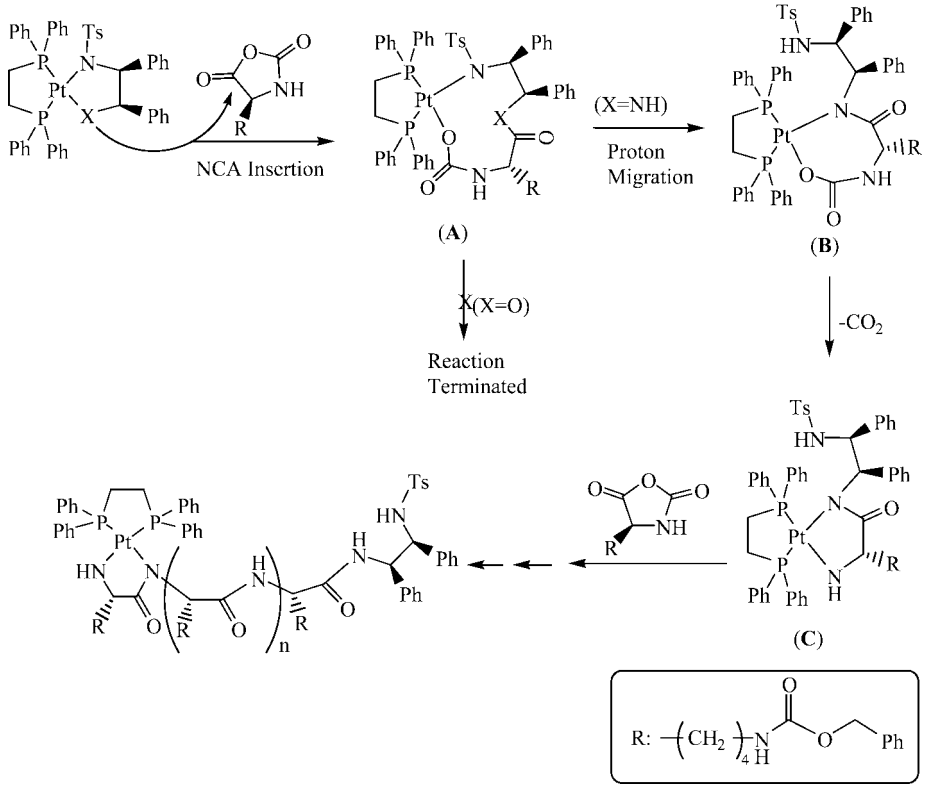


Figure 4. ^{1}H NMR spectrum of poly N_{ξ}-carbobenzyloxy-*L*-lysine ([M]/[I] = 20, P(*Z*-Lys)-20) in dimethyl-d_6 sulfoxide (DMSO-d_6).

Single crystals suitable for X-ray structure determination of **2a** were recrystallized from a mixture of Et_2O/CH_2Cl_2. However, single crystals of complex **2b** were obtained from a mixed solvent of CH_2Cl_2, THF and diethyl ether. The ORTEP diagrams of **2a** and **2b** are showed in Figure 1. The molecular structure of **2a** shows that the geometry around Pt is distorted square planar with the bond angles of P(1)−Pt−N(1) and P(2)−Pt−O(3) of **2a** being 168.77(12) and 176.53(12)°, respectively. The platinum atom is ca. 0.11 Å under the PPNO mean plane. The bond length of Pt−P(1), Pt−P(2), Pt−N(1), and Pt−O(3) in **2a** are 2.2299(12), 2.2354(13), 2.033(3), and 2.074(4) Å respectively, which are all compatible with the bond distances found in [(dppe)Pt(OCHPhCHPhNSO$_2$(4-^{t}Bu-C_6H_4)].[11] The molecular structure of **2b** is similar to that of **2a**. The bond distances of Pt−P(1), Pt−P(2), Pt−N(1), and Pt−N(2) in **2b** are 2.230(3), 2.2337(18), 2.077(6), and 2.026(5) Å, respectively, which are all compatible with those of [(dppe)Pt((4-^{t}BuC_6H_4)SO$_2$NCHPhCHPhNSO$_2$(4-^{t}BuC_6H_4)].[11] The bond angles of P(1)−Pt−N(1) and P(2)−Pt−N(2) of **2b** are 168.64(18) and 176.50(18)°.

Polymerization of *Z*-Lys-NCA. The catalytic activities of complexes **2a** and **2b** toward ring-opening polymerization of *Z*-Lys-NCA were studied systematically and the experimental results are listed in Table 1. When complex **2a** was used as an

Scheme 2. Proposed Mechanism for Ring-Opening Polymerization of *Z*-Lys-NCA Initiated by Pt Complexes



initiator with monomer (*Z*-Lys-NCA) in an initiator ratio ([M]/[**2a**]) of 20, no reaction was observed after 144 h at 28 °C (entries 1−2). In contrast, the monomer had gone to completion after 24 h based on NMR spectroscopic studies, while the reaction temperature was increased to 60 °C. However, the isolated yield is quite low (9.3%) due to low molecular weight which can be verified by GPC experimental results. GPC analysis shows that the number average of molecular weight (M_n) of this polymer is only 1700 with very high polydispersity index (PDI = M_w/M_n) which is far smaller than expected value of 5600. This result is similar to that obtained from the controlled experiments. In the absence of Pt complex (entry 4), no polypeptide was obtained after 144 h at room temperature. Similarly, 10.8% isolated yield of polypeptide was observed when the reaction was performed at 60 °C (entry 5). In addition, the ^{1}H NMR spectra of polypeptide samples of entries 3 and 5 are similar. These experimental results indicate that the polymerization is not initiated by complex **2a**. Instead, it probably occurs by solvent-induced oligomerization of monomer, which was proposed by Kricheldorf et al.[14]

The catalytic activity of complex **2b** for *Z*-Lys-NCA polymerization was also investigated (Table 1, entries 6−12). The M_n values of the resulting polypeptide increased in proportion to increasing [M]/[I], implying the living property of complex **2b**. As a result, the polydispersity indices of these polymers are quite narrow ranging from 1.07 to 1.13 (Figure 2). In the resumption experiment (entry 12), excess *Z*-Lys-NCA monomer was added after the polymerization effected by the first addition had gone to completion. Figure 3 shows that the molecular weight increases for the final polymer (peak B, M_n = 20 300, PDI = 1.19), relative to the first (peak A, M_n = 9700, PDI = 1.12). This result supports living polymerization of *Z*-Lys-NCA. In addition, the ^{1}H NMR spectrum of the poly(*Z*-Lys) (Figure 4) shows that the chain end of the polymer is 4-methylbenzenesulfonamide, as evidence, implying a coordination insertion by an amido−sulfonamidate group to initiate NCA polymerization. The integral value of the ratio peak *i* (4.97 ppm, methylene proton of carbobenzyloxy group in repeat units) to peak *p* (2.23 ppm, methyl of tolusulfonyl group at the end chain) is 17, estimating the Mn value of the polymer is 4800, which is closed to the GPC result. Experimental results indicate that complex **2b** is an appropriate initiator for living ring-opening polymerization of *Z*-Lys-NCA yielding polypeptides.

The amido−amidate metal complexes such as Ru and Ni have shown to be efficient initiators for living polymerization of NCA monomer.[6,8] The mechanism for these types of reaction has been proposed by Deming et al.[8] On the basis of activities of complexes **2a** and **2b**, our polymerization reaction seems to follow the mechanism proposed by Deming as shown in Scheme 2. The first step of the reaction is NCA insertion from the functional group X (O^- in **2a** or HN^- in **2b**) of the complex to the carbonyl group of the NCA monomer yielding intermediate (**A**). After the NCA insertion, a proton migration occurs from X (when X = NH in **2b**) to the nitrogen atom of NTs group giving intermediate (**B**). However, when X is the oxygen atom in **A**, the polymerization does not proceed due to the absence of H atom as observed in complex **2a**. Decarbonylation of intermediate **B** generates a new amido-amidate platinum complex (**C**), which will restart a NCA insertion and so on. The inability to form a stable five-member ring amido−amidate platinum intermediate is probably the reason for the low activity of complex **2a**.

In conclusion, two novel Pt complexes (**2a** and **2b**) have been synthesized and their absolute structures were confirmed by spectroscopic methods as well as X-ray structural studies. The major difference between **2a** and **2b** is that the chelating groups are O^-, N^- in **2a** and HN^-, N^- in **2b**. To the best of our knowledge, complex **2b** is the first Pt complex showing efficient activities for living NCA polymerization with narrow PDIs (1.07−1.19). In contrast, complex **2a** is inactive. These results support the proton migration mechanism and give us insight for designing effective Pt complex for living NCA polymerization.

Acknowledgment. Financial support from the National Science Council of the Republic of China and helpful comments and editing from Prof. Kwoliang D. Tau and Prof. C. Pugh are gratefully appreciated.

Supporting Information Available: Tables giving further details of the crystal structure determination, atomic coordinates and isotropic thermal parameters, bond lengths and angles, and anisotropic displacement parameters for **2a** and **2b** and cif files for both compounds. This material is available free of charge via the Internet at http://pubs.acs.org.

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MA7025836