Polymerization of *o*-Trimethylsilylphenylacetylene Initiated by a Tungsten Carbene Complex

Der-Jang LIAW,[†] Kai-Ruey HU, Hao-Hsien CHIANG,
and En-Tang KANG*

*Department of Chemical Engineering, National Taiwan Institute of Technology,
Taipei, Taiwan 106, Republic of China*

** Department of Chemical Engineering, National University of Singapore,
Kent Ridge, Singapore 0511*

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ABSTRACT: The polymerization of *o*-trimethylsilylphenylacetylene (*o*-Me₃SiPA) initiated by tungsten carbene complex (I) was investigated under various conditions. Both a larger molar mass and larger yield of polymer were obtained in CCl₄ and CHCl₃ and in the presence of a Lewis acid such as AlCl₃. The higher the temperature and the lower the initiator concentration, the larger was the molar mass of the polymer. The molar mass increases with concentration of cocatalyst SnCl₄ and shows a maximum value for a ratio [SnCl₄]/[I]=1. Moreover, when a solution of tungsten carbene complex in CCl₄ was irradiated with UV light, the molar mass was remarkably enhanced. Kinetic orders and apparent rate constants were determined by gas chromatography. According to thermogravimetric results for poly(*o*-Me₃SiPA), there is no significant interaction between the polymer and oxygen below 260°C. Above 260°C, the loss of mass in the presence of oxygen follows a two-step process. X-Ray diffraction measurements show that poly(*o*-Me₃SiPA) has an amorphous structure.

KEY WORDS *o*-Trimethylsilylphenylacetylene / Tungsten Carbene Complex / Apparent Rate Constant / CCl₄ / TGA / Cocatalyst /

Acetylene derivatives such as 1-heptyne, phenylacetylene and tert-butylacetylene are polymerized by tungsten carbene complex (I) to produce the corresponding polymers with larger molar mass.^{1–5} Catalyst (I) relatively easy to prepare and to handle,

has satisfactory thermal stability.^{6,7} The intramolecular coordination in the carbene complex

(I) appears to increase its stability and facilitate complexation of the first alkyne unit.^{1–5,8}

Several substituted polyacetylenes have been synthesized using groups 5 and 6 transition-metal catalysts.^{9,10} Among those polymers are Si-containing polyacetylenes, some of which exhibit unique properties not observed in hydrocarbon polyacetylenes. For example, poly-[1-(trimethylsilyl)-1-propyne] [poly(TMSP)] shows extremely high gas permeability^{11,12} and ethanol perselectivity in the ethanol/water pervaporation.^{13,14} Masuda reported that poly(*o*-trimethylsilylphenylacetylene) [poly(*o*-Me₃SiPA)] has a larger molar mass than that of poly(phenylacetylene) with transition metal catalysts.¹⁵ This indicates that the ortho sub-

[†] To whom all correspondence should be addressed.

stituent favors increased molar mass of the polymer because of its steric hindrance. Good photoconductive properties were observed in poly(*o*-Me₃SiPA).¹⁶ Detailed kinetic experiments and mechanisms have never been reported.

We describe here comprehensive results on the polymerization of *o*-Me₃SiPA with this tungsten carbene complex (I) under various conditions. The effects of concentration of cocatalyst on the molar mass were examined. The kinetic order and apparent rate constants were investigated with a gas chromatography (GC). The mechanism and thermal properties of poly(*o*-Me₃SiPA) are discussed.

EXPERIMENTAL

Monomer Preparation

The monomer (*o*-Me₃SiPA) was prepared according to the following scheme with the methods of Brandsma¹⁷ and Masuda *et al.*¹⁵:

The monomer (*o*-Me₃SiPA) was carefully distilled: bp 85°C (1.3 kPa) [lit.^{15,17} 85°C (1.3 kPa)]; yield 78.8%; purity >99.9% (by GC).

The monomer (*o*-Me₃SiPA) thus obtained was characterized by analytical techniques using IR, ¹H NMR, ¹³C NMR, and ²⁹Si NMR spectra.^{18–20} IR: ν/cm^{-1} $\equiv\text{C}-\text{H}_{\text{str}}$ 3310, $\text{C}-\text{H}_{\text{str}}$ 2900–3060, $\text{C}\equiv\text{C}_{\text{str}}$ 2130, $\text{Si}-\text{CH}_3$ deform 1245, $\text{Si}-\text{phenyl}$ 1117, methyl rocking 834, $\text{Si}-\text{CH}_3$ str 751, 1,2-disubstituted aromatic 721. In the ¹H NMR spectrum (CDCl₃ δ /ppm, TMS) of the monomer appear sharp signals at 0.51 (s, 9H, Si(CH₃)₃), 3.29 (s, 1H, HC $\equiv$ C–), 7.4 and 7.61 (2m, 4H, ArH).²¹ The ¹³C NMR spectrum (CDCl₃) of the monomer exhibits signals of methyl carbons δ –1.079, of *sp* car-

Scheme 1. Synthesis of the tungsten carbene complex.

bons δ 80.2, 85.2, and of *sp*² carbons δ 127.3, 127.9, 128.6, 133.3, 133.8, and 142.8 ppm. In the ²⁹Si NMR spectrum of monomer, there appears a signal of silyl silicon (δ –3.85 ppm), for which TMS was as an external reference.

Catalyst Preparation

The catalyst, tungsten carbene complex I, was prepared according to the method of Rudler^{2,6} as shown in Scheme 1 (mp 77°C).

The crude solid obtained was purified on a chromatographic column of silica gel with hexane as the eluent and was recrystallized from pentane solution.

Polymerization

A typical polymerization procedure is as follows: Tungsten carbene complex catalyst (0.01 g) and solvent CCl₄ (1.76 ml) were introduced into a Schlenk tube. The contents of the tube were flushed with nitrogen and sealed in vacuum by the freeze-thaw technique. The tube was kept in the dark and placed in a tank at a constant temperature 40°C for 15 min. The monomer, *o*-trimethylsilyl phenylacetylene (*o*-Me₃SiPA, 0.50 ml) was added to the solution by a syringe.

The mixture was kept in the dark at 40°C for 20 h. The reaction solution was red and homogeneous at the beginning of polymerization, but gradually changed from red to dark purple. The polymerization reaction was termi-

nated with a toluene-methanol (volume ratio 2:1) mixture (1 ml); the viscous solution was diluted with toluene (10 ml) and poured into methanol (1000 ml) with stirring to precipitate the dark purple polymer formed. The polymer was filtered and dried for about 24 h at 60°C under vacuum and weighed.

Polymer Characterization

The number and mass average molar masses ($\bar{M}_n$ and $\bar{M}_w$) were determined by gel permeation chromatography (GPC). Four Waters (Ultrastaygel) columns (300 × 7.7 mm; 10², 10³, 10⁴, 10⁵ Å in a series) were used for GPC analysis with tetrahydrofuran (THF) (1 ml min⁻¹) as the mobile phase. The eluents were monitored (Gilson Model 116) using light at 254 nm for the detection of benzene ring. Polystyrene was used as a standard.

A X-ray diffractogram was recorded with the powder method (Philips X-ray diffractometer, model PW 1710). For thermogravimetric analysis (Du Pont 9900 instrument) the heating rate was 10°C min⁻¹.

Kinetic measurements were made following monomer concentration variation on a GC (Varian 3700) equipped with columns (PEG 6000, 2 meters). Bromobenzene was used as the internal standard.

The polymer was characterized by IR, ¹H NMR, ¹³C NMR, and ²⁹Si NMR spectra. IR: ν/cm^{-1} C=C, 1583, SiC-H, 1245, Si-C, 834. ¹H NMR (in CDCl₃): δ/ppm 0.07 (9H, Si(CH₃)₃), 4.40–7.80 (⊙, =CH-); ¹³C NMR (in CDCl₃): δ/ppm 123–150 (C=C, ⊙), 1.0 (Si(CH₃)₃); ²⁹Si NMR (in CDCl₃): δ/ppm -5.90 (Si(CH₃)₃). The formation of polymer was indicated by the characteristic absorption maximum (λ_{max} 541 nm, $\epsilon = 11301 \cdot \text{mol}^{-1} \text{cm}^{-1}$).

RESULTS AND DISCUSSION

Polymerization under Various Conditions

The results of polymerization of *o*-trimethylsilyl phenylacetylene initiated with several cat-

alysts are shown in Table I. At 60°C, the coordinated carbene catalyst was clearly more efficient than other catalysts such as 2,2'-azobisisobutyronitrile (AIBN), noncoordinated carbene or Fischer's catalyst. The polymer obtained with coordinated carbene catalyst easily dissolved in organic solvents such as hexane, benzene and toluene, and chlorinated aliphatic hydrocarbon such as methylene chloride, chloroform and carbon tetrachloride. Table I shows that a greater yield and smaller molar mass of polymer were obtained when the polymerization was performed at a lower ratio of $[M]_0/[I]_0$ in toluene. When the polymerization was conducted with a Lewis acid such as AlCl₃ (No. 7) or in nonpolar solvent such as CCl₄ (No. 8) and CHCl₃ (No. 9), poly(*o*-Me₃SiPA) was quantitatively obtained with a large molar mass. Similar results were previously obtained for tert-butylacetylene with a tungsten carbene complex.^{4,5} Masuda *et al.* observed that the polymerization of tert-butylacetylene progressed with large yield in CCl₄ by WCl₆.²² When polymerizations were performed in chlorinated aliphatic hydrocarbons such as methylene chloride and 1,2-dichloroethane, the polymer yield and molar mass decreased with increasing dipole moment of solvent.²³ A higher yield and molar mass of polymer were obtained when we polymerized phenylacetylene in nonpolar solvents (*e.g.*, hexane) than with polar solvents (*e.g.*, CH₂Cl₂). This was also observed by Masuda for the polymerization of phenylacetylene catalyzed with WCl₆.²⁴ Polar solvents (*e.g.*, CH₂Cl₂ or ClCH₂CH₂Cl) might decrease coordination between the tungsten carbene complex and monomer so to diminish the rate of polymerization. Moreover, when the solution of tungsten carbene complex in CCl₄ was irradiated with UV light (250-W high-pressure mercury lamp) at 40°C for 60 min, the molar mass was remarkably enhanced (No. 12, Table I). The catalyst solution irradiated with UV was deep red with fine black particles, possibly due to removal of the tungsten carbene complex (I) from

Table I. Results of the polymerization of *o*-trimethylsilylphenylacetylene under various conditions^a

No.	Catalyst [I]	Solvent	$\frac{[M]_0}{[I]_0}$	Temp. °C	Polymer ^b			$\bar{M}_w/\bar{M}_n$
					Yield	$\bar{M}_n^c$	$\bar{M}_w^c$	
						%	$\times 10^{-3}$	
1	AIBN	Toluene	40	60	0	—	—	
2	Noncoordinated carbene ^d	Toluene	40	60	0	—	—	
3	Fischer catalyst ^e	Toluene	40	60	0	—	—	
4	Coordinated carbene ^f	Toluene	10	60	53.5	2.4	6.9	2.88
5	Coordinated carbene ^f	Toluene	20	60	22.2	12	35	2.92
6	Coordinated carbene ^f	Toluene	40	60	8.4	22	63	2.86
7	Coordinated carbene ^{f,g}	Toluene	40	30	99.1	163	538	3.30
8	Coordinated carbene ^f	CCl ₄	100	30	100	91	189	2.08
9	Coordinated carbene ^f	CHCl ₃	100	30	88.3	40	74	1.85
10	Coordinated carbene ^f	CH ₂ Cl ₂	100	30	25.0	26	56	2.15
11	Coordinated carbene ^f	(CH ₂ Cl) ₂	100	30	0	—	—	
12	Coordinated carbene ^{f,h}	CCl ₄	100	40	82.6	435	1145	2.63

^a Polymerization time, 24 h; $[M]_0 = 1.0 \text{ mol l}^{-1}$. ^b Methanol-insoluble product. ^c Measured by GPC in THF; polystyrene was used as the standard.

^d Noncoordinated carbene.

^e Fischer catalyst.

^f Coordinated carbene.

^{*} Polymerization time, 20 h; $[M]_0 = 1.0 \text{ mol l}^{-1}$. AlCl₃ was used as cocatalyst. $[\text{AlCl}_3]/[\text{I}]_0 = 12$. ^h Tungsten carbene complex was irradiated in CCl₄ for 60 min with a 365 nm Ushio 250 W high pressure mercury lamp at a distance of 5 cm.

its coordinated bond and tungsten dichloro-carbene $\left(\begin{array}{c} \text{Cl} \\ | \\ \text{Cl} \end{array} \text{C}=\text{W}(\text{CO})_2=\text{C} \begin{array}{c} \text{Cl} \\ | \\ \text{Cl} \end{array} \right)$ immediately

forms from the reaction of tungsten carbene complex and CCl₄ (Scheme 2, *vide infra*) and subsequently initiates polymerization.^{5,25,26}

The effect of temperature on polymerization in CCl₄ is shown in Table II. The polymer yield reached 100% at any temperature. The molar mass increased with temperature of polymerization.

Table III shows that the molar mass is a function of initial concentration of initiator (for 20 h) in CCl₄. The polymer yield reached 100% at any $[M]_0/[I]_0$ ratio. The molar mass increased with decreasing initial concentration of initiator at a fixed concentration of mono-

Table II. Effects of temperature on the polymerization of *o*-Me₃SiPA in CCl₄^a

Temp.	Polymer ^b			
	Yield	$\bar{M}_n^c$	$\bar{M}_w^c$	$\bar{M}_w/\bar{M}_n$
	°C	$\times 10^{-3}$	$\times 10^{-3}$	
	%			
30	100	92	189	2.05
40	100	128	208	1.63
60	100	226	575	2.54
80	100	257	585	2.28

^a Polymerization time, 24 h; $[M]_0 = 1 \text{ mol l}^{-1}$; $[M]_0/[I]_0 = 100$. ^b Methanol-insoluble product. ^c Measured by GPC in THF; polystyrene was used as standard.

mer.

Figure 1 shows variation of the mass-average molar mass ($\bar{M}_w$) with varied ratio $[M]_0/[I]_0$ during polymerization $\bar{M}_w$ increased first with

Table III. Effects of the initial tungsten carbene complex concentration $[I]_0$ on the polymerization of *o*-Me₃SiPA in CCl₄ at 40°C^a

$[M]_0/[I]_0$	Polymer ^b			
	Yield %	$\bar{M}_n^c$ $\times 10^{-3}$	$\bar{M}_w^c$ $\times 10^{-3}$	$\bar{M}_w/\bar{M}_n$
100	100	128	208	1.63
60	100	114	188	1.65
40	100	75	98	1.31
20	100	46	81	1.76

^a Polymerization time, 20 h; $[M]_0 = 1 \text{ mol l}^{-1}$. ^b Methanol-insoluble product. ^c Measured by GPC in THF; polystyrene was used as the standard.

Figure 1. Relationship between $\bar{M}_w$ of poly(*o*-Me₃SiPA) and polymerization time at 40°C in CCl₄ solution. The ratio $[M]_0/[I]_0$, 10 (●), 20 (■), 40 (▲). $[M]_0 = 1 \text{ mol l}^{-1}$.

conversion up to an asymptotic values and remained constant until the end of polymerization regardless of the value of $[M]_0/[I]_0$. The polymerization by tungsten carbene complex approached approximately 90% conversion in 3 h ($[M]_0/[I]_0 = 40$). That the molar mass remained constant after 60 min might be explained by the occurrence of termination reactions and also by the existence of transfer reactions in the course of polymerization, as reported by Fontanille *et al.*²⁷ using a binuclear complex of a tungsten catalytic system.

The effect of temperature on the molar mass

Figure 2. Effects of temperature on the $\bar{M}_w$ of the polymerization of *o*-Me₃SiPA, the ratio $[M]_0/[I]_0 = 40$ in CCl₄ solution. (●) 20°C; (■) 40°C; (▲) 60°C. $[M]_0 = 1 \text{ mol l}^{-1}$.

in the polymerization of *o*-trimethylsilylphenylacetylene is shown in Figure 2. The curve resembles that of Figure 1. The mass average molar mass increases with temperature of polymerization. This indicates that as the temperature is raised, the catalytic activity may be significantly enhanced. The molar mass increased first with conversion up to asymptotic values during the initial stage of polymerization, then remained constant until the end of polymerization due to termination and transfer reactions.²⁷

As mentioned-above (Table I, No. 7) a Lewis acid such as AlCl₃ enhanced the molar mass and yield of the polymer. Table IV shows the effects of other cocatalysts on the polymerization of *o*-Me₃SiPA by tungsten carbene complex. The polymer yield reached 100% regardless of the concentration of SnCl₄ in CCl₄. However, the molar mass increased with concentration of SnCl₄, and showed maximal values for $[\text{SnCl}_4]/[I]_0 = 1$. The variation of molar masses in Table 4 shows that the tungsten carbene complex was affected by the aluminum cocatalyst in the following order: $(\text{C}_2\text{H}_5)_{1.5}\text{AlCl}_{1.5} > (\text{C}_2\text{H}_5)_2\text{AlCl} > (\text{C}_2\text{H}_5)_3\text{Al}$, corresponding to the order of the Lewis acidity, $(\text{C}_2\text{H}_5)_{1.5}\text{AlCl}_{1.5} > (\text{C}_2\text{H}_5)_2\text{AlCl} > (\text{C}_2\text{H}_5)_3\text{Al}$.

Table IV. Effects of cocatalysts on the polymerization of *o*-Me₃SiPA by the tungsten carbene complex catalyst [I]

Cocatalyst	[Cocatalyst] [I] ₀	Polymer ^a			
		Yield	$\bar{M}_n^b$ × 10 ⁻³	$\bar{M}_w^b$ × 10 ⁻³	$\bar{M}_w/\bar{M}_n$
		%			
SnCl ₄ ^c	0.0	100	128	208	1.63
SnCl ₄ ^c	0.6	100	139	284	2.04
SnCl ₄ ^c	1.0	100	194	387	1.99
SnCl ₄ ^c	2.0	100	139	272	1.96
SnCl ₄ ^c	3.0	91	79	177	2.24
(C ₂ H ₅) _{1.5} AlCl _{1.5} ^d	1.0	100	46	83	1.80
(C ₂ H ₅) ₂ AlCl ^d	1.0	10	6	11	1.83
(C ₂ H ₅) ₃ Al ^d	1.0	7	—	—	—

^a Methanol-insoluble product. ^b Measured by GPC in tetrahydrofuran (THF); polystyrene was used as the standard.^c Polymerized in CCl₄ at 40°C for 20 h; [M]₀ = 1.0 mol l⁻¹; [M]₀/[I]₀ = 100. ^d Polymerized in toluene at 40°C for 20 h; [M]₀ = 1.0 mol l⁻¹; [M]₀/[I]₀ = 100.

Al.²⁸ Thus, the cocatalyst with the best acceptor properties appeared to be the most active. This is possibly due to cocatalyst complex formation with the CO ligand of the initiator. Such complexation would induce a decrease of the intramolecular coordination of the double bond. The mechanism of the polymerization of alkynes initiated by initiator (I) would eventually be the decoordination of the ethylenic bond followed by complexation of the monomer.

Mechanism of Polymerization

The mechanism of polymerization of *o*-trimethylsilylphenylacetylene is proposed in Scheme 2. First, with carbene complex I in CCl₄, the carbene complex I is removed from its coordinated bond and tungsten dichloro-carben II may be immediately formed. Then the intramolecularly coordinated bond in the catalyst I is replaced by the triple bond of the monomer leading to complex III. The next step is the insertion through a metallacyclobutene intermediate IV leading to the first carbenic active center V. The existence of intermediate IV has been proposed by several authors.^{1,8,10,24} The intermediate has been

isolated and characterized in the case of titanium and tungsten complexes, by Grubbs *et al.*²⁹ and Ivin *et al.*,³⁰ respectively. The first step is bimolecular and agrees with the initial kinetic order relative to monomer and initiator I to be described later. The new metal carbene complex V is highly reactive due to the absence of a heteroatom at the carbenic carbon and cannot be isolated.⁸ Carbene complex V is able to induce polymerization through a steady-state process.^{31,32}

Kinetic Experiments

To obtain the apparent rate constant (k_{app})₀, the kinetic order of the rate equation was determined by GC. The initially maximal rates of polymerization (R_p)₀ were determined at initial stages of polymerization. In order to determine the kinetic order of the monomer, the catalyst concentration ([I]₀) was fixed and the monomer concentration ([M]₀) was varied from 0.318 to 0.826 mol l⁻¹ at 40°C in CCl₄. The results are shown in Figure 3.

The rate of polymerization was proportional to the monomer concentration. A similar test was carried out to determine the kinetic order of the catalyst [I] ranging from 2.9 × 10⁻³ to

Scheme 2. Mechanism for the polymerization of *o*-tri-methylsilyl phenylacetylene.

$15.0 \times 10^{-3} \text{ mol l}^{-1}$ at 40°C in CCl_4 . The results appear in Figure 4. The kinetic order of the catalyst is also unity. Thus, the rate of polymerization of *o*-trimethylsilylphenylacetylene may be determined as follows:

$$(R_p)_0 = (k_{\text{app}})_0 \times [M]_0 [I]_0 = -d[M]/dt \quad (1)$$

in which $(R_p)_0$ is the apparent rate of polymerization and $(k_{\text{app}})_0$ is the apparent rate constant. At other temperatures, the rates of polymerization were proportional to the concentrations of monomer and catalyst. The results of the initial apparent rate of polym-

Figure 3. Kinetics of the addition of *o*-Me₃SiPA to the catalyst at 40°C in CCl_4 . Determination of kinetic order with respect to monomer, $[I]_0 = 6 \times 10^{-3} \text{ mol l}^{-1}$.

Figure 4. Kinetics of the addition of *o*-Me₃SiPA to the catalyst at 40°C in CCl_4 . Determination of kinetic order with respect to catalyst, $[M]_0 = 0.60 \text{ mol l}^{-1}$.

Table V. Initial apparent rates $(R_p)_0$ and constants $(k_{\text{app}})_0$ for the polymerization of *o*-Me₃SiPA initiated by the tungsten carbene complex catalyst at various temperatures in CCl_4 ^a

Temperature °C	$(R_p)_0 \times 10^5$ $\text{mol l}^{-1} \text{ s}^{-1}$	$(k_{\text{app}})_0 \times 10^3$ $\text{l} \cdot \text{mol}^{-1} \text{ s}^{-1}$
50	10.8	44.6
45	4.0	16.5
40	2.5	10.3
30	1.7	6.9

^a $[M]_0 = 0.583 \text{ mol l}^{-1}$; $[M]_0/[I]_0 = 140$.

erization $(R_p)_0$ and rate constants $(k_{\text{app}})_0$ in CCl_4 are presented in Table V. Both $(R_p)_0$ and $(k_{\text{app}})_0$ increased with temperatures. The

Figure 5. X-Ray diffraction diagram of poly(*o*-Me₃SiPA).

Figure 6. TGA curves for poly(*o*-Me₃SiPA) in nitrogen, air and oxygen. (Heating rate 10°C min⁻¹.)

activation enthalpy (ΔH_p) and entropy (ΔS_p) of the propagation reaction were calculated as 69.7 kJ mol⁻¹ and -66.2 J mol⁻¹ K⁻¹, respectively.

Properties and Structure of Poly(*o*-Me₃SiPA)

Figure 5 shows a X-ray diffractogram of poly(*o*-Me₃SiPA). The broad diffraction lines at $2\theta = 15.0^\circ$ and 22.5° indicate that poly(*o*-Me₃SiPA) obtained from tungsten carbene complex has an amorphous structure.

Figure 6 shows the TGA curves of poly(*o*-Me₃SiPA) obtained from room temperature to 800°C. Loss of mass of poly(*o*-Me₃SiPA) occurred above 300°C in nitrogen. The polymer was stable at room temperature in air for six months. In the presence of oxygen, the onset

Table VI. Changes in number-average molar mass ($\bar{M}_n$) on heating poly(*o*-Me₃SiPA) in presence of air at 200°C

Heat treatment	$\bar{M}_n \times 10^{-4}$	$\bar{M}_w/\bar{M}_n$
Before	18.9	2.1
After 1 h	7.53	2.3
After 2 h	4.08	2.4

of mass loss of poly(*o*-Me₃SiPA) occurred at a slightly lower temperature than in nitrogen. At temperatures above 360°C, the curves of loss of mass of poly(*o*-Me₃SiPA) in nitrogen and in the presence of oxygen showed large differences. In the presence of oxygen, the decrease of mass slowed down considerably between 400 and 460°C before a second rapid mass loss step occurs. The amount of residue remaining at 700°C increased and the white residue was probably SiO₂. This was also observed by Tang *et al.*³³ and Neoh *et al.*³⁴

Table VI shows the number average molar mass ($\bar{M}_n$) changes with the heat treatment of poly(*o*-Me₃SiPA) in the presence of air at 200°C for 2 h.

The molar mass apparently decreased with heating for 1 h or 2 h above 200°C in air. The shapes of the molar mass distribution curves before and after thermal treatment scarcely altered for this polymer, which indicates that degradation takes place randomly. At a low temperature of degradation (200°C), the effect of oxidation was not readily detected in the IR spectra. Neoh *et al.*³⁴ reported that the IR absorption spectrum of the poly(*o*-Me₃SiPA) sample after heating to 270°C is similar to that of the original sample. However, when the sample was heated to 430°C, the spectrum showed lines due to oxygen-containing groups, such as O-H, C=O, and Si-O.

The polymer had the form of a dark purple solid ($\lambda_{\max}$ 541 nm), dissolved completely in common organic solvents such as hexane, toluene, and CHCl₃ etc. and formed a strong, free-standing film on solution casting.

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