

ORIGINAL ARTICLE

Synthesis and characterization of novel polytriazoleimides by CuAAC step-growth polymerization

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Cu(I)-catalyzed 1,3-dipolar cycloaddition step-growth polymerization was exploited in the synthesis of a novel class of polytriazoleimides. The polymerization with diazides and imide-containing dialkynes was readily carried out under mild conditions. The chemical structures of the resulting novel polyimides were characterized by Fourier transform infrared and nuclear magnetic resonance. These polymers exhibited good solubility in common polar organic solvents such as N-methyl-2-pyrrolidinone, N,N-dimethylacetamide, dimethylformide and dimethylsulfoxide. The flexible polytriazoleimide films were easily prepared from homogeneous polyimide solutions. The films had good mechanical properties with tensile strengths of 76.2–92.4 MPa as well as elongations at breakage of 4.8–6.9%. The resulting polytriazoleimide films showed a glass transition temperature of 221–254 °C and a decomposition temperature (at 5% weight loss) of 365–377 °C in nitrogen. *Polymer Journal* (2010) 42, 216–222; doi:10.1038/pj.2009.337; published online 13 January 2010

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INTRODUCTION

Organic polymers containing imide groups in the main chain have excellent thermal stability and mechanical properties, good chemical resistance, high dimensional stability, and good electric properties.^{1–4} Polyimides have been extensively used in many fields. A variety of polyimides have been molecularly designed on the basis of knowledge acquired about the structure-property relationships to satisfy the specific requirements for optimal performance in specialty applications.^{2,5–6} However, the recent trend in polyimide research seems to focus more on the development of structural and functional polyimides with new properties.^{7–8} In general, polyimides are prepared by condensation polymerization, which has some disadvantages such as the release of small molecule compounds during polymerization. To be applicable and useful in polyimide synthesis, a polymerization reaction must proceed with a high yield and no by-products. Cycloaddition polymerization with the Cu(I)-catalyzed cycloaddition of azides and alkynes (CuAAC) is a simple and powerful approach for the preparation of new polyimides.

CuAAC is known as the 'cream of the crop' of click chemistry.^{9,10} Although click chemistry was initially postulated as a general concept for organic synthesis, this strategy also has an enormous potential in materials and polymer sciences. A wide range of polymer architectures has been synthesized by CuAAC.^{11–18} During the past few years, polymer chemists have developed CuAAC into a new polymerization

technique. The step-growth polymerization of diazide and dialkyne derivatives by thermal 1,3-dipolar cycloaddition was first reported by Johnson *et al.*,^{19,20} leading to linear polymers containing 1,4- and 1,5-substituted triazole rings. This catalyst-free approach was also used to synthesize linear high molecular weight poly(aryltriazole)s.²¹ Fleury and co-workers were the first to report the kinetic study of CuAAC step-growth polymerization.^{22,23} A series of functionalized polyesters was prepared by CuAAC step-growth polymerization without the need of protecting groups.^{24,25} However, the reaction as a new polymerization technique is seldom exploited in the synthesis of polyimides. We report herein the preparation of novel polyimides containing 1,2,3-triazole units in the main chain by the CuAAC step-growth polymerization of diazide and dialkyne. The results show that high molecular weight linear polytriazoleimides could be obtained. Strong and flexible polytriazoleimide films were easily prepared from homogeneous solutions and showed good mechanical and thermal properties.

1,2,4-triazole compounds are widely used as corrosion inhibitors and adhesion promoters on copper or copper-based products.^{26–28} However, 1,2,3-triazole compounds have a good affinity for metallic surfaces and are far more stable than 1,2,4-triazole compounds to attack by other chemical entities.^{29,30} We therefore believe that polyimide materials with new molecular structures based on 1,2,3-triazole may have advantageous properties for high-performance metal coatings and adhesives.

EXPERIMENTAL PROCEDURE

Materials

4,4'-Oxydiphthalic anhydride, 2,2-bis [4-(3,4-dicarboxyphenoxy) phenyl] propane dianhydride and 3,3'- or 4,4'-benzophenonetetracarboxylic dianhydride were used as purchased from the Shanghai Synthetic Resin Institute (Shanghai, China). N,N-dimethylacetamide, 3-amine-phenylacetylene, tetrahydrofuran, dimethylformide, N-methyl-2-pyrrolidinone (NMP), toluene (analytical reagent grade), dichloroethane (analytical reagent grade), sodium azide (chemical purity) and magnesium sulfate (anhydrous, analytical reagent grade) were purchased and used as received from Shanghai No. 1 Reagent Company (Shanghai, China).

Measurements

Nuclear magnetic resonance (NMR) spectra were recorded on a AVANCE 500 (Bruker BioSpin GmbH, Rheinstetten, Germany) (500 MHz). Fourier transform infrared (FT-IR) spectra were determined by a Bio-Rad Digilab Division FTS-165 spectrometer (Bio-Rad Corporation, Hercules, CA, USA). The inherent viscosities of the obtained polyimides were measured with an Ubbelohde viscometer at 30 °C. Elemental analyses were performed with the Elementar Analysensysteme GmbH vario EL III (Elementar Analysensysteme GmbH, Hanau, Germany). Differential scanning calorimetry analyses were performed with a Universal V2.3 TA Instrument (ANALYZE Inc, Chandler, AZ, USA) 2910 modulated system. The heating rate was 20 °C min⁻¹ at a flow rate of nitrogen of 15 cm³ min⁻¹. Thermogravimetric analysis (TGA) was performed on a TGA/SDTA 851 analyzer (Mettler-Toledo (Schweiz) GmbH, Greifensee, Switzerland) with a heating rate of 10 °C min⁻¹. The mechanical properties were measured on an Instron 1122 tensile apparatus (Instron Corporation, Norwood, MA, USA) with 120×10 mm² specimens in accordance with GB1040-79 at a drawing rate of 100 mm min⁻¹. Wide-angle X-ray diffractometer measurements were performed at room temperature on a D/MAX 2550 VB/PC X-ray diffractometer (RIGAKU Corporation, Tokyo, Japan) with nickel-filtered Cu K α radiation (wavelength 1.5418 Å) at 40 kV and 30 mA with 2 θ ranging from 0 to 60°.

Synthesis of phthalimide dialkyne monomers

A general procedure for the synthesis of dialkyne monomers is given as follows. In a 250-ml three-necked flask equipped with a refluxing condenser and stirrer, 4 mmol 2,2-bis [4-(3,4-dicarboxyphenoxy) phenyl] propane dianhydride, 8 mmol 3-amine-phenylacetylene and 50 ml acetone were charged. The solution was formed after stirring for a few minutes. The solution was heated until refluxing occurred. The reaction continued for 6 h. Then 50 ml acetic anhydride and 70 ml triethylamine as catalyst were added. The temperature of the reaction was increased to 80 °C and maintained for 4 h. The product was precipitated in solvent. The crude product was collected by filtration, washed several times with acetone and dried at 80 °C for 24 h in a vacuum oven.

3, 3-Bis (N-acetylenephenylphthalimide) ether of bisphenol A

Yield: 90%. FT-IR (neat, cm⁻¹): 3276 (\equiv C–H stretch), 2103 (C \equiv C) 1774 (C=O antisym stretch), 1719 (C=O sym stretch, imide I), 1376 (C–N–C, imide II), 793 (C=O).

¹H-NMR (500 MHz, dimethylsulfoxide (DMSO)-*d*₆, p.p.m.): δ =1.72 (s, 6H, –CH₃), 4.31 (s, 2H, –C \equiv C–H), 7.12~7.98 (22H, –C₆H₄–, –C₆H₃ and –C₆H₄) p.p.m. ¹³C NMR (125 MHz, DMSO-*d*₆, p.p.m.): δ =166.0 (N–C=O), 162.8, 132.1, 129.3, 128.6, 122.8, 111.5 (–C₆H₃–); 152.4, 147.1, 130.1, 119.7 (O–C₆H₄–); 134.1, 131.1, 130.1, 127.8, 125.9, 125.1 (–C₆H₄–C \equiv C–H), 82.5 (–C \equiv CH), 81.7 (–C \equiv CH), 42.0 (–C(CH₃)₂–), 30.5(–CH₃).

ELEM.ANAL. Calcd. for C₄₇H₃₀N₂O₆: C, 78.55%; N, 3.90%; H, 4.18%. Found: C, 78.10%; N, 3.82%; H, 4.16%.

3, 3-Bis (N-acetylenephenylphthalimide) ether

Yield: 95%. FT-IR (neat, cm⁻¹): 3274 (\equiv C–H stretch), 2099 (C \equiv C), 1776 (C=O antisym stretch), 1714 (C=O sym stretch, imide I), 1382 (C–N–C, imide II), 748 (C=O).

¹H-NMR (500 MHz, DMSO-*d*₆, p.p.m.): δ =4.31 (s, 2H, –C \equiv C–H), 7.12~7.98 (14H, –C₆H₄– and –C₆H₃) p.p.m. ¹³C NMR (125 MHz, DMSO-*d*₆, p.p.m.): δ =167.1 (N–C=O), 161.9, 133.2, 130.5, 128.2, 123.4, 114.8 (–C₆H₃–), 135.5, 132.4, 131.4, 129.1, 127.2, 126.1 (–C₆H₄–), 83.6 (–C \equiv CH), 82.7 (–C \equiv CH). ELEM.ANAL. Calcd. for C₃₂H₁₆N₂O₅: C, 75.59%; N, 5.51%; H, 3.15%. Found: C, 75.30%; N, 5.39%; H, 3.00%.

3, 3-Bis (N-acetylenephenylphthalimide) ketone

Yield: 96%. FT-IR (neat, cm⁻¹): 3278 (\equiv C–H stretch), 2102 (C \equiv C) 1778 (C=O antisym stretch), 1722 (C=O sym stretch, imide I), 1382 (C–N–C, imide II), 748 (C=O). ¹H-NMR (500 MHz, DMSO-*d*₆, p.p.m.): δ =4.32 (s, 2H, C \equiv C–H), 7.12~7.98 (14H, –C₆H₄– and –C₆H₃). ¹³C NMR (125 MHz, DMSO-*d*₆, p.p.m.): δ =194.0 (–C=O), 166.2 (N–C=O), 142.0, 136.2, 134.4, 132.1, 123.8, 112.5 (–C₆H₃–), 132.4, 131.5, 130.3, 129.4, 128.2, 122.2 (–C₆H₄–), 83.1 (–C \equiv CH), 81.5 (–C \equiv CH). ELEM.ANAL. Calcd. for C₃₃H₁₆N₂O₅: C, 76.15%; N, 5.38%; H, 3.08%. Found: C, 76.12%; N, 5.36%; H, 2.93%.

Preparation of diazide monomers

p-Xylylene diazide (XDA) and 4,4'-biphenyl dibenzyl azide (BPDBA) were synthesized in high yield according to the previously reported procedure.^{31–34} The spectroscopic data were consistent with the reported values.

p-Xylylene diazide: m.p.: 27–29 °C (reported value: 27.5–29.0 °C³²), FT-IR: 2098 cm⁻¹ (azide), ¹H-NMR: (CDCl₃, TMS): 7.33 (s, 4H, Ar–H), 4.35 (s, 4H, Ar–CH₂N₃).

4,4'-Biphenyl dibenzyl azide: m.p.: 71–72 °C (reported value: 69–72 °C³⁴), FT-IR: 2109 cm⁻¹ (azide), ¹H-NMR: (CDCl₃, TMS): 7.39–7.42 (d, 4H, Ar–H), 7.60–7.26 (d, 4H, Ar–H), 4.40 (s, 4H, Ar–CH₂N₃).

Synthesis of polytriazoleimides

The synthesis of polytriazoleimide PTAI1 (3, 3-Bis (N-acetylenephenylphthalimide) ether of bisphenol A (BAPPEBPA)-XDA) was used as an example to illustrate the general synthetic route for the preparation of polytriazoleimides: to a 100-ml three-neck round-bottom flask equipped with a magnetic stirrer and a condenser were charged 10 mmol BAPPEBPA, 10 mmol XDA and NMP (50 ml). The temperature of the mixture was increased to 60 °C under stirring. Then sodium ascorbate (0.198 g, 1 mmol) and CuSO₄ 5H₂O (0.125 g, 0.5 mmol) were added to the flask. After the mixture was stirred for 5 min, 10 mmol triethylamine was added. The solution was stirred at 60 °C for 4 h to produce a viscous polytriazoleimide solution. Then the viscous polytriazoleimide solution was poured into 1000 ml water. The precipitation was collected and washed with water. Then the dried precipitation was dissolved in NMP and precipitated again in water. The precipitation was dried at 100 °C under vacuum for 24 h. As a result, the corresponding polytriazoleimide PTAI1 was obtained. Yield: 95%.

PTAI2 (BAPPEBPA-BPDBA), PTAI3 (3, 3-Bis (N-acetylenephenylphthalimide) ketone (BAPPK)-XDA), PTAI4 (BAPPK-BPDBA) and PTAI5 (BAPPE-XDA) were synthesized by a similar method with high yield.

PTAI1 (BAPPEBPA-XDA): ¹H-NMR (DMSO): 1.68 (s, 6H, –CH₃), 5.62 (s, 4H, –CH₂–), 7.05–7.98 (26H, –C₆H₄–, –C₆H₃–, –C₆H₄– and –C₆H₄–), 8.67 (s, 2H triazole-H).

PTAI2 (BAPPEBPA-BPDBA): Yield: 94%. ¹H-NMR (DMSO): 1.68 (s, 6H, –CH₃), 5.64 (s, 4H, –CH₂–), 7.04–7.97 (30H, –C₆H₄–, –C₆H₃–, –C₆H₄– and –C₆H₄–C₆H₄–). 8.65 (s, 2H triazole-H).

PTAI3 (BAPPK-XDA): Yield: 94%. 5.64 (s, 4H, –CH₂–), 7.05–7.99 (26H, –C₆H₄–, –C₆H₃–, –C₆H₄– and –C₆H₄–), 8.67 (s, 2H triazole-H).

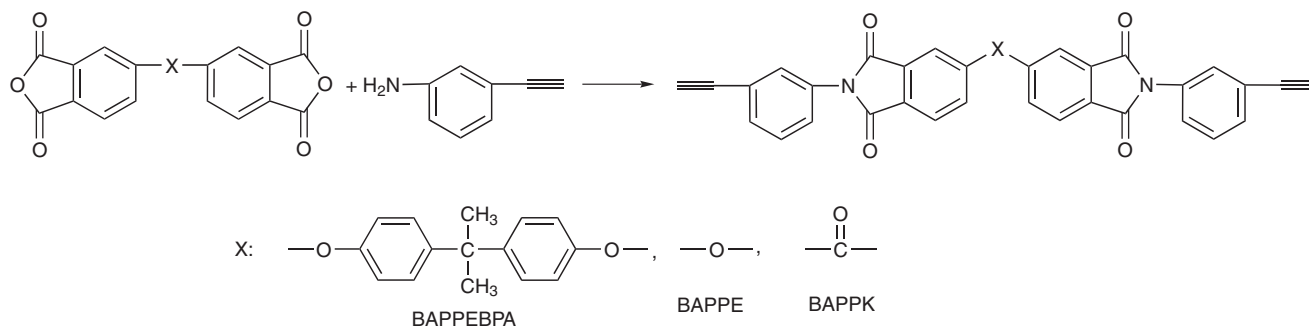
PTAI4 (BAPPK-BPDBA): Yield: 95%. 5.63 (s, 4H, –CH₂–), 7.04–7.98 (30H, –C₆H₄–, –C₆H₃–, –C₆H₄– and –C₆H₄–C₆H₄–). 8.66 (s, 2H triazole-H).

PTAI5 (BAPPE-XDA): Yield: 95%. 5.64 (s, 4H, –CH₂–), 7.08–7.98 (26H, –C₆H₄–, –C₆H₃–, –C₆H₄– and –C₆H₄–), 8.65 (s, 2H triazole-H).

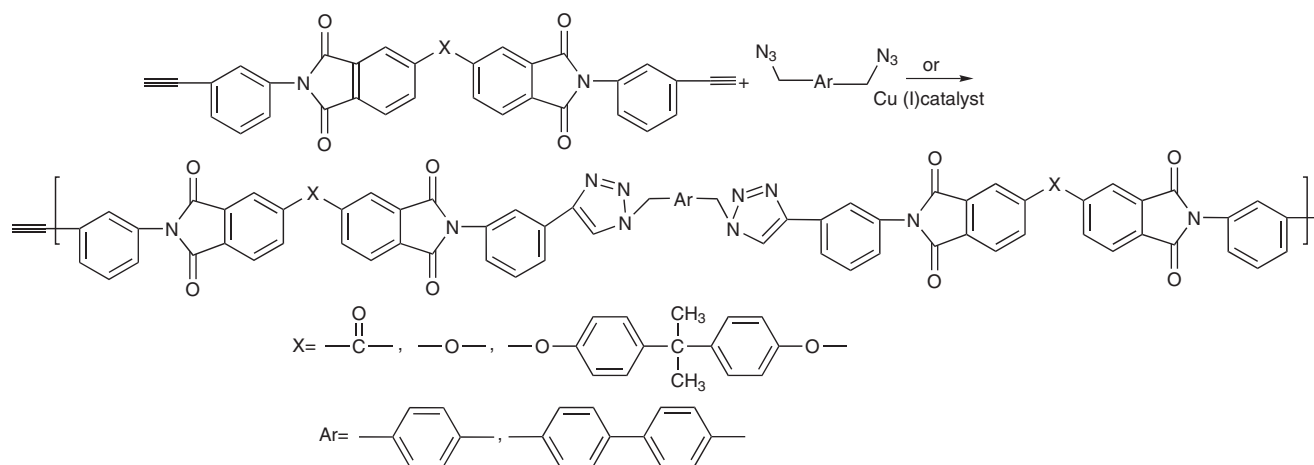
RESULTS AND DISCUSSION

Synthesis of monomers

The synthesis of phthalimide dialkyne monomers is shown in Scheme 1. The dialkyne monomers, namely, BAPPE, BAPPEBPA and BAPPK with phenylacetylene endcapping, were synthesized by the reaction with calculated stoichiometric ratios of 1:2 of anhydride and 3-amine-phenylacetylene in acetone and subsequently cyclodehydrated by chemical imidization in the presence of triethylamine. We used acetone as the solvent to obtain a homogeneous reaction solution. After cyclodehydration by chemical imidization, the resulting monomers were precipitated from solvent and then purified by



Scheme 1 Synthesis of phthalimide dialkyne monomers.



Scheme 2 CuAAC step-growth polymerization of alkyne and azide compounds.

washing with acetone, and the structures were confirmed by FT-IR and $^1\text{H-NMR}$ spectroscopies. All the spectroscopic data obtained were in good agreement with the expected structures. Furthermore, the yields of BAPPEBPA, BAPPE and BAPPK were 90, 95 and 96%, respectively, and the white powder phthalimide dialkyne monomers in this work were stable in air at room temperature.

Synthesis of polytriazoleimides

Polytriazoleimide was prepared from imide-containing dialkynes (BAPPEBPA, BAPPE and BAPPK) and the diazides (XDA and BPDBA) by 1,3-dipolar cycloaddition polymerizations in NMP as shown in Scheme 2. In this work, step-growth polymerization was carried out in the presence of Cu(I) catalyst at 60°C .

Polymerization was carried out through the reaction of stoichiometric amounts of dialkynes with diazides in NMP. BAPPEBPA has good solubility in NMP. When the polymerization of BAPPEBPA and diazides was conducted at the upper-limit concentration (about 25% solid content) in NMP at 60°C , the viscous resin solution was obtained after 2 h. The polytriazoleimides (PTAI1, PTAI2) were easily obtained after post-treatment of the solution. However, BAPPE and BAPPK were partially soluble in NMP. The click polymerization of BAPPE or BAPPK and diazide was conducted at a concentration of 5% solids in the presence of Cu(I) catalyst at 60°C for 4 h, which was almost the upper-limit concentration for BAPPE and BAPPK. The yield of polymers was low, and the polymers had low molecular weight. When the polymerization of BAPPE, BAPPK and diazides was

Table 1 Solubility^a and inherent viscosities (η_{inh}) data of polytriazoleimides

Polymer ^b	Solvent					η_{inh} (dl g ⁻¹) ^c
	DMF	DMAc	DMSO	NMP	THF	
PTAI1	++	++	++	++	–	0.58
PTAI2	++	++	++	++	–	0.51
PTAI3	++	++	++	++	–	0.42
PTAI4	++	++	++	++	–	0.39
PTAI5	++	++	++	++	–	0.48

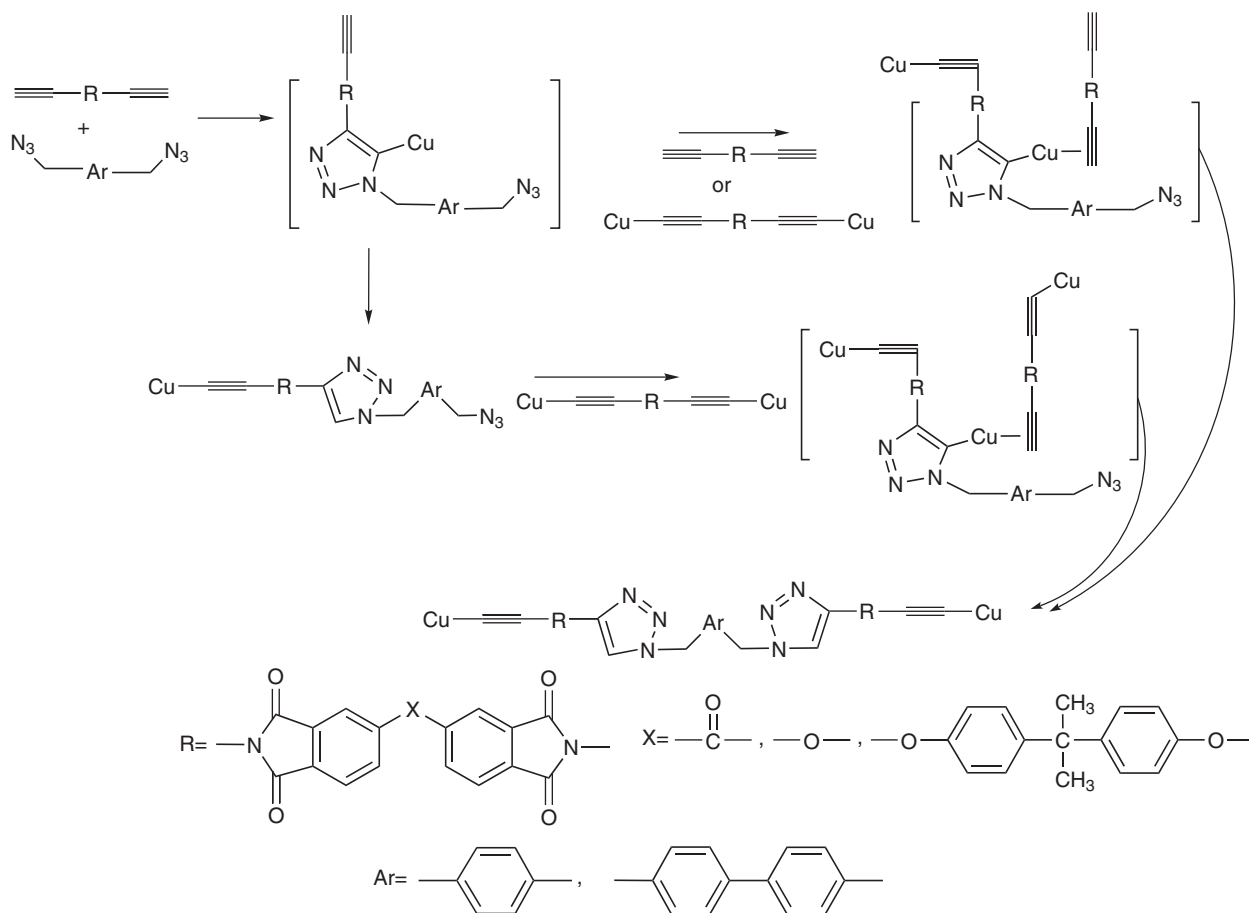
Abbreviations: DMAc, N,N-dimethylacetamide; DMF, dimethylformide; DMSO, dimethylsulfoxide; NMP, N-methyl-2-pyrrolidinone; THF, tetrahydrofuran.

^aThe qualitative solubility was determined at 3.0% (w/v).

^b++Soluble at room temperature; + soluble on heating; – insoluble even on heating.

^cDetermined with 0.5% solutions in a solvent (DMAc) at 30°C .

conducted as an emulsion in NMP at about 20% solids or more, the polymers PTAI3 (BAPPK-XDA), PTAI4 (BAPPK-BPDBA) and PTAI5 (BAPPE-XDA) were readily obtained. Similarly, we obtained PTAI6 (BAPPE-BPDBA) as a low molecular weight polymer. Table 1 lists the inherent viscosities of the resulting polymers: the polymers had inherent viscosities in the range of $0.39\text{--}0.58\text{ dl g}^{-1}$, which implies that polytriazoleimides have high molecular weights compared with conventional polyimides.³⁵ This fact also indicates that the 1,3-dipolar



Scheme 3 The proposed mechanism of the CuAAC step-growth polymerization.³⁶

cycloaddition polymerization is effective for the preparation of polytriazoleimides.

The use of a Cu(I) catalytic system results in the exclusive formation of the 1,4-substituted 1,2,3-triazole, and it accelerates the reaction tremendously. The mechanism of Cu(I)-catalyzed 1,3-dipolar cycloaddition has been extensively investigated.^{10,36} In the CuAAC step-growth polymerization, it begins with the formation of Cu(I) acetylide, as shown in Scheme 3. Then diazide is converted into the Cu(I)–C bond-containing triazole intermediate. The formation of the resulting Cu–C bond-containing (triazole) species is then followed by proteolysis of the Cu(I)–C bond to regenerate the catalyst or to bind alkyne to produce a system of Cu-acetylide. The Cu-acetylide of the pendant azide serves to accelerate the reactions.

The chemical structures of polytriazoleimides were characterized by FT-IR and ¹H-NMR. As shown in Figure 1, the imide characteristic bands at 1780, 1720 and 1370 cm⁻¹ had no change after polymerization, which implied that polymerization did not affect the imide units. The absorption bands of the triazole at 3120 cm⁻¹ appeared, and the absorption bands associated with the vibrational stretching of C≡C–H at 3270 cm⁻¹ and C≡C and –N₃ at 2099 cm⁻¹ disappeared, which indicated that the acetylene and azide groups of the monomers underwent polycycloaddition reactions to give the polytriazoleimides.

The ¹H-NMR spectroscopy of polytriazoleimides showed the presence of the expected repeating unit of polymers. Figure 2 shows the high-resolution ¹H-NMR spectroscopy of the BAPPEBPA monomer and PTAI2 (derived from BAPPEBPA and BPDBA). The acetylene

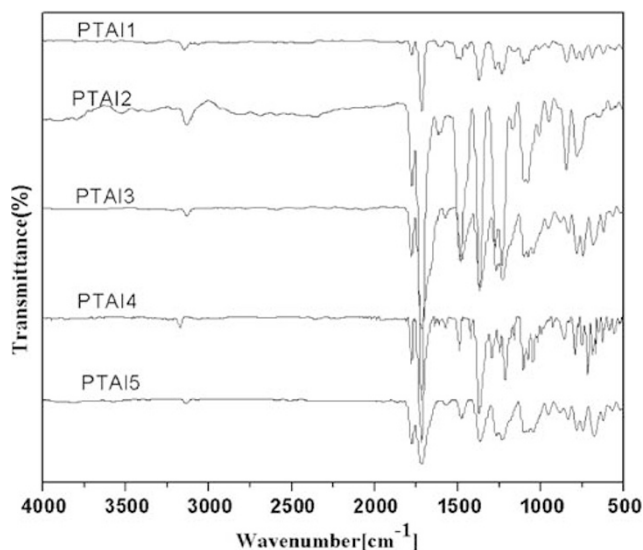


Figure 1 FT-IR spectra of polytriazoleimides.

protons of BAPPEBPA resonated at δ 4.31. This peak completely disappeared after polymerization. The resonance of the methylene protons adjacent to the azide group of BPDBA also disappeared. New resonance peaks were observed at δ 8.65 and 5.63. The peak at 8.65 was associated with the resonances of 1,2,3-triazole rings (d in

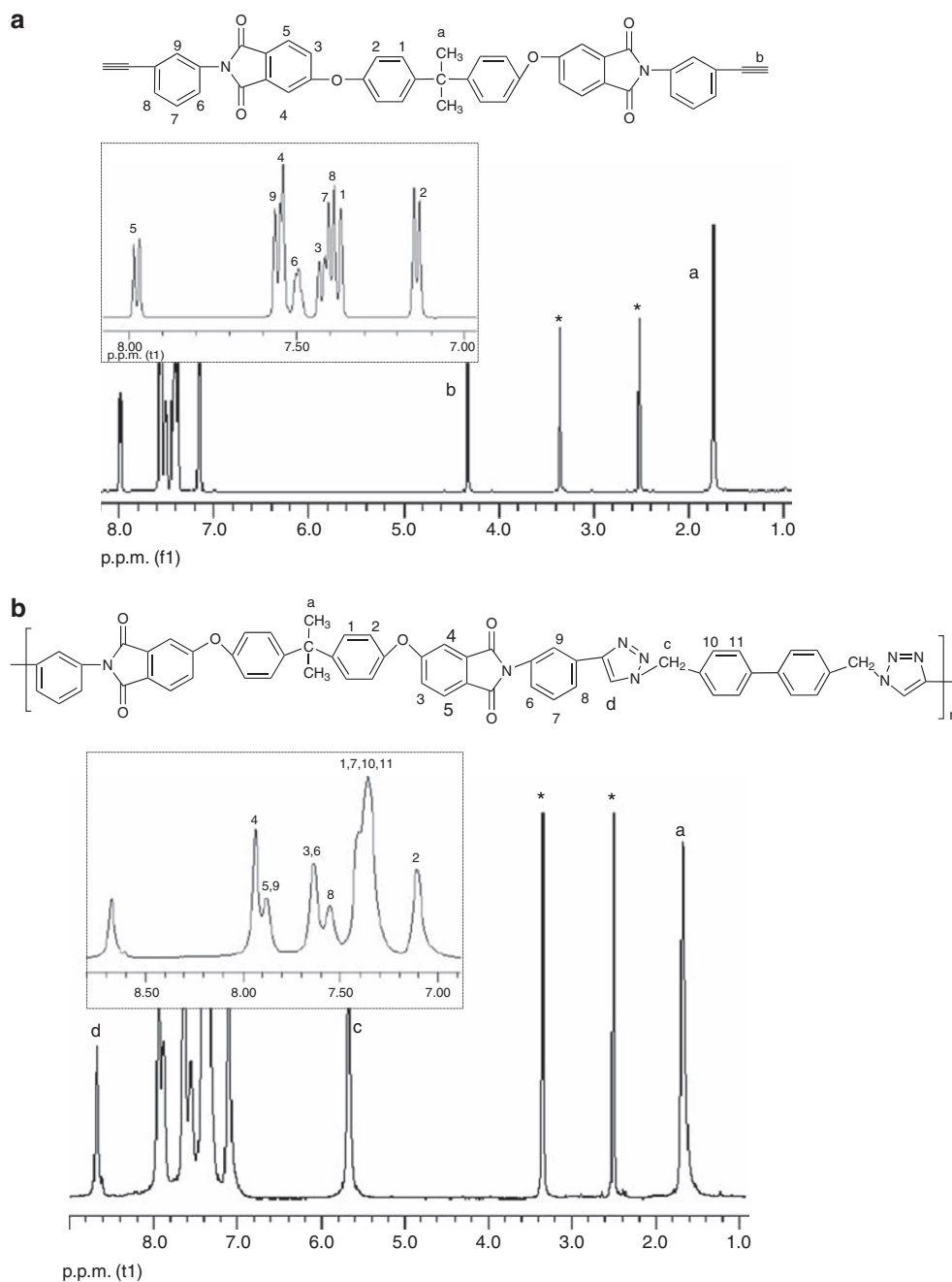


Figure 2 $^1\text{H-NMR}$ spectra of BAPPEBPA and PTAI2 (BAPPEB PABPDBA). (a) BAPPEBPA; (b) PTAI2 (BAPPEB PA-BPDBA). * represents the signal of solvent (DMSO).

Figure 2). The peaks at 5.63 (c) are due to the downfield shift of the benzyl proton resonances of BPDBA after the polymerization reaction. The absorption peaks at 7.2–8.0 p.p.m. were assigned to the aromatic protons in the polytriazoleimide backbone.

Properties of the polytriazoleimides

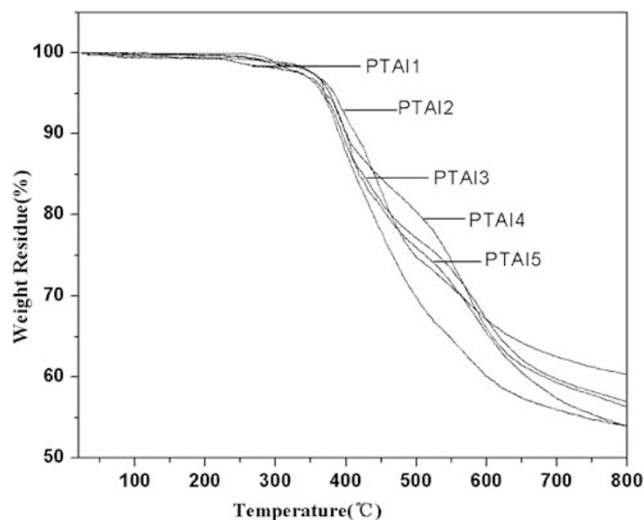
The novel polytriazoleimides could dissolve in organic polar solvents. The solubility of the polymers was determined by dissolving 0.3 g of polymers in 10 ml of solvent, as shown in Table 1. It can be seen that polytriazoleimides could be dissolved in most strong dipolar solvents, such as DMSO, NMP and *N,N*-dimethylacetamide, even at room temperature in most cases. Although the dialkyne monomers such as

BAPPE and BAPPK were partially soluble in *N,N*-dimethylacetamide or NMP, polytriazoleimide could be dissolved in most organic polar solvents. The result indicates that the polymers containing 1,2,3-triazole rings and imide units were dissolved readily in organic polar solvents at room temperature. The good solubility of polytriazoleimides may be attributed to 1,2,3-triazole rings and imide units in the polymer backbone.

The thermal properties of the triazole-containing polytriazoleimides were determined by differential scanning calorimetry and TGA, and the results are listed in Table 2. The values of the glass transition temperature (T_g) of these polytriazoleimides were in the range of 221–252 °C. As expected, the T_g values of these polytriazoleimides

Table 2 Thermal and tensile properties of the polytriazoleimides

Polymer	T_g	T_{d5}	Char Yield ^a (%)	Tensile Strength (MPa)	Elongation (%)	Modulus (GPa)
PTAI1	221	365	53.9	92.4	6.4	1.89
PTAI2	224	377	60.2	89.7	6.4	1.87
PTAI3	249	369	57.0	76.2	6.4	1.86
PTAI4	250	376	56.3	84.6	6.9	1.80
PTAI5	253	369	53.8	83.1	4.8	2.03

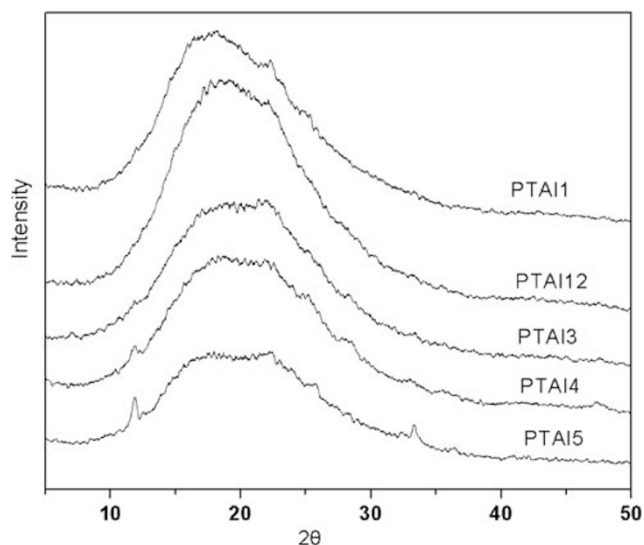
^aResidual weight (%) when the polymers were heated to 800 °C in nitrogen.

Figure 3 TGA curves of polytriazoleimides.

depended on the structure of the dialkyne component and decreased with the increasing flexibility of the polymer backbones. According to the results, PTAI1 (BAPPEBPA-XDA) and PTAI2 (BAPPEBPA-BPDBA) had lower T_g because of the presence of a flexible ether bridge between the phthalimide and phenyl units.

Figure 3 shows the TGA curves of these polytriazoleimides. The polytriazoleimides have high initial decomposition temperatures. The temperatures at 5% weight losses of the polytriazoleimides reached 365–376 °C in nitrogen. Their char yields at 800 °C in nitrogen were in the range of 53.8–60.2 wt%. Compared with conventional polyimides,^{35,37} the polytriazoleimides showed lower decomposition temperatures because of the weak bonding of the –C–N– adjacent to diazide and the easy breakage during the heating process.

The crystallinity of the polytriazoleimides was examined by wide-angle X-ray diffractometer analysis. The wide-angle X-ray diffractometer patterns for films of the polyimides are shown in Figure 4, in which PTAI1–PTAI4 displays amorphous patterns, and PTAI5 shows a semicrystalline pattern. The amorphous nature of PTAI1–PTAI4 could be attributed to the weak interpolymer chain interactions. PTAI5 showed a semicrystalline pattern because of a rigid backbone resulting in a high degree of in-plane orientation.

The polytriazoleimide films could be prepared from PTAI1–PTAI5 by casting the polymer NMP solution on glass plates followed by thermal heating in the following procedure: 80 °C/2 h, 120 °C/1 h, 150 °C/1 h, 180 °C/4 h in air. Table 2 summarizes the tensile strengths and moduli of the polytriazoleimide films. The PTAI films showed high mechanical properties when compared with reported polyimides.^{35,37} The films had tensile strengths of 76.2–92.4 MPa, tensile


Figure 4 Wide-angle X-ray diffraction patterns of polytriazoleimides.

moduli of 1.80–2.03 GPa, and elongations at breakage of 4.8–6.9%, which indicates that they are strong and tough polymeric materials.

CONCLUSION

A series of novel polytriazoleimides was synthesized by the copper-catalyzed step-growth polymerization of diazide-dialkynes and characterized by IR, NMR, wide-angle X-ray diffractometer, differential scanning calorimetry, TGA and inherent viscosity. The results showed that the polytriazoleimides, with inherent viscosities of 0.39–0.58 dl g⁻¹, had good solubility in polar solvents and could be easily cast into transparent, tough and flexible films. These novel polytriazoleimide films also exhibited good thermal stability and mechanical properties.

1,2,3-Triazoles are noteworthy for their pseudoaromatic nature, large dipole moment, and excellent hydrogen-bonding ability.³⁸ We believe that the properties and good stability of polytriazoleimides could be advantageous in applications such as high-performance metal coatings and adhesives. The functionalities and applications of these types of materials are currently under investigation.

ACKNOWLEDGEMENTS

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