NEW OPTICALLY ACTIVE ORGANO-SOLUBLE POLY(AMIDE-IMIDE)S FROM [N,N'-(4,4'-DIPHTALOYL)-BIS-L-AMINO DIACID]S AND 1,2-BIS[4,4'-AMINOPHENOXY] ETHANE: SYNTHESIS AND CHARACTERIZATION

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ABSTRACT

Six new dicarboxylic acids **3a-f** were synthesized by the reaction of 3,3',4,4'-biphenyltetracarboxylic dianhydride (BPDA) **1** with L-amino acids **2a-f** in a solution of glacial acetic acid/pyridine (Py) at refluxing temperature. Then six new optically active poly(amide-imide)s (PAI)s with good inherent viscosities were synthesized by direct polycondensation reaction of [N,N'-(4,4'-diphtaloyl)-bis-L-amino diacid]s with 1,2-bis[4,4'-aminophenoxy] ethane (APE) **4** in a medium of N-methyl-2-pyrrolidone (NMP)/ triphenyl phosphite (TPP)/ calcium chloride (CaCl₂)/pyridine. Not only PAIs are optically active but also soluble in various organic solvents. These resulting new polymers can be used in column chromatography for the separation of enantiomeric mixtures. The resulted polymers were fully characterized by means of FTIR, ¹H-NMR spectroscopy, elemental analyses, inherent viscosity, specific rotation, solubility tests and UV-Vis spectroscopy. Also thermal properties of the PAIs **3a-f** were investigated using thermal gravimetric analysis (TGA).

Keywords: Poly(amide-imide); Thermal properties; Organo-soluble polymer; Inherent viscosity.

INTRODUCTION

Since their development in the 1960s, polyimides have become an important class of polymers, finding a wide range of applications in the aerospace and microelectronics industries. Aromatic polyimides are well known high-performance polymers because of their excellent thermal stability, mechanical and electrical properties and chemical resistance [1, 2]. However, polyimides are often insoluble and intractable characteristics resulting in processing difficulties which limit their applications [3].

Modification of high performance polymers by increasing the solubility and lowering the transition temperatures while maintaining thermal stability are of particular interest. Copolycondensation is one of the possible ways for modification of polymer properties. Thus, processing of polyimides many copolyimides, such as poly(amide-imide)s, poly(ester-imide)s, and other copolymers have been prepared [4-9]. The synthesis of poly(amide-imide)s is more attractive than the other methods of copolymerization, because solubility and processability can be improved without significantly sacrificing the thermal and mechanical properties, they are useful in numerous applications in electrical wire enamel, adhesives, and injection-molding and extrusion products [10-12]. These polymers are a type of chemicals materials, which could become one of the new sources of a family of environmentally friendly.

We use amino acids as chiral agents which are often naturally occurring compounds therefore synthetic polymers based on amino acids are expected to be biodegradable and biocompatible.

This paper reports the preparation and basic characterization of photosensitive and thermally stable poly(amide–imide)s (PAI)s **5a-f** by the direct polycondensation reaction of [N,N'-(4,4'-diphtaloyl)-bis-L-amino diacid]s with 1,2-bis[4,4'-aminophenoxy] ethane (APE)**4**in a medium consisting of N-methyl-2-pyrrolidone (NMP), triphenyl phosphite (TPP), calcium chloride (CaCl₂) and pyridine (Py). As reported previously, APE has been synthesized through a two step reaction starting from 4-nitro phenol and 1,2- dibromo ethane in the presence of potassium carbonate, followed by catalytic reduction with hydrazine monohydrate 10% Pd/C [13-15].

EXPERIMENTAL

Materials

3, 3', 4, 4'- Biphenyltetracarboxylic dianhydride (1; Aldrich), L-alanine 2a, L-valine 2b, L-leucine 2c, L-2-amino-2-phenylacetic acid 2d, L-phenylalanine 2e and L-2-aminobutyric acid 2f (Merck) were used without previous purification. Diamine APE 4 (mp = 115- 117°C) was prepared according to our previous work [16]. NMP (Fluka), Py (Acros) and TPP (Merck) were used as received. Commercially available CaCl₂ (Merck) was dried under vacuum at 150 °C for 6 h.

Techniques

¹H-NMR and ¹³C-NMR spectra were recorded on a Bruker 300 MHz instrument (Germany). Fourier transform infrared (FTIR) spectra were

recorded on Galaxy series FTIR 5000 spectrophotometer (England). Spectra of solid were performed by using KBr pellets. Vibration transition frequencies were reported in wave numbers (cm⁻¹). Band intensities were assigned as weak (w), medium (m), shoulder (sh), strong (s) and broad (br). Inherent viscosities were measured by a standard procedure by using a Technico Regd Trad Mark Viscometer. UV-Vis absorptions were recorded at 25°C in the 270–790 nm spectral regions with a Perkin-Elmer Lambda 15 spectrophotometer on DMF solution by using cell lengths of 1 cm. Specific Rotations were measured by an A-Kruss polarimeter. Thermal Gravimetric Analysis (TGA and DTG) data of polymers were taken on a Mettler TA4000 System under N₂ atmosphere at rate of 10°C/min. Elemental analyses were performed by Vario EL equipments.

Monomer synthesis

[N, N'-(4,4'-diphtaloyl)-bis-L-amino diacid]s 3a-f

2.942 g (10.00 mmol) of 3, 3', 4, 4'- biphenyltetracarboxylic dianhydride 1, 20.00 mmol of L-amino acids **2a–f**, 80 mL of mixture of acetic acid/pyridine (3:2) and a stirring bar were placed into a 250-mL round-bottomed flask. The mixture was stirred at room temperature overnight and refluxed for 4-10 h. The solvent was removed under reduced pressure, and the residue was dissolved in 100 mL of cold acidic water. A white to cream precipitate was formed, filtered off, and dried to give compounds [N, N'-(4, 4'-diphtaloyl)-bis-L-amino diacid] s **3a–f**.

Polymer synthesis

A mixture of di carboxylic acid **3a-f** (1 mmol), di amine APE **4** (1 mmol), calcium chloride (0.350 g), TPP (0.8 ml), pyridine (1.2 ml) and NMP (4.0 ml) was refluxed for 10 h. After cooling, the reaction mixture was poured into methanol (50 ml) to precipitate the corresponding polymer. The precipitated polymer was then separated by vacuum filtration and washed with methanol (30 ml) and hot water (100 ml) and dried at 120°C under vacuum for 24 h. IR and NMR spectroscopic results of the obtained polymers will be discussed in the Results and Discussion section.

RESULTS AND DISCUSSION

Monomer synthesis

Asymmetric di carboxylic acids 3a-f were synthesized by the condensation reaction of 3,3',4,4'- biphenyltetracarboxylic dianhydride 1 with two equimolars of L-alanine 2a, L-valine 2b, L-leucine 2c, L-2-amino-2-phenylacetic acid 2d, L-phenyl alanine 2e and L-2-aminobutyric acid 2f in an acetic acid/pyridine solution. In this work, we used six diacids 3a-f for direct polycondensation (Scheme 1). Di acid 3e was synthesized previously [17]. The yields and some physical properties of these compounds are shown in Table 1. Chemical structure and purity of the optically active di carboxylic acids 3a-f were proved by using elemental analysis, FTIR, ¹H-NMR and ¹³C-NMR spectroscopic techniques. These data are shown in Table 2.



Scheme 1. Synthesis of the dicarboxylic acids 3a-f.

Table	1.	Yields	and	some	physical	properties	of chiral	the	di	carboxy	li
acids 3a-f .											

Entry	Amino acid	Yield (%)	Mp (°C)	$\left[\alpha\right]_{D}^{25(a)}$
3a	L-Alanine	94	287-289	-7.5
3b	L-Valine	92	270-271	+4.5
3c	L-Leucine	83	275-277	+2.1
3d	L-2-amino-2-phenyl acetic acid	91	245-246	-8.2
3e	L-Phenyl alanine	94	295-297	-6.5
3f	L-2-Aminobutyric acid	88	263-265	+14.6

^(a) Measured at a concentration of 0.5 g/dl in DMF at 25°C.

Table 2. ¹H-NMR, ¹³C-NMR, FTIR spectra and elemental analyses data of the di carboxylic acids derivatives **3a-f**.

diacid	Spectral data
3a	¹ H-NMR (DMSO- <i>d_o</i> δ ppm): 12.87-12.93 (s, br, 2H), 8.28-8.32 (m, 4H), 8.00-8.03 (m, 2H), 4.90-4.92 (q, 2H), 1.56-1.58 (d, 6H). ¹³ C-NMR (DMSO- <i>d_o</i> , δ ppm): 171.49, 167.15, 144.75, 134.08, 132.63, 131.34, 124.40, 122.53, 47.58, 15.18. FT-IR Peaks (cm⁻¹): 3100-3419 (m, sh,br), 2928 (w), 1772 (w), 1710 (s, br), 1620 (w), 1425 (w), 1384 (m), 1300 (w), 1248 (m), 1149 (m), 1084 (w), 937 (w), 742 (m). Elemental analysis: calcd for $C_{22}H_{16}O_8N_2$: C, 60.55; H, 3.67; N, 6.42. found: C, 60.04; H, 3.31; N, 6.32.
3b	¹ H-NMR (DMSO- <i>d</i> , δ ppm): 12.92-13.10 (s, br, 2H), 8.22-8.35(m, 4H), 8.04-8.06(m, 2H), 4.48-4.51(d, 2H), 2.60-2.62(m, 2H), 0.84-1.07(dd, 6H). ¹³ C-NMR (DMSO- <i>d</i> , δ ppm): 170.17, 167.49, 145.13, 134.39, 132.49, 131.20, 124.56, 122.95, 57.61, 28.45, 21.27, 19.70. FT-IR Peaks (cm⁻¹): 2986-3410 (m, sh,br), 2933 (w), 1772 (w), 1710 (s, br), 1620 (w), 1431 (w), 1377 (m), 1300 (w), 1267 (m), 1194 (m), 1080 (w), 900 (w), 746 (m). Elemental analysis: calcd for $C_{20}H_{20}N_{2}$: C, 63.41; H, 4.87; N, 5.69. found: C, 62.50; H, 4.21; N, 4.99.
3c	¹ H-NMR (DMSO- <i>d</i> , δ ppm): 12.85-12.95(s, br, 2H), 8.29-8.40(m, 4H), 7.99-8.07(m,2H), 4.77-4.85(m,2H), 1.88-2.2(dd, 4H), 1.35-1.65(m, 2H), 0.84-0.91(m,12H). ¹³ C-NMR (DMSO- <i>d</i> , δ ppm): 171.16, 167.48, 145.17, 134.39, 132.62, 131.34, 124.53, 122.96, 50.78, 25.12, 23.42, 21.29. FT-IR Peaks (cm ⁻¹): 3176-3400 (m, sh,br), 2960 (w), 1774 (w), 1695 (s, br), 1622 (w), 1431 (w), 1379 (m), 1300 (w), 1244 (m), 1157 (m), 1091 (w), 918 (w), 748 (m). Elemental analysis: calcd for $C_{28}H_{28}O_{8}N_{2}$: C, 64.61; H, 5.38; N, 5.38. found: C, 63.24; H, 4.99; N, 5.07.

3d	¹ H-NMR (DMSO- <i>d_s</i> , δ ppm): 12.70- 12.56(s, br, 2H), 8.23(s, br, 4H), 7.92-7.95(m, 2H), 7.16(m, 10H), 5.12- 5.16(dd, 2H), 3.47-3.51(m, 4H). ¹³ C-NMR (DMSO- <i>d_s</i> , δ ppm): 170.17, 177.16, 167.13, 145.07, 137.76, 134.52, 132.17, 130.83, 129.17, 128.80, 127.03, 124.27, 123.00, 52.86, 34.45. FT-IR Peaks (cm⁻¹) : 3067-3400 (m, sh,br), 2960 (w), 1774 (w), 1718 (s, br), 1604 (w), 1510 (w), 1373 (m), 1300 (w), 1224 (m), 1105 (m), 1091 (w), 941 (w), 740 (m). Elemental analysis: calcd for $C_{32}H_{30}O_8N_2$: C, 67.36; H, 5.26; N, 4.91. found: C, 66.85; H, 5.10; N, 4.71.
Зе	¹ H-NMR (DMSO- d_s , δ ppm): 12.67-12.46(s, br, 2H), 8.31-8.36(m, 4H), 8.23-8.28(m, 2H), 7.34-7.50(m, 10H), 6.07(s, 2H). ¹³ C-NMR (DMSO- d_s , δ ppm): 169.36, 167.00, 145.13, 135.41, 134.48, 132.53, 131.27, 129.15, 129.03, 128.79, 128.44, 127.85, 124.68, 123.07, 55.85. FT-IR Peaks (cm⁻¹): 3060-3400 (m, sh,br), 2960 (w), 1774 (w), 1718 (s, br), 1593 (w), 1527 (w), 1375 (m), 1317 (w), 1201 (m), 1140 (m), 1066 (w), 920 (w), 700 (m). Elemental analysis: calcd for $C_{35}H_2Q_8N_2$: C, 70.01; H, 4.02; N, 4.67. found: C, 69.74; H, 3.87; N, 4.18.
3f	¹ H-NMR (DMSO- d_{o} , δ ppm): 12.65-12.43(s, br, 2H), 8.32-8.35(m, 4H), 8.04-8.06(m, 2H), 4.68- 4.74(m, 2H), 2.04-2.18(m, 4H), 0.84-0.89(t, 6H). ¹³ C-NMR (DMSO- d_{o} , δ ppm): 170.91, 167.53, 145.10, 134.41, 132.41, 131.31, 124.55, 122.97, 53.86, 22.00, 11.28. FT-IR Peaks (cm⁻¹): 3340 (w), 2933 (w), 1772 (m), 1714 (s), 1670 (s), 1606 (s), 1458 (m), 1375 (m), 1300 (w), 1228 (m), 1176 (m), 1070 (w), 949 (m), 740 (s), 522 (m). Elemental analysis: calcd for C ₂₄ H ₂₀ O ₈ N ₂ : C, 62.06; H, 4.31; N, 6.03. found: C, 61.42; H, 4.11; N, 5.83.

These FTIR data showed absorption around 2500 and 3400 cm⁻¹, which was assigned to the COOH groups. Peaks appearing at around 1700- 1770 cm⁻¹ (acid C=O and symmetric imide stretching), 1390- 700 cm⁻¹ imide charasteristic ring vibration) confirmed the presence of imide ring and carboxylic groups in these compounds. Also ¹³C-NMR data showed carboxylic acid and imide carbons and aromatic carbons in related signals.

As an example, the ¹H-NMR spectrum of diacid **3f** showed peaks between 0.84 and 0.89 ppm as a triplet, which was assigned for two CH₃ group (d) peak between 2.04 and 2.18 ppm as a multiplet, which was assigned to the CH₂ (c) protons and peaks between 4.68 and 4.74 ppm as a doublet of doublet, which was assigned to the CH (b) protons, which are chiral centers. The peaks at 8.04-8.35 ppm were assigned to aromatic protons (e, f and g). Also a broad peak in 12.95 ppm was assigned to COOH groups (Fig. 1). The measured results in elemental analyses of these compounds were closely corresponded to the calculated ones, demonstrating that the expected compounds were obtained.

Polymer synthesis

The direct polycondensation of a dicarboxylic acid and the diamine is one of the well-known methods for (PAI)s synthesis. In this work, we synthesized (PAI)s **5a–f** containing ether and methylene moieties by direct polycondensation reactions of six chiral [N,N'-(4,4'-diphtaloyl)-bis-L-aminodiacid]s**3a–f**with 1,2-bis[4,4'-aminophenoxy] ethane**4**by using triphenylphosphite (TPP) and pyridine as condensing agents (Scheme 2).

All the polycondensations proceeded readily in a homogeneous solution. Tough and stringy precipitates formed when the viscous polymer solutions were trickled into the stirring methanol.

Yields and some physical properties of these new (PAI) s **5a-f** are given in Table 3. All the polymers were obtained in high yields (82-94%), and the inherent viscosities (0.30-0.45 dl/g) was measured in DMF solutions. Due to the presence of chiral amino acid moieties **2a-f** in the polymer backbone, the polymers **5a-f** are optically active and the specific rotations are given in Table 3. Also the resulting polymers have a range of color between cream and light brown.



Fig. 1. 'H-NMR spectrum (DMSO- d_{ρ}) of di carboxylic acid **3f** Scheme 2. Synthesis rout of (PAI)s **5a-f**

Table 3. Yields and some physical properties of (PAI) s 5a-f.

diacid	polymer	Yield (%)	$\eta_{inh}(dL/g)^{(a)}$	$\left[\alpha\right]_{D}^{~25(a)}$	Color
3 a	5a	89	0.31	+105	Light Yellow
3b	5b	92	0.30	+117	Cream
3c	5c	82	0.41	+94.5	Cream
3d	5d	83	0.42	+111.5	Dark cream
3e	5e	94	0.45	+101.5	Light brown
3f	5f	84	0.39	+66.5	Cream

^(a) Measured at a concentration of 0.5 g/dl in DMF at 25 °C.

Polymer characterization

The structure of polymers was confirmed as (PAI) s by means of FTIR spectroscopy and elemental analyses. Representative FTIR spectrum of PAI **5f** was shown in Figure 2. The polymer showed the C=O asymmetric stretching of imide at 1772 cm⁻¹, the C=O symmetric stretching of imide at 1714 cm⁻¹ and C-N stretching at 1375 cm⁻¹. The absorption bands of amide groups appeared at 3340 cm⁻¹ (N-H stretching). All of these PAIs exhibited strong absorption around 1380 and 730 cm⁻¹, which shows the presence of the heterocyclic imide groups. FTIR spectroscopy data for all of PAIs **5a-f** are listed in table 4.

Table 4	FTIR	characterization	of PAIs	5a-f
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Polymer	Spectra data
5a	FT-IR Peaks (cm⁻¹): 3350 (m, br), 3066 (w), 2945 (w), 1776 (m), 1714 (s, br), 1672 (s), 1593 (s), 1492 (s), 1380 (m), 1320 (w), 1245 (m), 1140 (m), 1052 (m), 922 (m), 743 (m).
5b	FT-IR Peaks (cm⁻¹): 3375 (w), 3065 (w), 1776 (w), 1720 (s), 1625 (w), 1524 (s), 1385 (m), 1248 (m), 1122 (w), 1056 (w), 1082 (m), 925 (s), 726 (w).
5c	FT-IR Peaks (cm⁻¹): 3354 (w), 2924 (w), 1776 (m), 1722 (s, br), 1610 (m), 1515 (s), 1386 (s), 1248 (s), 1176 (w), 1088 (w), 1053 (w), 825 (w), 725 (s), 617 (w), 524 (w).
5d	FT-IR Peaks (cm⁻¹): 3345 (w), 2961 (m), 1776 (w), 1716 (s), 1675 (m), 1638 (w), 1587 (m), 1465 (m), 1385 (s), 1321 (w), 1201 (m), 1113 (w), 725 (w).

5e	FT-IR Peaks (cm⁻¹): 3358 (w), 2916 (w), 1776 (w), 1720 (s, br), 1616 (m), 1515 (s), 1388 (s), 1295 (m), 1252 (m), 1107 (w), 1099 (w), 1055 (w), 825 (w), 723 (s), 524 (m).
5f	FT-IR Peaks (cm⁻¹): 3340 (w), 2933 (w), 1772 (m), 1714 (s), 1670 (s), 1606 (s), 1458 (m), 1375 (m), 1300 (w), 1226 (m), 1176 (m), 1070 (w), 949 (m), 740 (s), 522 (m).

Fig.2. FTIR spectrum of PAI 5f

The ¹H-NMR spectrum of PAI **5a** showed peaks that confirm its chemical structure (Fig. 3). The aromatic protons and four methylene protons related these last ones to the diamine **4**, appeared in the region of 6.73-8.31 ppm and 4.24-4.48 ppm respectively. A single peak at 9.74 ppm is assigned for N-H amide groups in the polymer chain. Also the elemental analyses of the resulting (PAI)s **5a-f** were in good agreement with the calculated values for the proposed structure (Table 5).

Fig.3. ¹H-NMR spectrum (DMSO-d₄) of PAI 5a

Polymer	Formula		%C	%Н	%N			
5a	$C_{36}H_{28}N_4O_8$	Calcd	67.10	4.34	8.69			
	(644.28) _n	Found	66.74	3.95	7.89			
5b	$C_{40}H_{36}N_4O_8$	Calcd	68.59	5.14	7.99			
	(700.32) _n	Found	68.10	4.65	7.71			
5c	$C_{42}H_{40}N_4O_8$	Calcd	69.25	5.49	7.68			
	(728.34) _n	Found	69.10	5.23	7.43			
5d	$C_{46}H_{32}N_4O_8$	Calcd	71.89	4.16	7.28			
	(768.38) _n	Found	69.84	4.98	6.87			
5e	$C_{48}H_{36}N_4O_8$	Calcd	72.38	4.52	7.03			
	(796.40) _n	Found	72.32	4.21	6.69			
5f	$C_{38}H_{32}N_4O_8$	Calcd	67.88	4.75	8.32			
	(672.30) _n	Found	67.82	4.65	8.08			

Table 5. Elemental analysis of PAIs 5a-f.

Solubility of the PAIs

Solubility of (PAI)s **5a-f** was investigated as 0.01 g of polymeric sample in 2 mL of solvent. These poly(amide-imide)s have good solubility in aprotic organic solvents. Remarkably, all of these PAIs were easily soluble at room temperature in aprotic polar solvents such as NMP, N, N'-dimethylacetamide (DMAc), N,N'-dimethylformamide (DMF), and insoluble in solvents such as chloroform, ethanol and methanol. It is due to the flexibility effect of the etheric structure of the diamine (Table 6).

Table 6. Solubility of PAIs 5a-f.

Solvent	5a	5b	5c	5d	5e	5f
DMAc	+	+	+	+	+	+
DMSO	+	+	+	+	+	+
DMF	+	+	+	+	+	+
NMP	+	+	+	+	+	+
МеОН	-	-	-	-	-	-
EtOH	-	-	-	-	-	-
CHCl ₃	-	-	-	-	-	-
CH ₂ Cl ₂	-	-	-	-	-	-
H ₂ O	-	-	_	—	_	_

+, Soluble at room temerature. -, Insoluble at room temperature

UV-Vis Absorption characteristics

Photo-sensitive property of the new poly(amide-imide)s **5a-f** in the DMF solution was studied by a UV spectrophotometer. All polymer solutions exhibit

the same two positions of absorption maximum in UV-Vis spectra at 330– 337 nm. The absorption maximum at around 340 nm corresponds to $n \rightarrow \pi^*$ transition of the nonbonding electrons which is present in nitrogen and oxygen atoms in the polymer backbone. The UV-Vis absorption spectrum of PAI **5f** in DMF is shown in Fig. 4. The spectrum of PAI **5f** exhibited a typical peak around 330 nm ($n \rightarrow \pi^*$ transition).



Fig.4. UV-Vis absorption spectrum of PAI 5f in DMF solution

Thermal properties

TGA and derivative of thermogravimetric (DTG) analysis at a rate of 10 °Cmin⁻¹ in a nitrogen atmosphere were utilized to examine the thermal properties of the PAIs. Obtained results are summarized in Table 7. Figure 5 shows TGA results of the PAIs **5b** and **5d**; respectively.

The thermal stability of the polymers was studied on the basis of 5 % and 10 % weight losses (T_s and T_{10} respectively) of the polymers and the residue at 800 °C (char yield). The results revealed that the PAIs were thermally stable up to 400 °C (Table 7).

The char yield can be applied as a decisive factor for estimating the limited oxygen index (LOI) of polymers using Van Krevelen and Hoftyzer's equation [18]:

LOI = 17.5 + 0.4CR

Where CR is the char yield.

PAIs **5b** and **5d** had LOI values around 35, which were calculated from their char yield. On the basis of the LOI values, such macromolecules can be classified as self-extinguishing polymers.

Table 7. Thermal behavior of PAIs 5b and 5d.

polymer	$T_5(^{\circ}C)^a$	$T_{10}(^{\circ}C)^{a}$	Char yield (%) ^b	LOI °
5b	420	460	45	35.5
5d	412	450	46	35.9

 $^{\rm a}$ Temperature at which 5% or 10% weight loss was recorded by TGA at a heating rate of 10 $^{\circ}C/min$ under $N_{\rm 2}.$

^b Weight percentage of material left after TGA analysis at a maximum temperature of 800 °C under N₂.

^c Limiting Oxygen Index (LOI).



Fig.5. TGA curves of the (PAI)s 5b and 5d.

CONCLUSIONS

In this article, we have successfully synthesized 6 dicarboxylic acid **3a-f** containing amino acidic moieties. A series of new thermally stable PAIs **5a-f** were prepared from chiral [N, N'-(4, 4'-diphtaloyl)-bis-L-amino diacid]s **3a-f** with 1,2-bis[4,4'-aminophenoxy] ethane **4** by direct polycondesation method. The results presented here also clearly demonstrate that incorporating the imide group into the polymer main chain as well as combination of the wholly aromatic backbone and several functional groups enhanced the thermal stability of the new polymers. These polymers are expected to have high solubility due to the presence of the alkyl groups in the polymer chain. These properties could make these PAIs attractive for practical applications such as processable high-performance engineering plastics, column chromatography for the separation of the enantiomeric mixtures.

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