

Synthesis and photophysical properties of novel organo-soluble polyarylates bearing triphenylamine moieties

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Abstract Two series of new blue photoluminescent aromatic polyesters (polyarylates) were synthesized from 4, 4'-dicarboxytriphenylamine and 4,4'-dicarboxy-4"-methyltriphenylamine with various bisphenols by the diphenylchlorophosphate (DPCP) activated direct polycondensation in a medium of pyridine and lithium chloride. These polymers were amorphous and readily soluble in various common organic solvents including DMAc, THF, and chloroform, and could be cast from their chloroform solutions into transparent films due to their excellent solubility. These polyarylates exhibited moderately high T_g values (186–264 °C) and thermal stability. In THF solution, these triphenylamine-containing polyarylates showed UV-Vis absorption bands at 359–365 nm and photoluminescence peaks around 427–451 nm in the blue region.

Key words polyarylates · triphenylamine · electrochemistry · photoluminescence · blue-light-emitting polymers

Introduction

Interest in molecular engineering of physical properties for high-performance polymers persists because small alterna-

tion of molecular structure of a polymer can dramatically influence performance and processing properties. Generally, alteration of high-performance polymers focuses on changes in substitution pattern of aromatic cyclic units comprising the bulk of such polymers. Change in chain stiffness or rigidity via modification of primary and secondary structures is particularly effective. [1] It is well known that wholly aromatic polyesters (polyarylates) possess high thermal stability and excellent mechanical properties. [2] So far, however, most studies have focused on their high-performance applications. There is no application using polyarylates as photonic/electronic device materials. Thus, modulation of their photophysical and electrical properties by means of a simple condensation synthetic method may be an impressive challenge in terms of new development of polymeric light-emitting diodes (PLEDs) materials.

Arylamine-containing aromatics have attracted considerable interest as hole-transporting materials for use in multilayer organic electroluminescence (EL) devices because of their low ionization potential and high hole mobility. [3–6] The electroactive site of triphenylamine (TPA) is the nitrogen center, which is linked to three phenyl groups in a propeller-like geometry. The anodic oxidation pathway of TPA was well reported and the electrogenerated TPA cation radical dimerized to form tetraphenylbenzidine, which is more easily oxidized than the TPA molecule. [7] The electrochemical properties of TPA are affected when some of the hydrogen atoms are substituted with groups of different electronic strengths. In our previous studies it was found that TPA revealed lower oxidation potential and the formed cation radical was stabilized when electro-donating groups (methyl, methoxy) were substituted at the *para*-phenyl position. [8–10] The feasibility of utilizing spin-coating and ink-jet printing processes for large-area EL

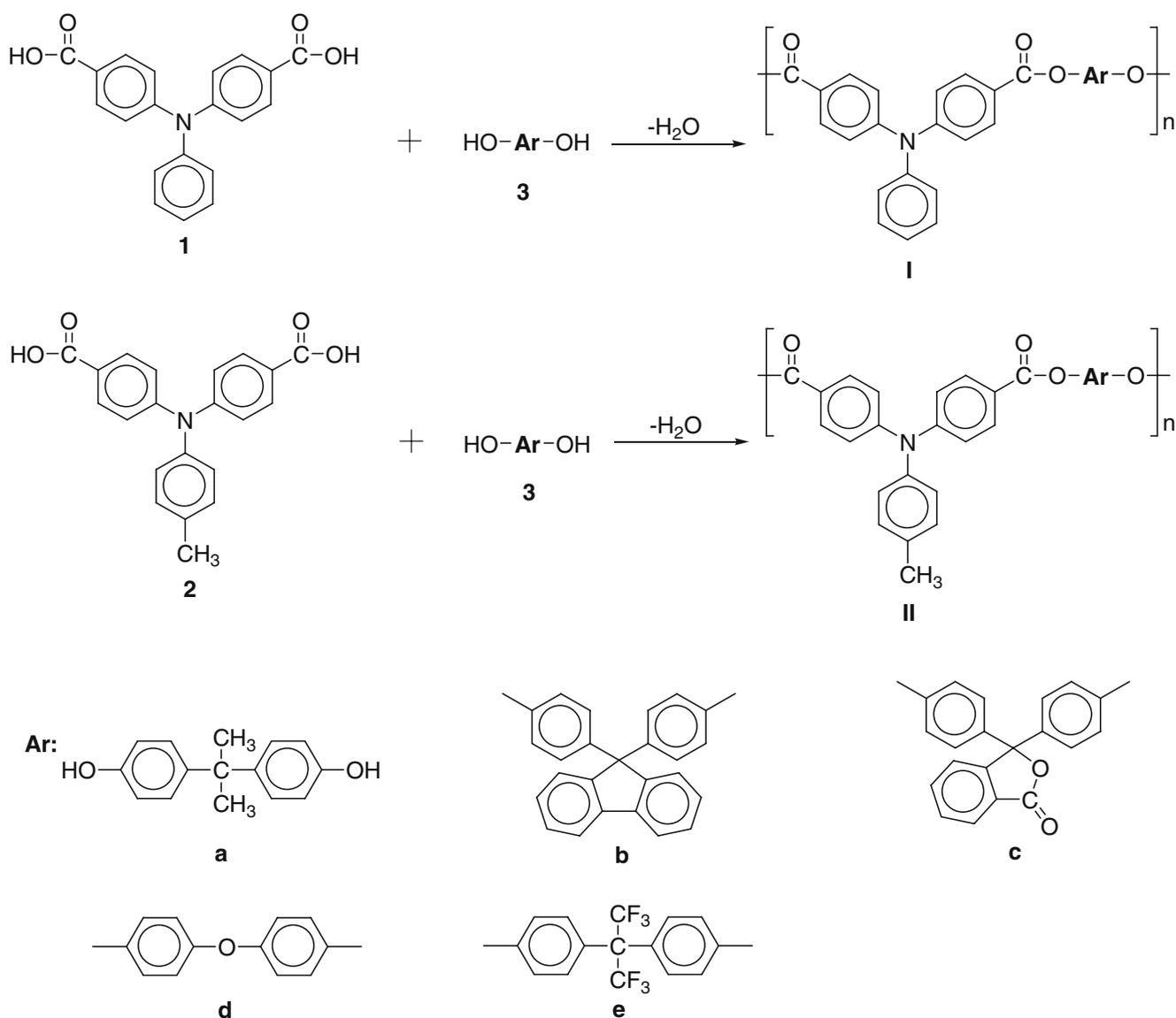
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devices and possibilities of various chemical modifications (to improve emission efficiencies and allow patterning) make polymeric materials containing triarylamine units very attractive. [11–19] To enhance the hole injection ability of polymeric emissive materials such as poly(1,4-phenylenevinylene)s (PPV) and polyfluorenes (PF), there have been several reports on PPV and PF derivatives involving hole-transporting units such as triarylamine or carbazole group in the emissive π -conjugated core/main chains [20–24] or grafting them as side chains in a polymer [25–28] or attaching them onto the polymer chain-ends or the outer surface of dendritic wedges. [29, 30] However, the solubility of many highly conjugated polymers is low, particularly for blue-emitting species. These targeted blue-emitting polymers therefore often bear large alkyl, alkoxy,

or aryloxy groups to improve solubility, thus lower their glass transition temperatures (T_g s) and thermal stability.

To obtain high T_g hole-transporting polymers, many investigators have prepared polymers containing TPA units in the main chain. Ogino et al. have successfully prepared TPA-containing polymers which had hole-transporting ability. [31, 32] Kakimoto et al. reported that the charge injection and electroluminescent efficiency were improved remarkably by the incorporation of the hole-transporting polyimide containing a TPA moiety in the backbone. [33, 34] Recently, we have reported the synthesis of soluble aromatic polyamides and polyimides bearing triphenylamine units in the main chain. [35–40] Because of the incorporation of bulky, three-dimensional TPA units along the polymer backbone, all the polymers were amorphous



Scheme 1 Synthesis of polyarylates.

Table 1 Inherent viscosity^a and solubility^b of polyarylates

Polymer code	η_{inh} (dl/g)	Solvent ^c								
		NMP	DMAc	DMF	<i>m</i> -Cresol	CHCl ₃	THF	Toluene	MeCN	
<i>Ia</i>	0.25	++	++	++	+	++	++	++	–	
<i>Ib</i>	0.30	++	++	±	±	++	++	±	–	
<i>Ic</i>	0.23	++	++	++	+	++	++	±	–	
<i>Id</i>	0.41	++	+	±	±	++	+	±	–	
<i>Ie</i>	0.27	++	++	++	+	++	++	++	–	
<i>IIa</i>	0.38	++	++	++	++	++	++	++	–	
<i>IIb</i>	0.25	++	++	++	++	++	++	±	–	
<i>IIc</i>	0.43	++	++	++	++	++	++	±	–	
<i>IId</i>	0.52	++	++	++	++	++	++	±	–	
<i>Ile</i>	0.34	++	++	++	++	++	++	++	–	

^a Measured at a polymer concentration of 0.5 g/dl in NMP at 30° C.

^b The solubility was determined by using 1 mg sample in 1 ml of solvent. ++ : soluble at room temperature; + : soluble on heating; ± : partial soluble or swelling on heating; – : insoluble even on heating.

^c NMP: *N*-methyl-2-pyrrolidone; DMAc: *N,N*-dimethylacetamide; DMF: *N,N*-dimethylformamide; THF: tetrahydrofuran; CHCl₃: chloroform; MeCN: acetonitrile.

with good solubility in many aprotic solvents, and exhibited excellent thin-film-forming capability. In this article, we therefore design a novel class of *para*-methyl substituted TPA-based polyarylates derived from the dicarboxylic acid monomer 4,4'-dicarboxy-4''-methyltriphenylamine, [41] which is a blue light (454 nm) emitter with fluorescence quantum yield of 46%, and various bisphenols. The general properties of these polymers such as solubility, crystallinity, and thermal properties are reported. The electrochemical and photoluminescent properties of these polymers prepared by casting solution onto an indium-tin oxide (ITO)-coated glass substrate are also described herein and are compared with those of structurally related ones from 4,4'-dicarboxytriphenylamine [42].

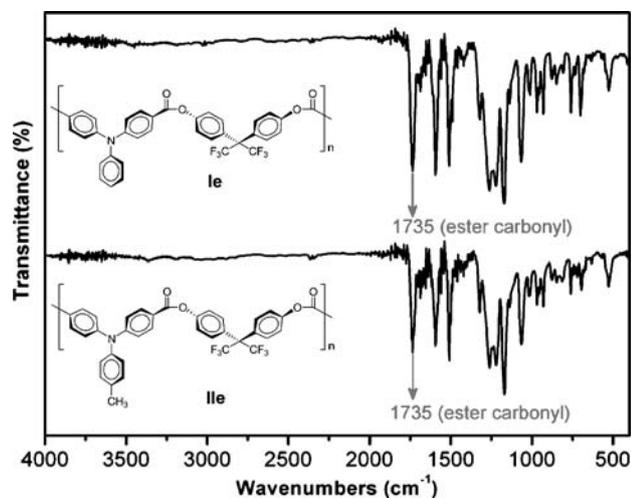


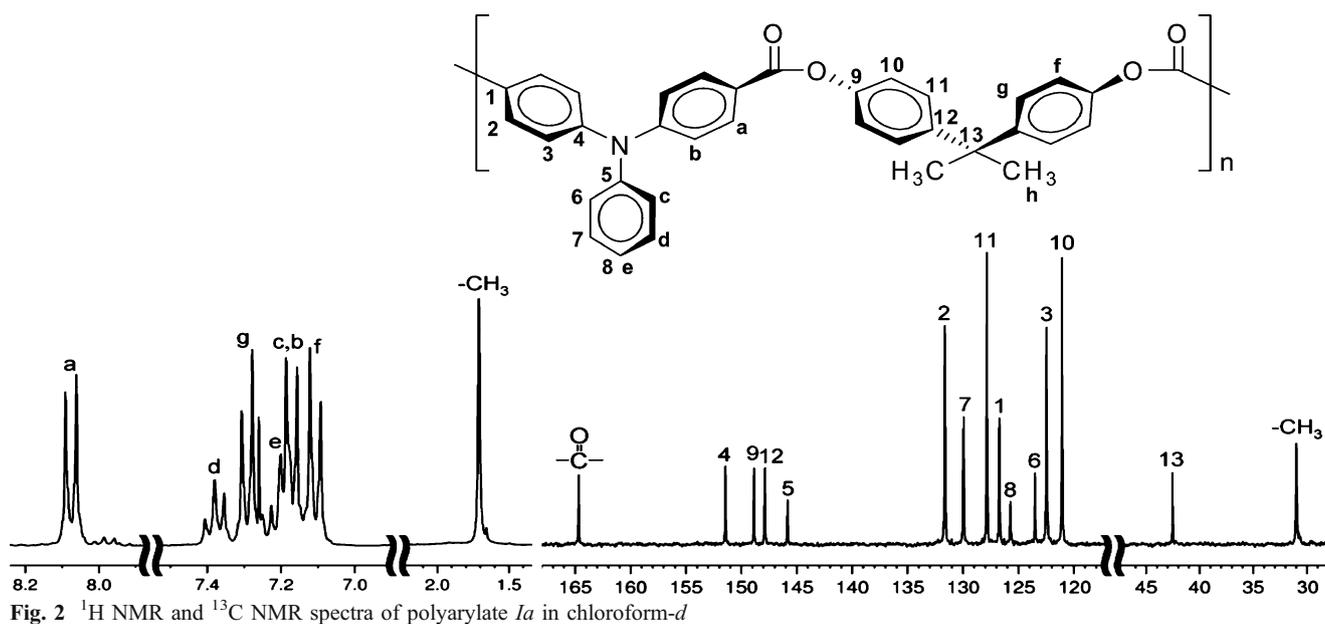
Fig. 1 FTIR spectra of polyarylates *Ie* and *Ile*

Experimental section

General directions

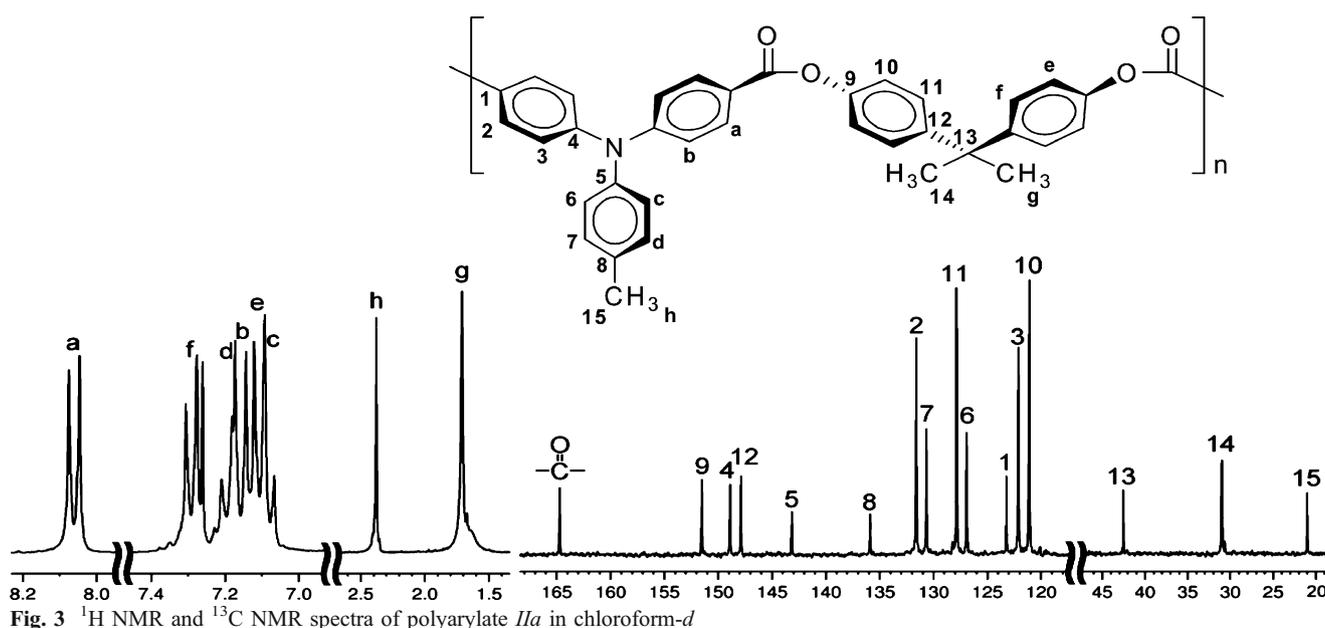
4,4'-Dicarboxy-4''-methyltriphenylamine (**2**) (mp: 277–281° C by DSC) and 4,4'-dicarboxytriphenylamine (**1**) (mp: 313–315° C by DSC) were synthesized by the condensation of 4-fluorobenzonitrile with *p*-toluidine and aniline, respectively, followed by the alkaline hydrolysis of the intermediate dinitrile compounds according to previously reported procedures. [41, 42] Aniline (ACROS), *p*-toluidine (Lancaster), sodium hydride (95%; Aldrich), 4-fluorobenzonitrile (TCI), *N,N*-dimethylacetamide (DMAc) (TEDIA), *N,N*-dimethylformamide (DMF) (ACROS), *N*-methyl-2-pyrrolidinone (NMP) (TEDIA), pyridine (Py) (TEDIA), and diphenyl chlorophosphate (DPCP) (ACROS) were used without further purification. The bisphenol monomers that include 4,4'-isopropylidenediphenol (**3a**) (bisphenol A) (ACROS), 9,9-bis(4-hydroxyphenyl)fluorene (**3b**) (TCI), phenolphthalein (**3c**) (Aldrich), 4,4'-dihydroxydiphenyl ether (**3d**) (TCI), and 2,2-bis(4-hydroxyphenyl)hexafluoropropane (**3e**) (TCI) were purified by recrystallization. Commercially obtained anhydrous lithium chloride was dried under vacuum at 150°C for 10 h. Tetrabutylammonium perchlorate (TBAP) was obtained from ACROS and recrystallized twice from ethyl acetate and then dried in vacuum prior to use. All other reagents were used as received without further purification.

Infrared spectra were recorded on a PerkinElmer RXI FT-IR spectrometer. Elemental analyses were run in an Elementar VarioEL-III. ¹H and ¹³C nuclear magnetic resonance (NMR) spectra were measured on a Varian Unity



Inova 500 FT-NMR system. The inherent viscosities were determined at 0.5 g/dl concentration using Tamson TV-2000 viscometer at 30°C. Wide-angle X-ray diffraction (WAXD) measurements were performed at room temperature (ca. 25°C) on a Siemens Kristalloflex D-5000 X-ray diffractometer (operating at 40 kV, 20 mA) with Ni-filtered Cu-K α ($\lambda=1.5418$ Å). The scanning rate was 2°/min over a range of $2\theta=10$ –40°. Ultraviolet-Visible (UV-Vis) spectra of the polymer films were recorded on a Varian Cary 50 Probe spectrometer. Thermogravimetric analysis (TGA) was conducted with a PerkinElmer Pyris 1 TGA. Experiments were carried out on approximately 6–8 mg film samples heated in flowing nitrogen or air (flow rate=20

cm 3 /min) at a heating rate of 20°C/min. Differential scanning calorimetry (DSC) analyses were performed on a PerkinElmer Pyris Diamond DSC at a scan rate of 20°C/min in flowing nitrogen (20 cm 3 /min). Thermomechanical analysis (TMA) was conducted with a PerkinElmer TMA 7 instrument. The TMA experiments were conducted at a scan rate of 10°C/min with a penetration probe 1.0 mm in diameter under an applied constant load of 50 mN. Softening temperatures (T_s) were taken as the onset temperatures of probe displacement on the TMA traces. Electrochemistry was performed with a CHI 611B electrochemical analyzer. Voltammograms are presented with the positive potential pointing to the left and with increasing



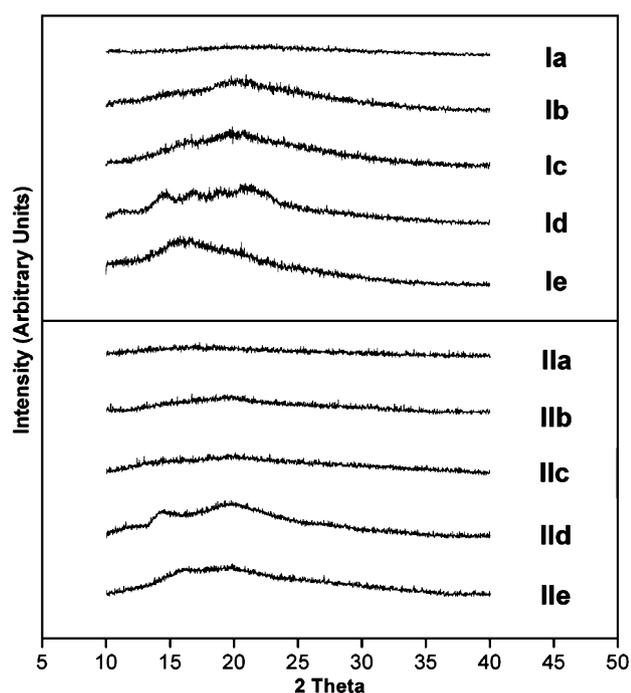


Fig. 4 WAXD patterns of the polyarylate films

anodic currents pointing downwards. Cyclic voltammetry was conducted with the use of a three-electrode cell in which ITO (polymer films area about 0.7×0.5 cm) was used as a working electrode and a platinum wire as an auxiliary electrode at a scan rate of 100 mV/s against a home-made Ag/AgCl reference electrode in acetonitrile (CH_3CN) solution of 0.1 M TBAP under nitrogen atmosphere. Absorption spectra were measured with a HP 8453 UV-Visible spectrophotometer. Photoluminescence spectra were measured with a Jasco FP-6300 spectrofluorometer.

The fluorescence quantum yields (Φ_{PL}) of polymer solution were determined in THF against quinine sulfate (ACROS) in 1 N H_2SO_4 (aq) as the standard ($\Phi_{\text{PL}}=0.546$). All corrected fluorescence excitation spectra were found to be equivalent to their respective absorption spectra.

Preparation of polyarylates via the direct polycondensation [43]

A typical example of polycondensation is described as follows: A solution of diphenylchlorophosphate (DPCP) (0.69 g), LiCl (0.09 g), and pyridine (3.0 ml) was stirred at room temperature for 30 min and then added dropwise for 20 min to a hot solution (120°C) containing 0.333 g (1.00 mmol) of 4,4'-dicarboxytriphenylamine (*I*) and 0.228 g (1.00 mmol) of bisphenol A in pyridine (2.0 ml). The final solution was heated at 120°C for 3 h under stirring. The obtained polymer solution was poured slowly into 200 ml of water, and the white precipitate was filtered and washed with methanol. Precipitations from chloroform into methanol were carried out twice for further purification and then dried at 120°C under vacuum. The inherent viscosity of the polymer *Ia* was 0.25 dl/g measured at a concentration of 0.5 g/dl in NMP at 30°C . IR (film): 1,735 ($\text{C}=\text{O}$ stretch), 1,200–1,250 cm^{-1} ($\text{C}-\text{O}$ stretch). ANAL. Calcd for $(\text{C}_{35}\text{H}_{27}\text{NO}_4)_n$ (525.59): C, 79.98 %; H, 5.18 %; N, 2.66 %. Found: C, 79.06 %; H, 5.28 %; N, 2.52 %.

Preparation of the polyarylate films

A polymer solution was made by the dissolution of about 0.5 g of the polyarylate sample in 10 ml of chloroform. The homogeneous solution was poured into an 8-cm-diameter glass Petri dish, which was placed in a room temperature

Table 2 Thermal properties of polyarylates^a

Polymer Code	T_g ($^\circ\text{C}$) ^b	T_s ($^\circ\text{C}$) ^c	T_d at 5% weight loss ($^\circ\text{C}$) ^d		T_d at 10% weight loss ($^\circ\text{C}$) ^d		Char yield (wt %) ^e
			N_2	Air	N_2	Air	
<i>Ia</i>	203	206	465	460	480	480	32
<i>Ib</i>	254	255	485	480	515	505	45
<i>Ic</i>	246	246	475	470	495	495	48
<i>Id</i>	186	183	485	480	500	495	42
<i>Ie</i>	206	206	480	470	495	485	52
<i>IIa</i>	201	193	475	465	510	500	45
<i>IIb</i>	254	265	490	470	520	515	52
<i>IIc</i>	264	264	480	475	490	485	59
<i>IId</i>	189	188	480	475	515	510	57
<i>IIe</i>	205	199	480	470	515	495	50

^a The polymer film samples were heated at 200°C for 1 h prior all the thermal analyses.

^b Midpoint temperature of baseline shift on the second DSC heating trace (rate $20^\circ\text{C}/\text{min}$) of the sample after quenching from 400°C .

^c Softening temperature measured by TMA with a constant applied of 50 mN at a heating rate of $10^\circ\text{C}/\text{min}$.

^d Decomposition temperature, recorded via TGA at a heating rate of $20^\circ\text{C}/\text{min}$ and a gas-flow rate of $20\text{ cm}^3/\text{min}$.

^e Residual weight percentage at 800°C in nitrogen.

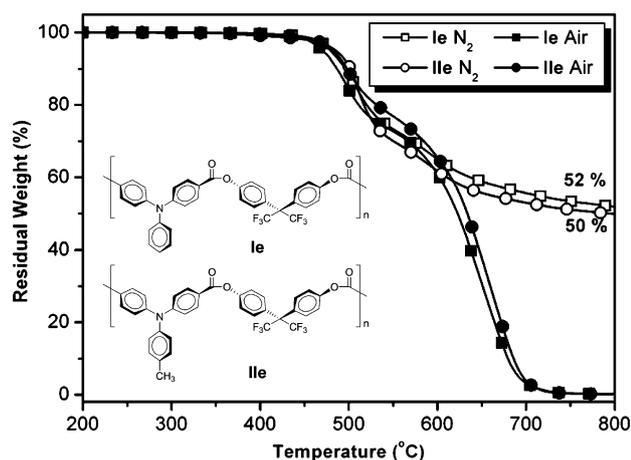


Fig. 5 TGA thermograms of polyarylates *Ie* and *IIe* at a scan rate of 20° C/min

overnight for slow release of the solvent. Then the obtained semidried polymer film was stripped off from the glass substrate and further dried in oven at 120°C for 3 h. The obtained films were about 50~90 μm thick and were used for X-ray diffraction measurements, solubility tests, thermal and optical analyses.

Results and discussion

Polymer synthesis

Two series of new aromatic polyarylates with triphenylamine units were prepared from the dicarboxylic acid

monomers, 4,4'-dicarboxytriphenylamine and 4,4'-dicarboxy-4''-methyltriphenylamine, with various aromatic diols by the direct polycondensation reaction using DPCP and pyridine as condensing agents (Scheme 1). All the polymerizations proceeded homogeneously throughout the reaction and afforded clear, moderately high viscous polymer solutions. Most of the polymers precipitated in a fiber-like form when the resulting polymer solutions were slowly poured into water. These polyarylates were obtained in almost quantitative yields with inherent viscosity values in the range of 0.23–0.52 dl/g (Table 1), and the formation of polyarylates was confirmed by elemental analysis, IR, ^1H and ^{13}C NMR spectroscopy. Figure 1 shows typical FTIR spectra of polyarylates *Ia* and *IIa*. The characteristic absorptions of ester group appear around 1,735 cm^{-1} (C = O stretching) and in the region of 1,200–1,300 cm^{-1} (C–O stretching). Figure 2 and Fig. 3, respectively, show a typical set of ^1H and ^{13}C NMR spectra of polyarylates *Ia* and *IIa* in chloroform-*d*, where all the peaks have been readily assigned to the hydrogen and carbon atoms of the recurring unit.

Basic characterization

From the typical diffraction patterns shown in Fig. 4, the X-ray diffraction studies of the polyarylates indicated that all the polymers were essentially amorphous. The solubility behavior of polyarylates was tested qualitatively, and the results are summarized in Table 1. All the polyarylates were highly soluble in common organic solvents and could be solution-cast into transparent and colorless films. The

Table 3 Optical and electrochemical properties of polyarylates

Index	Solution λ (nm) ^a			Film λ (nm)				Oxidation (V) (vs. Ag/AgCl) E_{onset}	Gap ^e (eV)	HOMO ^f (eV)	LUMO ^g (eV)
	Abs max ^b	PL max	Φ_{PL} (%) ^c	λ_0 ^d	Abs max ^b	abs onset	PL max				
<i>Ia</i>	360	427	26.3	390	363	398	441	1.34	3.12	5.66	2.54
<i>Ib</i>	362	427	27.6	388	365	398	443	1.33	3.12	5.65	2.53
<i>Ic</i>	362	435	30.7	391	365	402	450	1.29	3.08	5.61	2.53
<i>Id</i>	359	432	32.6	396	363	403	442	1.27	3.08	5.59	2.51
<i>Ie</i>	364	436	28.9	389	365	400	444	1.36	3.10	5.68	2.58
<i>IIa</i>	363	440	26.9	408	371	406	449	1.23	3.05	5.55	2.50
<i>IIb</i>	363	443	30.4	410	372	402	448	1.19	3.08	5.51	2.43
<i>IIc</i>	365	447	27.8	416	372	413	458	1.19	3.00	5.51	2.51
<i>IId</i>	363	443	26.7	410	370	407	448	1.26	3.04	5.58	2.54
<i>IIe</i>	365	451	26.6	413	369	408	448	1.25	3.04	5.57	2.53

^a Polymer concentration of 10^{-5} M in THF at room temperature.

^b Excitation wavelength.

^c These values were measured by using quinine sulfate (dissolved in 1 N H_2SO_4 (aq) with a concentration of 10^{-5} M, assuming Φ_{PL} of 0.546) as a standard at 24–25° C.

^d The cutoff wavelengths (λ_0) from the transmission UV/Vis absorption spectra of polymer films. (polyarylates thickness: 1–3 μm).

^e The data were calculated by the equation: $\text{gap} = 1240/\lambda_{\text{abs, onset}}$.

^f The HOMO energy levels were calculated from cyclic voltammetry and were referenced to ferrocene (4.8 eV).

^g LUMO = HOMO - gap.

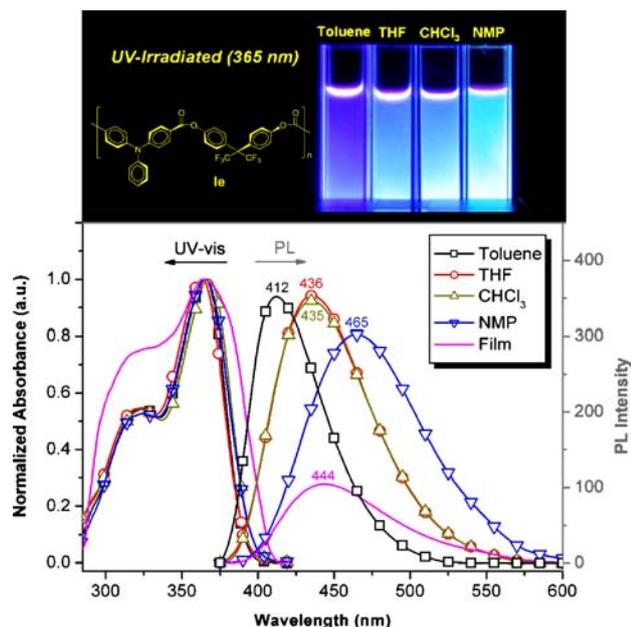


Fig. 6 UV-vis absorptions and PL spectra of the solutions of polyarylate *Ie* in various solvents: NMP, CHCl_3 , THF, and toluene at a concentration of 10^{-5} M, as well as its thin solid film

enhanced solubility can be attributed to the introduction of TPA group into the polymer backbone, thus, the excellent processability makes these polymers as potential candidates for practical applications by spin- or dip-coating processes. The thermal properties of the polyarylates were investigated by TGA, DSC, and TMA. The results are summarized in Table 2. Typical TGA curves of representative polyarylates *Ie* and *Iie* in both air and nitrogen atmospheres are shown in Fig. 5. All the polyarylates exhibited good thermal stability with insignificant weight loss up to 450°C in nitrogen. The 10% weight-loss temperatures of these polymers in nitrogen and air were recorded in the range of $480\text{--}520$ and $480\text{--}515^\circ\text{C}$, respectively. The amount of carbonized residue (char yield) of these polymers in nitrogen atmosphere was more than 30% at 800°C . The high char yields of these polymers can be ascribed to their high aromatic content. The T_g s of all the polymers could be

Table 4 Maxima of UV absorption (λ_{abs}), fluorescence (λ_{PL}), and quantum yield (Φ_{PL}) for *Ie* in different solvents^a

Solvent	$\lambda_{\text{abs, max}}$ (nm)	$\lambda_{\text{PL, max}}$ (nm)	Φ_{PL} (%) ^b
Toluene	365	412	19.8
THF	364	436	28.9
CHCl_3	368	435	28.9
NMP	365	465	29.6

^a Polymer concentration of 10^{-5} M in different solvents.

^b These values were measured by using quinine sulfate (dissolved in 1 N H_2SO_4 (aq) with a concentration of $10\text{--}5$ M, assuming Φ_{PL} of 0.546) as a standard at $24\text{--}25^\circ\text{C}$ from Fig. 6.

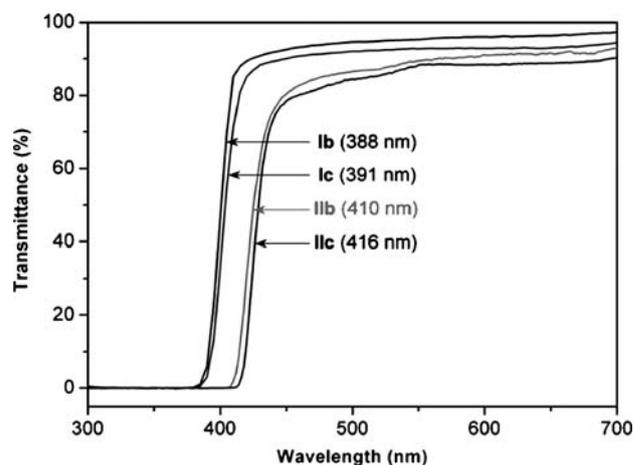


Fig. 7 Transmission UV-visible absorption spectra of some polyarylate films ($1\text{--}3\ \mu\text{m}$ in thickness)

easily measured by the DSC thermograms; they were observed in the range of $183\text{--}265^\circ\text{C}$ and decreased with increasing flexibility of the bisphenol component. All the polymers indicated no clear melting endotherms up to the decomposition temperatures on the DSC scans. This result also supports the amorphous nature of these TPA-containing polyarylates. The T_g values measured by TMA are also listed in Table 2, and they are generally comparable to the T_g values obtained by the DSC technique.

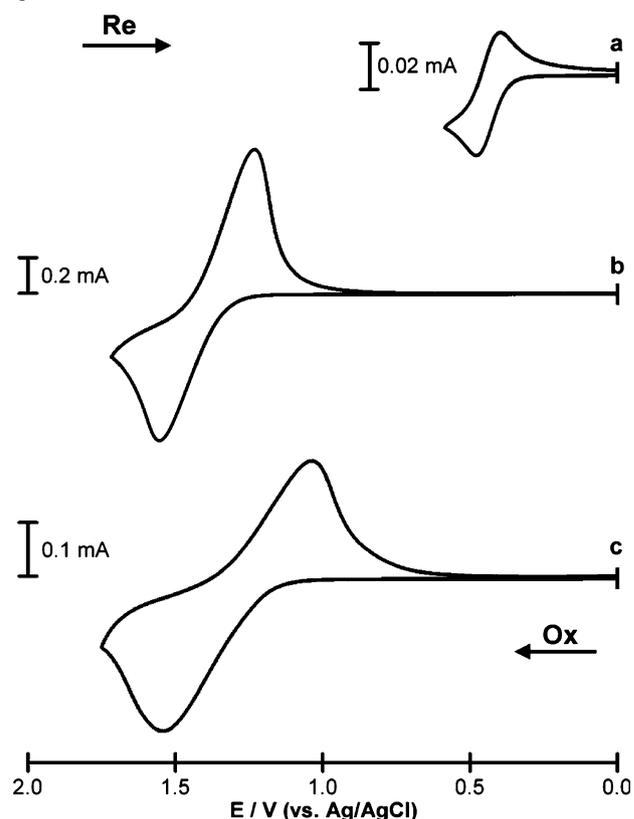


Fig. 8 Cyclic voltammograms of **a** ferrocene **b** polyarylate **Ib** **c** IIb films onto an indium-tin oxide (ITO)-coated glass substrate in CH_3CN containing 0.1 M TBAP. Scan rate= $0.1\ \text{V/s}$

Optical properties

The optical and electrochemical properties of the polyarylates were investigated by UV-Vis and photoluminescence spectroscopy and cyclic voltammetry. The results are summarized in Table 3. In THF solution, these polymers exhibited strong UV-Vis absorption bands at 359–365 nm, assignable to the π - π^* transition resulting from the conjugated TPA core. The maximum photoluminescence (PL) intensity of the polymer solutions in THF appeared around 427–451 nm, which corresponds to the blue region. Figure 6 illustrates the absorption and PL spectra of the solutions of polyarylate *Ie* in various solvents, as well as the spectra of its thin solid film. Key optical data of the solutions of polymer *Ie* are summarized in Table 4. It is interesting to note that the PL emission of polymer *Ie* in NMP is red-shifted compared to that of its thin solid film. The maximum PL intensity of the solutions of polymer *Ie* in NMP, THF, chloroform, and toluene solution, and its solid-state thin film appeared at 465, 436, 435, 412, and 444 nm, respectively. All the PL spectra of these polymers showed a blue shift when the solvent was changed from NMP to THF or chloroform. This result suggests that solvent-induced aggregation seems to simulate film behavior in these polymer films excited states. Generally, solvation should increase the interaction between polymer chain and solvent, which may consume certain excitation energy and lead to increase on the emission wavelength. The emission maxima increased dramatically as the medium changing from less polar (THF) to polar (NMP). The solvatochromic shifts of the emission spectra are much larger than those of absorption spectra, implying that the excited-state energy levels are influenced more than those in the electronic ground state. [44] The fluorescence spectra of all the polyarylates in THF solutions exhibited emission maxima at 427–451 nm in the blue region with quantum yield (Φ_{PL}) of 0.26–0.33. The introduction of bulky triphenylamine units into the polymer main chain effectively restricted intermolecular interactions and packing. Thus, the absorption and PL spectra of both solution and solid-state thin film of these polyarylates were similar to each other, with a strong blue-light emission upon exposure to UV irradiation. The polymer films were also measured for optical transparency using UV-Vis spectroscopy. The UV-Vis transmission spectra of the polymers films are shown in Fig. 7, and the cutoff wavelengths (absorption edge; λ_0) were recorded in the range of 388–416 nm. It revealed that most of the polymers were light colored with high transparency in visible light region.

Electrochemical properties

The electrochemical properties of the polyarylates were investigated by cyclic voltammetry conducted for the cast films on an ITO-coated glass substrate as working electrode in dry acetonitrile containing 0.1 M of TBAP as an electrolyte under nitrogen atmosphere. The typical cyclic voltammograms for polyarylates *Ib* and *Iib* are shown in Fig. 8. These two polyarylates exhibited reversible oxidation redox couples with onset potential at 1.33 and 1.19 V, respectively, corresponding to one electron removal from the nitrogen atoms at TPA structure in each repeating unit to yield a stable delocalized radical cation. [41] In addition, the polyarylates *II* had lower oxidation potentials occurring at the electroactive nitrogen atom, which is more electron-rich than the nitrogen atom of polyarylates *I* surrounded by phenyl group without electron-donating methyl substituent. The energy of the HOMO and LUMO levels of the investigated polyarylates can be determined from their onset oxidation potentials and the onset absorption wavelength, and the results are listed in Table 3. For example, the onset oxidation potential for polymer *Iib* has been determined as 1.19 V vs Ag/AgCl. The external ferrocene/ferrocenium (Fc/Fc^+) redox standard $E_{1/2}$ is 0.48 V vs Ag/AgCl in CH_3CN . Assuming that the HOMO energy for the Fc/Fc^+ standard is 4.80 eV with respect to the zero vacuum level, the HOMO energy for polyarylate *Iib* has been evaluated to be 5.51 eV.

Conclusions

Two series of new triphenylamine-based polyarylates having strong fluorescence emissions in the blue region with high quantum yields up to 33% were successfully prepared from 4,4'-dicarboxytriphenylamine and 4,4'-dicarboxy-4''-methyltriphenylamine with various aromatic diols. The results presented herein also demonstrated that incorporating bulky triphenylamine group into polymer backbone enhanced the processability of the rigid polymer backbone while maintaining good thermal stability. These polyarylates were amorphous with high T_g s and could afford transparent films by the solution casting method. Thus, these novel triphenylamine-containing polyarylates have a great potential as a new primary light source to white light-emitting materials due to their proper HOMO values and high thermal stability.

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