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Temperature and frequency dependent dielectric properties of electrically conducting oxidatively synthesized polyazomethines and their structural, optical, and thermal characterizations



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ABSTRACT

Three azomethine diol monomers were synthesized by condensing with methanolic solution of aromatic aldehydes with ethylenediamine. These monomers were oxidatively polymerized using NaOCl as an oxidant. The structures of the monomers and polymers were confirmed by various spectroscopic techniques. Spectral results showed that the repeating units are linked by C–C and C–O–C couplings. The polyazomethines have fluorescent property with high stokes shift. Solid state electrical conductivity of polymers both in I_2 doped and undoped states, temperature and frequency dependent dielectric measurements were made by two probe method. The electrical conductivities of polyazomethines were compared based on the charge densities on imine nitrogens obtained from Huckel calculation. The conductivity of polymers PHNAE has shown high dielectric constant at low applied frequency of 50 Hz at 393 K due the presence of bulky naphthalene unit in polymer chain.

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1. Introduction

Polyazomethines (PAMs) have received increasing scientific and technological interest of researches due to their importance in many fields like chemical gas sensors, light emitting diodes, photovoltaic devices etc., [1-3]. Recently, azomethine oligomers and polymers containing hydroxyl group have had usefulness in semiconductivity, paramagnetism and high energy resistance materials. Azomethine polyphenols were used to prepare high temperature resistance inhibitors, thermostabilizers, graphite materials, epoxy oligomers, block copolymers, adhesives and photoresists [4–6]. But, their poor solubility making them as less processable. To improve their solubility polar groups containing PAMs like polyazomethine ethers [7], polyacrylate-azomethines [8], polyazomethine carbonates [9], polyamide-azomethine-esters [10], and polyazomethine sulfones [11] have been synthesized. Also, PAMs containing alkoxy substituents have been presented with good solubility and high thermal stability [12]. Additionally, optical and semiconducting properties of these PAM have also been widely investigated for many years because of wavelength dependent photo and electroluminescence and non-linear optical properties. The conductivities of PAMs are increased by dopants [13], so they have been widely used in the field of opto electronics [14–16]. Synthesis of several PAMs using azomethine monomers were accomplished oxidatively using oxidants like NaOCl, H₂O₂ and air O₂[17,18]. The possibility to produce polymers in aqueous ambient conditions provides an important option in green chemistry aspects. Kaya et al. and others [18,19] have synthesized several PAMs by oxidative polymerization and characterized them for various properties. The electrical properties such as iodine doped conductivity of oxidatively polymerized PAMs have been studied widely. But very few reports only are found in the literature dealing with the dielectric property of PAM.

So, the present study is focused on synthesis of polyazomethines with varying degree of substituents and ring size to explore optical and electrical properties with a special focus on dielectric property. The structural characterization of synthesized compounds were made by FT-IR, UV–visible, NMR techniques. Fluorescence of monomers and polymers, electrical conductivity of polymers and dielectric properties of polymers at different temperature and frequencies were carried out.



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Scheme 1. Synthesis of monomers.



Scheme 2. Synthesis of polymers.

2. Experimental

2.1. Materials

4-Hydroxy-3-methoxybenzaldehyde, 4-hydroxy-3ethoxybenzaldehyde, 2-hydroxy-1-naphthaldehyde, ethylenediamine were purchased from Sigma Aldrich. Sodium hypochlorite (6% aqueous solution), dimethylacetamide (DMAC), dimethylsulfoxide (DMSO), tetrahydrofurane (THF), methanol, ethanol, acetonitrile, acetone, toluene, ethyl acetate, heptane, hexane, CCl₄, CHCl₃, KOH and HCl were obtained from by Merck, India and used as received.

2.2. Synthesis of monomer

The azomethine diol monomers N,N'-bis(4-hydroxy-3ethoxybenzylidene)ethylenediamine (HEBE), N,N'-bis(4-hydroxy-3-methoxybenzylidene)ethylenediamine (HMBE), and N,N'-bis(2hydroxy-1-naphthalidene)ethylenediamine (HNAE) were synthesized by the condensation reaction of 4-hydroxy-3ethoxybenzaldehyde (HEB), 2-hydroxy-3-methoxybenzaldehyde (HMB) and 2-hydroxy-1-naphthaldehyde (HNA) with ethylenediamine (EDA). The monomer, HEBE was synthesized by refluxing



Fig. 1. FT-IR Spectra of a) HEBE and b) PHEBE.

Tabla 1

Tuble 1				
FT-IR spectral	data of	monomers	and	polymers

Compound	Wave n	Wave number (cm ⁻¹)				
	-OH	-CH=N-	-C=C-	-C-O	Ar-CH	
HEBE PHEBE HMBE PHMBE HNAE PHNAE	3424 3424 3456 	1635 1623 1646 1601 1656 1601	1459 1449 1502 1514 1524 1514	 1228 1218 1206	3050 3072 3072 3078 3029 3061	

EDA and HEB (1:2 M ratio) in methanolic medium under vigorous stirring for 2 h (Scheme 1). The yellow coloured azomethine diol formed was filtered, dried recrystallized from acetonitrile. The same procedure was adopted for the synthesis of HMBE and HNAE monomers. The azomethine diol monomers are obtained with good yield (80–89%).

HEBE:¹H-NMR (DMSO) δ (ppm): 13.55 (s,-OH), 8.56 (s,-CH= N-), 6.99 (t, Hb, Hd), 6.77 (s, Hc), 3.37 (s, Hf), 4.01 (d, OCH₂), 1.32 (t, CH₃). C¹³-NMR (DMSO) δ (ppm): 152.06 (C1), 147.55 (C2), 118.28 (C3), 116.57 (C4), 118.90 (C5), 123.73 (C6), 167.62 (C7), 58.91 (C8), 64.36 (OCH₂), 15.23 (CH₃). **HMBE:**¹H-NMR (DMSO) δ (ppm): 9.64 (s, -OH), 8.18 (s,-CH=N-), 7.30 (d, Hb), 7.07 (d, Hc), 6.80 (d, Hd), 3.77 (s, Hf), 3.45 (t, -OCH₃). C¹³-NMR (DMSO) δ (ppm): 149.91 (C1),



Fig. 2. ¹H-NMR spectra of (a) HEBE and (b) PHEBE.



Fig. 3. ¹³C-NMR spectra of (a) HEBE and (b) PHEBE.

148.35 (C2), 110.34 (C3), 128.17 (C4), 123.12 (C5), 115.66 (C6), 161.91 (C7), 61.42 (C8), 55.90 (-OCH₃). **HNAE:**¹H-NMR (DMSO) δ (ppm): 14.78 (s, -OH), 8.54 (s, -CH=N-), 7.86 (d, Hc), 7.57 (d, Hd), 7.48 (t, He), 7.96 (d, Hf), 8.38 (d, Hg), 3.95 (s, Hh). C¹³-NMR (DMSO) δ (ppm): 157.9 (C1), 111.6 (C2), 140.21 (C3), 126.41 (C4), 126.72 (C5), 123.83 (C6), 127.81 (C7), 125.21 (C8), 115.92 (C9), 113.43 (C10), 157.57 (C11), 61.9 (C12).

2.3. Synthesis of polymers

The synthesized azomethine diol monomers HEBE. HMBE and HNAE were converted into polymers Poly(N,N'-bis(4-hydroxy-3ethoxybenzylidene) ethylenediamine) (PHEBE), Poly(N,N'-bis(4hydroxy-3-methoxybenzylidene) ethylenediamine) (PHMBE), and Poly(N,N'-bis(2-hydroxy-1-naphthalidene)ethylenediamine) (PHNAE) through OP reaction in aqueous alkaline medium using NaOCl as an oxidant. The slow addition of NaOCl to the hot aqueous alkaline solution of azomethine diol monomer generates phenoxy free radicals (Scheme 2) and are shown by the colour change from wine red to dark brown. The dark brown coloured solution was refluxed with constant stirring. After 5 h reaction the dark coloured solid polymer formed was filtered, washed with hot water, methanol to remove the electrolytic impurities and unreacted monomers respectively followed by drying in vacuum oven for 24 h. Other polymers were synthesized by using similar procedure with more than 70% yield.



Scheme 3. Resonance structure of HEBE monomer during OP.



Scheme 4. Combination of phenylene (C–C) and oxyphenylene (C–O–C) of PHEBE.



Fig. 4. UV-Visible spectra of monomers and polymers in DMSO.

Table 2UV-visible spectral data of monomer and polymers.

Compounds	λ _{max}	λ_{onset}	Band gap (E_g)
HEBE	268, 332, 432	473	2.67
PHEBE	264, 443	550	2.25
HMBE	264, 355, 392	432	2.87
PHMBE	273, 306, 412	473	2.62
HNAE	261, 308, 408, 427	457	2.71
PHNAE	269, 342, 442	484	2.56

PHEBE: ¹H-NMR (DMSO) δ (ppm): –OH, disappeared), 8.50 (s,–CH=N), 6.26–7.21 (m, Ar–H), 3.78 (Hf), 3.97 (OCH₂), 1.32 (CH₃). C¹³-NMR (DMSO); δ (ppm): 152.70 (C1), 146.65 (C2), 118.75 (C3), 116.67 (C4), 119.78 (C5), 123.84 (C6), 167.37 (C7), 58.62 (C8), 65.20 (OCH₂), 15.23 (CH₃). 167.62, 147.67 (C–O–C), 138.75, 124.46 (C–C). **PHMBE**: ¹H-NMR (DMSO): δ (ppm): 9.69 (s, -OH, terminal), 8.18 (s,–CH=N–), 6.53–7.38 (m, Ar–H), 3.83 (s, Hf), 3.51 (t, -OCH₃). C¹³-NMR (DMSO): δ (ppm): 161.97 (C1), 148.33 (C2), 11.13 (C3), 129.06 (C4), 126.56 (C5), 116.27 (C6), 161.97 (C7), 61.01 (C8), 56.34 (–OCH₃), 146.49 (C–O–C), 128.40, 116.32 (C–C). **PHMAE:** ¹H-NMR (DMSO) δ (ppm): 14.78 (–OH, terminal), 8.53 (s,–CH=N), 8.93–7.15 (m, Ar–H). C¹³-NMR (DMSO) δ (ppm): 158.92 (C1), 110.92 (C2), 140.23 (C3), 126.31 (C4), 125.23 (C5), 123.81 (C6), 127.83 (C7),

125.23 (C8), 115.93 (C9), 113.43 (C10), 157.54 (C11), 61.73 (C12), 142.11 (C-O-C), 130.10, 125.11, 116.24 (C-C).

2.4. Characterization techniques

The FT-IR spectra were recorded in KBr pellets in the region of 400-4000 cm⁻¹ using Perkin Elmer FT-IR 8000 spectrophotometer. ¹H-NMR and ¹³C-NMR spectra were recorded on Bruker AV400 MHZ spectrometer using DMSO-*d*₆ as a solvent. TG-DTA measurement was made in NETZSCH STA 409 PC thermal analyzer between 30 °C and 800 °C (in N₂; rate, 10 °C/min). The molecular weight of polyazomethines was determined by Gel permeation chromatography (GPC) using polystyrene standard and eluted in DMAC at a flow rate of 0.5 ml/min at 25 °C on a Water Alliance GPC model (GPC, Water 515 HPLC) fitted with water 2414 Refractive index detector and Styragel HMW 6E DMF column.

2.5. Optical properties

UV-visible spectra of compounds were recorded in DMSO solution with Systronics double beam UV-visible spectrophotometer 2202 in the range 200–800 nm. The fluorescence spectra of azomethine diol monomers and their polyazomethines were recorded on Jobin Yvon Horiba Fluoromax-3 spectrofluorometer in DMSO. Slit width in all measurements was 5 nm.



Fig. 5. Fluorescence excitation and emission spectrum of azomethine diol monomer (a) HEBE, (b) HMBE and (C) HNAE.

2.6. Electrical measurements

DC conductivity of I_2 doped and undoped polymers were carried out using two probe method with the support of Keithley electrometer (6517 B) in the range of 1 V–10 V. Iodine doping was carried out by exposing the polymer pellets with iodine vapour under atmospheric pressure in a desiccator at room temperature.

The dielectric studies of the polymers were carried out using Hioki 3532-50 LCR meter at various temperatures, in the frequency range of 50 Hz to 5 MHz.

3. Results and discussion

3.1. Solubility and molecular weight

The solubility tests were done in different solvents by using 1 mg sample in 1 mL of solvent at 30 °C. The monomers are soluble in acetonitrile, THF, DMSO, DMF DMAC and are insoluble in hexane, CHCl₃ and CCl₄. However, the polymers are soluble only in highly polar solvents like DMSO, DMF, DMAC and insoluble in other polar and non polar solvents because of their high molecular weight and non availability of polar –OH group [13].

The molecular weight of the polymers was determined by Gel permeation chromatography. The number average molecular weight (M_n) , weight average molecular weight (M_w) and

polydispersity index (PDI) of PHEBE, PHMBE and PHNAE were calculated from polystyrene standard calibration curve. The M_n , M_w and PDI values are found to be 44712, 68193 g mol⁻¹ and 1.52 for PHEBE, 12600, 48984 g mol⁻¹ and 3.88 for PHMBE, 22856, 57900 g mol⁻¹ and 2.53 for PHNAE respectively. The high PDI values of polymers are attributed to two types of coupling in polymerization, C–O–C and C–C and also evident for the more number of branches with structural heterogeneity in polymer chain [18].

3.2. Spectral analysis of monomers and polymers

FT-IR spectra of HEBE and PHEBE are shown in Fig. 1 and the spectral data are given in Table 1. The phenolic O–H stretching vibration of monomers are observed in the range of $3424-3456 \text{ cm}^{-1}$. The FT-IR spectra of the polymers, the peaks are broadened because of the polyconjugated structures. The azomethine stretching vibrations of monomers and polymers are observed in the range of $1601-1656 \text{ cm}^{-1}$. Aromatic C–H stretching vibrations are observed between 3029 and 3072 cm^{-1} . The absorption bands between 1449 and 1524 cm^{-1} correspond to C=C skeletal vibrations of aromatic ring. The broad vibration signals appeared in the region $3600-3100 \text{ cm}^{-1}$ is due to the disappearance of phenolic –OH group during polymerization by C–O–C coupling in PHEBE. The intensity of azomethine stretching



Fig. 6. Fluorescence excitation and emission spectrum of polymers (a) PHEBE, (b) PHMBE and (c) PHNAE.

Table 3Fluorescence spectral data of monomer and polymers.

Compounds	λ_{Ex}^{a}	λ _{Em} b	$\lambda_{\max} (Ex)^{c}$	$\lambda_{max} (Em)^d$	$\Delta \lambda_{ST}{}^e$
HEBE	360	440	369	440	71
PHEBE	370	500	372	504	132
HMBE	375	435	379	437	58
PHMBE	330	450	333	453	120
HNAE	360	425	361	429	68
PHNAE	355	430	365	435	70

^a Excitation wavelength for emission.

^b Emission wavelength for excitation.

^c Maximum excitation wavelength.

^d Maximum emission wavelength.

e Stokes shift.

vibrations around 1635 cm⁻¹ in HEBE monomer is drastically reduced and shifted to longer wave number after polymerization due to increase in conjugation. This is further confirmed by the appearance of a band at 1206 cm⁻¹ is assignable to the C–O stretching vibration. In the spectra of polymers there is a decrease in peak intensity and numbers of C–H out of plane bending vibration of aromatic ring in the region 850-600 cm⁻¹ attributed to the phenylene (C–C coupling) units in polymer chain [20].

The ¹H spectra of HEBE and PHEBE are shown in Fig. 2 and spectral data of are given in experimental part. The -OH and -CH=

N– groups of HEBE resonate at 13.55 and 8.56 ppm respectively. The aromatic protons are appearing in the region of 6.77-6.99 ppm. In the spectra of polymer the –OH peak is either absent (or) appearing as small hump indicates the involvement of –OH group via C–O–C coupling. In addition to C–O–C coupling, there is C–C coupling also taking place in polymerization, this is shown by the increase in number of peaks for aromatic protons (6.26-7.21 ppm) due to the creation of new chemical environment.

The ¹³C-NMR spectra of HEBE and PHEBE are shown in Fig. 3. The C–C coupling occur only at ortho to –OH group of HEBE monomer as the radical site is formed at ortho position. Since, the C–C coupling increases the electron donating at the coupling site, the C4 carbon resonates in the upfield (118.02 ppm). The additional peaks appeared in the ¹³C-NMR spectrum of PHEBE is due to C–O–C and C–C couplings taken place (Fig. 3b). These results are in accordance with the mechanism proposed by Kaya et al. [21]. Possible resonance structures and combination of phenylene (C–C) and oxyphenylene (C–O–C) of HEBE are given in Schemes 3 and 4.

3.3. Optical properties

UV–vis spectra of the azomethine monomers and polyazomethines are given in Fig. 4. The absorption peaks at 261–273 and 306–442 nm are indicating the $\pi \to \pi^*$ and $n \to \pi^*$ transition of the benzenoid and imine bond of monomers. Also, this band (R



Fig. 7. I-V characteristics of I₂ doped (a) PHEBE, (b) PHMBE and (c) PHNAE polymers with different time intervals. (d) Electrical conductivity changes of the I₂ doped polymers vs doping time at room temperature.

band) extended up to 400–600 nm in the spectrum of polymer. The spectra of the polymers are red shifted from monomers spectra. This is an evidence for the increase in conjugation during the polymerization. Optical band gaps of monomers and polymers were calculated by $E_g = 1242/\lambda_{onset}$ formula and results are given in Table 2. Where λ_{onset} is, the onset wavelength, which is determined from the intersection of two tangents in the absorption edges. The band gap values calculated shows that the synthesized polymers have lower optical band gap due to the polyconjugated structure.

Fluorescence measurements of the monomers and polymers were carried out in DMSO solution with 100 mg/L concentration. The excitation and emission spectra of monomers and polymers are shown in Figs. 5 and 6. The emission maximum of azomethine diol monomers and polymers appeared in the range of 429–440 nm and 430–504 nm respectively. The results are given in from Table 3. All the polymers have recorded higher fluorescence in DMSO when compared with their monomers. This is because of extended conjugation of polymers via C–C and C–O–C coupling. The difference in wavelength between absorption and emission maxima of

the monomers and polymers is used to calculate stokes shift. Calculated stokes shift values are given in Table 3. Polymers are having higher stokes shift values than their corresponding monomer due to the extended conjugation in polymer chain [22]. The higher Stokes shift value supplies very low back ground signals and resultantly allow usage of the material in the construction of a fluorescence sensor [23].

3.4. Electrical properties

3.4.1. Conductivity

DC conductivity study was carried out using Keithley electrometer (6517 B) in the range of 1 V–10 V. Conductivities and their variation of polymers with respect to doping time (0–144 h) with iodine were determined by two probe method. The pellets were placed between two electrodes for the measurement. Fig. 7 (a–c) shows the I–V (Current-Voltage) characteristics curves of polyazomethines. The current is linearly increasing with an increase in voltage as well as iodine doping time as shown in Fig. 7. The



Fig. 8. Charge density distribution views of (a) HEBE, (b) HMBE and (c) HNAE.

conductivity of the samples was calculated using the given formula [24].

$$\sigma = [(IXL)/(VXA)] \tag{1}$$

where, I is the current, V is the voltage, L is the thickness of the pellet and A is the cross sectional area of the pellet. A graph is plotted between time and solid state conductivity values measured at air atmosphere. On doping with iodine the electron emitting imine nitrogen and electron pulling iodine coordinate and the formation of radical cation (polaron) structure in polymer chain (on imine nitrogen) is enabled. The electron vacancy formed due to this polaron facilitates the electron flow, and this causes increase in electrical conductivity. The electrical conductivity increases with increase in iodine vapour contact time. After 120 h of contact time the measured electrical conductivity of polymers are in the order PHNAE > PHEBE > PHMBE. Polymer PHNAE is having higher electrical conductivity (around 10^{-3} S cm⁻¹) than the other two polymers $(10^{-6} \text{ S cm}^{-1})$. In general, the electrical conductivity depends on the charge density on the nitrogen coordinating sites of the polymer chains. When the charge density on the coordinating site increases, the extent of iodine coordination with the coordinating site increases and they by conductivity increases [18]. By calculating the charge density of imine nitrogens of monomers by Huckel calculation method, the charge density imine nitrogens of polymers are compared [18]. The distribution of electron density of monomers are shown in Fig. 8. The charge density of imine nitrogens of monomers are in the order HNAE (-0.451, -0.287) > HEBE (-0.326, -0.298) > HMBE (-0.326, -0.297), which is same as the conductivity of the respective polymers. So, the order of conductivity of the polymers are proved with the help of electron density distributions of monomers. DC conductivity studies confirm that the polymers can be used as semi-conductive materials in electronic, opto-electronic and photovoltaic applications.

3.4.2. Dielectric properties

The frequency and temperature dependent dielectric constant and dielectric loss of polymers were measured. The plots of variation of dielectric constant and dielectric loss with logarithmic frequency at various temperature are shown in Fig. 9. The dielectric constant of the material was calculated using the formula [25].

$$\varepsilon_{\rm r} = {\rm Cd}/\varepsilon_0 {\rm A}$$
 (2)

where, C is the capacitance and d is the pellet thickness, A is the cross sectional area of the pellet and ε_0 is the free space permittivity of the pellet. The dielectric constant of PHEBE, PHMBE and PHNAE decreases with increase in frequency and beyond certain frequency, it has attained constant value. The synthesized polymers have high dielectric constant at low frequency as the dipoles have sufficient time to align with the field before it changes the direction. At high frequency, polymers have low dielectric constant because the dipoles do not have sufficient time to align before the field direction changes. When the frequency is low polymers exhibit high dielectric constant values with increase in temperature because the intermolecular forces between polymer chains are minimized and also enhances thermal agitation of polymer chains. Whereas, at low temperature, the dielectric constant is less because the segmental motion of the chain is practically freezed. The temperature dependent dielectric constant of polymers at a fixed frequency 50 Hz was analyzed and the plot shown in Fig. 10. At this constant frequency when the temperature increases dielectric constant increases. The increase in dielectric constant is very high for PHNAE and very low for PHEBE. The PHNAE polymer has naphthalene molety which is having more number of π bonds than the other two polymers with phenyl rings. These π bonds are loosely attached so, easily polarized, resulted in high dielectric constant. So, the PHNAE can be used to make passive component like capacitors, resistors etc. [26], The variation of dielectric loss at various temperature with increase in frequency is shown in Fig. 9 (b, d, f). The value of dielectric loss is high at lower frequencies and it is low at higher frequency regions. The low dielectric loss in high frequency region suggested that the synthesized polymers are suitable for electro-optical device applications [27].

3.5. Thermal properties

Thermal stability of polymers was studied by thermogravimetric analysis. TGA traces of polymers are shown in Fig. 11. Temperature corresponding to 10, 30, 50% weight loss and char yield are given in Table 4. The initial weight loss (2-3%) observed in the range of 30-110 °C is attributed to the presence of occluded moisture in polymers. All the polymers are undergoing single step degradation. The degradation may be mainly due to breaking of C–O–C etheric bond present in polymer. The polymers are slightly differing in their weight loss at various temperatures and char yield. This may be due to the propagation of polymer chain with more number of radical sites leading to the formation of polymer with more free ends (-OH group) which may be degrade easily. The intensity of –OH signal in ¹H-NMR is relatively high in PHNAE indicates more number of free ends. The results described that the polymers with long conjugation increases the delocalization of π electrons, leading to a higher resistance against temperature. The



Fig. 9. Dielectric constant (a, c, e) and dielectric loss (b, d, f) of PHEBE, PHMBE and PHNAE polymers with different temperature.

Та



Fig. 10. Dielectric constant of polymers with different temperature at 50 Hz.



Fig. 11. TG traces of polymers.

TGA results, shows that the synthesized polymers are thermally more stable than the previously reported azomethine derivatives of polymers [28]. Therefore, it can be used for applications in production of high temperature stable materials.

4. Conclusions

A series of polyazomethines were successfully synthesized via oxidative polymerization of azomethine diol monomers using NaOCI in aqueous alkaline medium. Structures of the synthesized monomers and polymers were supported by FT-IR, ¹H-NMR, ¹³C-NMR and UV-visible analyses. The spectral results confirm the existence of oxyphenylene (C–O–C) and phenylene (C–C) linkages in polyazomethine. The polymers have lower band gaps and good emission properties with high strokes shift values than their monomers, so it can be used in the preparation of fluorescence

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TG analysis	data	of	polymers.

Compound	T _{onset}	Weight loss temperature (°C)		C)	Char yield at 800 °C (Wt%)
		10%	30%	50%	
PHEBE	178	258	346	_	51.63
PHMBE	139	246	438	_	58.03
PHNAE	163	245	343	736	47.06

sensor material. High char yield in TG analysis suggests that the synthesized polymers are having good thermal stability and can be used as promising candidates for aerospace and high-temperature applications. I-V characteristics curves of synthesized polymers show the current is linearly increasing with increase in voltage as well as iodine doping time. Iodine vapour doped polymer PHNAE has recorded the maximum electrical conductivity of 10⁻³ Scm⁻¹ because, the charge density on imine nitrogen atoms of PHNAE is greater than the other two polymers. The high value of dielectric constant of PHNAE at 393 K is due to the presence of bulky naphthalene unit in polymer chain. So, the PHNAE can be used to make passive component like capacitors and resistors.

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