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RESEARCH ARTICLE

“SYNTHESIS, CHARACTERIZATION AND PHYSICO-CHEMICAL PROPERTIES OF POLYCYANURATES CONTAINING S-TRIAZINE RING IN THE MAIN CHAIN”.

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Abstract

Several polycyanurates were synthesised by polycondensation of the diacid chloride of 2-(*N*-methyl piperazine)-4,6-dichloro-*s*-triazine [MPDCT] with different diols such as: Bisphenol-A [BPA], Bisphenol-C [BPC], Bisphenol-S [BPS], Ethylene glycol [EG], Triethylene glycol [TEG], Propylene glycol [PG], Catechol [C], Resorcinol [R], Hydroquinone [Hq] and Phenolphthalein [Ph]. All the synthesized polycyanurates were characterized by solubility, density, viscosity measurements, IR spectra, NMR spectra and thermo gravimetric analysis [TGA]. The density of polycyanurates are measured pycnometrically, the highest density is 1.259 g/cm³ is found for PCPh while lowest density is 1.114 g/cm³ found for PCEG. Intrinsic viscosity, reduced viscosity and inherent viscosity for all the polycyanurates at various concentrations were determined by using Huggins & Kraemer method. The Intrinsic viscosity of the polycyanurates varies from 0.542 for PCPh to 0.350 for PCEG. The polycyanurates are found to stable more than 400 °C temperature thus it can be used for high temperature applications. Activation energy calculated for PCEG, PCPG and PCBPS by Broido and Horowitz & Metzger method is found to be 29.45 K.cal/mole, 29.29 K.cal/mole and 15.26 K.cal/mole respectively.

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Introduction:-

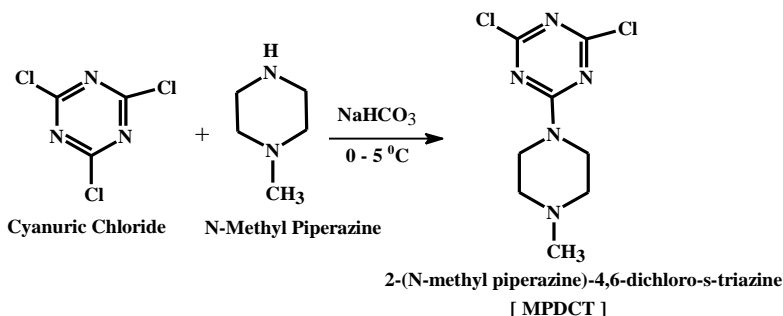
Polycyanurates are being designated as the next generation thermosetting polymers. Now days the polycyanurates are widely used in industries due to their outstanding performance with respect to resistance to fire, moisture, good mechanical strength, stability at cryogenic and elevated temperatures and good metal adhesion.[1-3] These unique properties of polycyanurates make them preferential materials for high temperature applications in aerospace, insulation, packaging, microelectronics and adhesive industries. The material can be chemically decomposed thus it can be recycle. Extensive literature exists on thermally stable polymers in which aromatic and heteroaromatic rings are linked together in the main chain. The problems have been tackled by many researchers over the last few decades to modifying the monomer structures. The presence of *s*-triazine ring in the main chain may alter the properties of polymers to great extent. Hence it was interesting to synthesize and characterize polyesters containing an *s*-triazine moiety in their backbone. [4-6] In the present investigation, the diacid chloride of 2-(*N*-methyl piperazine)-4, 6-dichloro-*s*-triazine [MPDCT] has been synthesized and from which different polycyanurates have been made by polycondensation with various diols.

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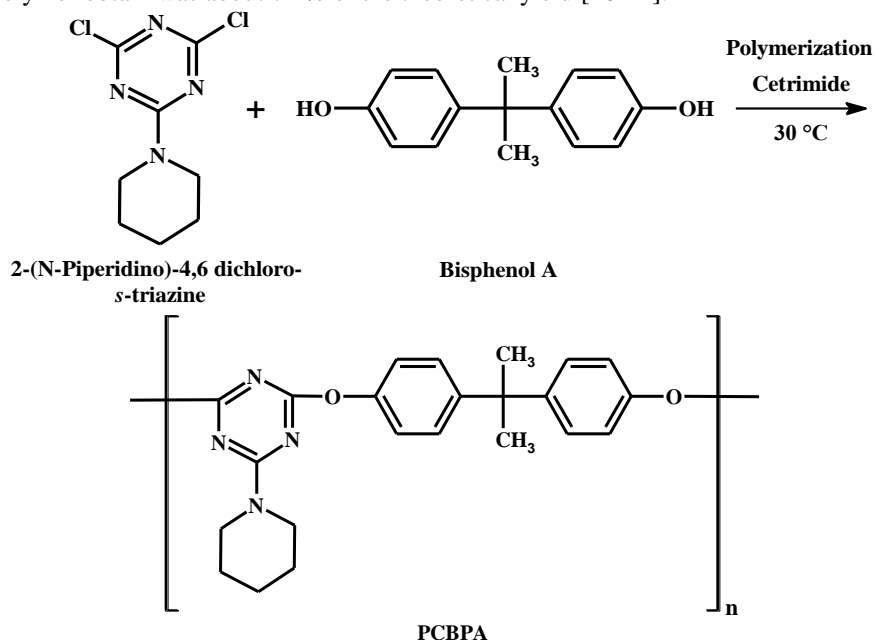
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Experimental:-**Step-1: Synthesis of 2-(N-methylpiperazine)-4, 6-dichloro-s-triazine [MPDCT]**

A solution of cyanuric chloride (18.44 g, 0.1 mole) in a 60 ml acetone was added with stirring to a cold solution (0-5 °C) of sodium bicarbonate (9.4 g, 0.1 mole) in 100 ml of distilled water in a three-necked flask (250 ml) equipped with a mechanical stirrer. This results in the formation slurry of cyanuric chloride. A solution of N-methyl piperazine (10.02 g, 0.1 mole) in 10 ml acetone was added to the cold slurry of cyanuric chloride with continuous stirring. After addition was completed, the reaction mixture was stirred for 2 hrs at 0-5 °C. The white coloured product was filtered and recrystallized from ethanol and dried in a vacuum desiccator (yield 89 %, m.p. 125 °C) [7-15].

**Step-2: Synthesis of Homopolyester from MPDCT and various diols:**

A solution of bisphenol-A (2.28 g, 0.01 mole), sodium hydroxide (1.6 g, 0.04 mole), 0.150 g of cetyl trimethyl ammonium bromide in 60 ml of double distilled water was stirred vigorously at 30 °C in a 250 ml three necked flask equipped with a mechanical stirrer. A solution of 2-(N-methyl piperazine)-4-6-dichloro-s-triazine (2.48 g, 0.01 mole) in 30 ml of chloroform was rapidly added to the aqueous solution and the emulsion was stirred vigorously for 8 hrs at 30 °C. The content were transferred to separating funnel and the aqueous layer was removed. The chloroform layer was washed with water and was finally run in to an excess of methanol from which the polymer precipitate out. The polymer was filtered, washed thoroughly with water and methanol. It was then dried at 85 °C. The dried polymer was further purified by dissolving it in chloroform and re-precipitated with methanol. The polymer obtained was about 72 % of the theoretical yield [16-22].

**Methods of Characterization:-****(1) Yield and colour:**

The yield of synthesized polycyanurates varies from 64 to 82 %. The highest yield obtained for PCC is 82% and lowest 64% for PCEG. The yield of the polycyanurates depends on the reactivity and the structure of the diols

component used. The approximate yield and the colour of all the synthesized polyesters are presented in **Table-2**. Colour of PCC is brick red, PCPh is red, PCR is reddish brown, PCHq is black and all other synthesized polycyanurates of this series are white colour. All the polyesters are obtained in powdery form.

(1) Solubility:-

30 to 50 mg sample of finely ground polycyanurate was placed in to a small test tube and 1 ml of solvent was added to each. The mixtures were stored at 25 °C for some time with occasional shaking. Formation of streaks while shaking indicated dissolution. Polymer samples that swelled without dissolving at 25 °C were heated to 50 °C in order to affect the process of dissolution. Several solvents were tested for this purpose.

Table-1:- Relative solubility of homopolyesters in various solvents

Solvents	PCBPA	PCBPC	PCBPS	PCC	PCHq	PCR	PCEG	PCTEG	PCPG	PCPh
Chloro Benzene	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Benzene	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Toluene	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Chloroform	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +
Acetone	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +
Carbon Tetrachloride	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Di Methyl Formamide	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +
Ethyl Acetate	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Methanol	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Ethanol	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
DMSO	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +
1,4-Dioxane	± +	+ +	+ +	+ +	± +	± +	± +	± +	+ +	+ +
1,2 Dichloro Ethane	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
2-Chloro Propanol	± +	± +	± +	± +	± +	± +	± +	± +	± +	± +
Pyridine	± +	± +	± +	± +	± +	± +	± +	± +	± +	± +

+ = Soluble, - = Insoluble, ± = partly soluble. 1st symbol indicates solubility at 25 ± 1 °C 2nd at 50 °C.

(2) Density characteristics:-

The density of a polymer is usually determining pycnometrically in a liquid inert to the polymer. The density of each polyester were determine at 25 ± 3 °C by suspending each of the polyesters in a liquid mixture of carbon tetrachloride and acetone and subsequently measuring the density of the liquid mixture by a pycnometer, are presented in **Table 2**. This liquid system is found to be inert to all polyesters since they remained in a state of suspension even for a prolonged time. Estimated accuracy of density is ± 0.001 g/cm³. The sequence of density of polyesters is as follow;

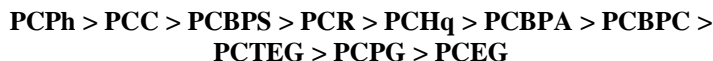
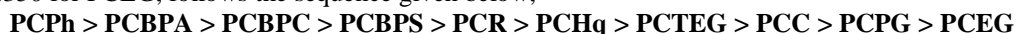


Table-2:- Density of polycyanurates:

Polymer Code	Yield (%)	Colour	Density (g /cm ³)
PCBPA	72	White	1.209
PCBPC	80	Reddish brown	1.189
PCBPS	76	White	1.219
PCEG	64	White	1.114
PCTEG	65	White	1.119
PCPG	66	White	1.117
PCC	82	Brick Red	1.221
PCR	79	Brown	1.216
PCHq	71	Black	1.211
PCPh	74	Red	1.259

(3) Viscosity Measurements:-

Dilute solution viscosity measurements were carried out using Ubbelohde suspended level viscometer. Intrinsic viscosity, reduced viscosity and inherent viscosity for all the polycyanurates at various concentrations were determined by using Huggins & Kraemer method at 25 ± 1 °C temperature. The relative viscosity (η_{rel}) and specific viscosity (η_{sp}) were calculated. Reduced viscosity and inherent viscosity were then calculated from experimental data. The Intrinsic viscosity of the polyesters synthesized from MPDCT and various diols varies from 0.542 for PCPh to 0.350 for PCEG, follows the sequence given below,



Huggins & Kraemer constant for all polyesters were derived from the graph (**Figures 1 to 5**) and shown in the **Table-4**. The values of Huggins & Kraemer coefficients are adequate to evaluate the solvent quality. Experimental results indicate that the values are lower than 0.5 are obtain from dilute polymer solution in good solvents. Higher the affinity between polymer and solution lower the value of K & β .

Table 3:- Solution viscosity of Polycyanurate PCBPA.**Solvent: DMF** **$t_0 = 172$ seconds**

Sr. No.	Con. C (g/dl)	Flow time (t sec)	$\eta_{rel} = t/t_0$	$\eta_{sp} = \eta_{rel} - 1$	$\eta_{red} = \eta_{sp}/C$	$\ln \eta_{rel}/C$
1.	0.2	191.1	1.114	0.111	0.555	0.526
2.	0.4	211.4	1.229	0.229	0.572	0.515
3.	0.6	233.0	1.354	0.354	0.591	0.505
4.	0.8	255.7	1.486	0.486	0.608	0.495
5.	1.0	279.6	1.625	0.625	0.625	0.485

Table-4:- Viscosity values and Huggins & Kraemer constant for homopolyesters:

Polymer Code	Intrinsic Viscosity $[\eta]$	Reduced Viscosity η_{sp}/C	Inherent Viscosity $\ln \eta_{rel}/C$	Huggins slope	Kraemer slope	Huggins Constant K	Kraemer Constant β
PCBPA	0.537	0.625	0.485	0.086	0.050	0.310	0.177
PCBPC	0.536	0.612	0.477	0.080	0.060	0.260	0.208
PCBPS	0.483	0.566	0.448	0.060	0.040	0.356	0.213
PCEG	0.350	0.386	0.324	0.040	0.0266	0.293	0.150
PCTEG	0.365	0.400	0.336	0.040	0.040	0.263	0.218
PCPG	0.356	0.394	0.331	0.046	0.036	0.301	0.198
PCC	0.361	0.404	0.339	0.043	0.028	0.330	0.169
PCR	0.404	0.450	0.371	0.046	0.033	0.282	0.202
PCHq	0.403	0.422	0.352	0.020	0.050	0.117	0.314
PCPh	0.542	0.659	0.506	0.116	0.036	0.399	0.122

Concentration of solution is 1 g/dl for all polymers.

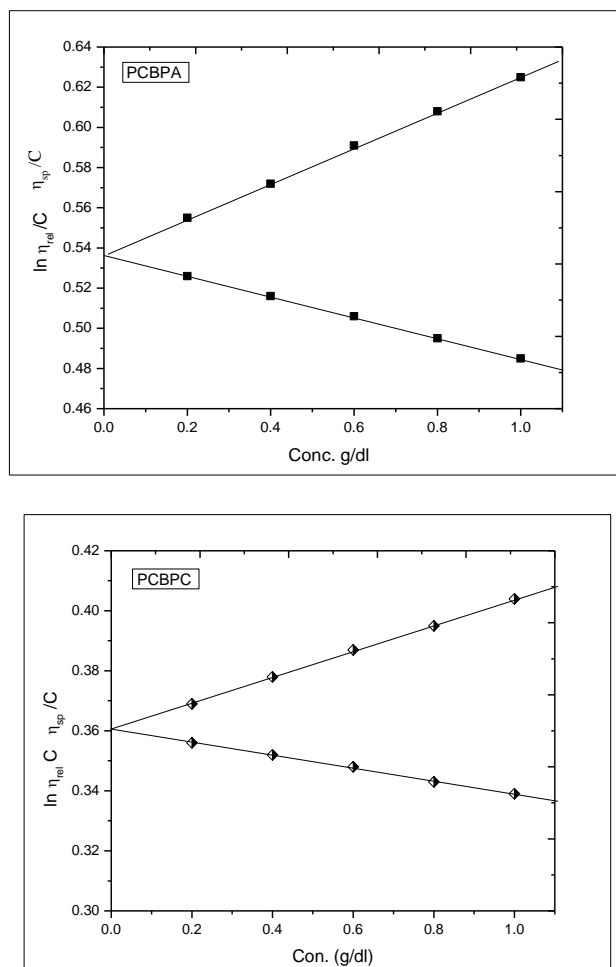
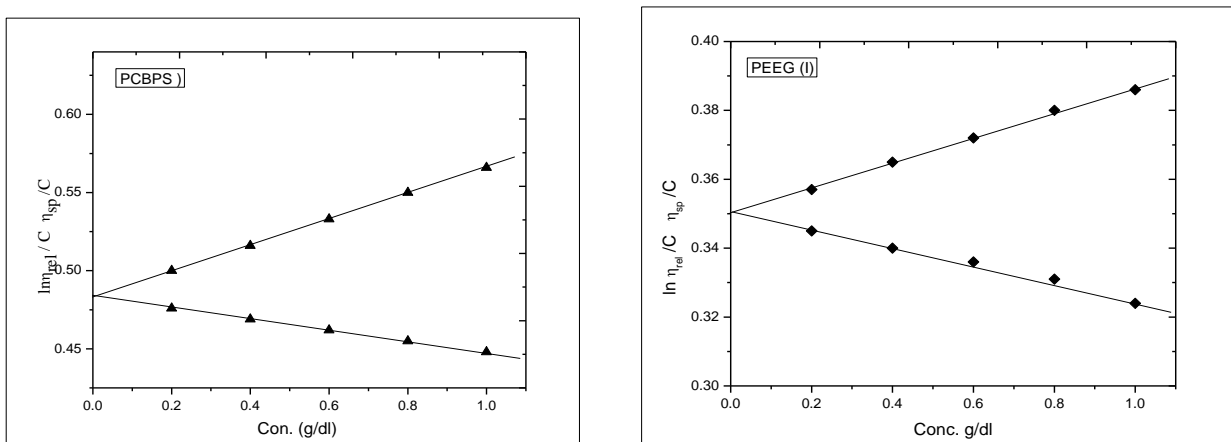
Figure-1:- Huggins & Kraemer plot for intrinsic viscosity of PCBPA & PCBPC**Figure-2:-** Huggins & Kraemer plot for intrinsic viscosity of PCBPS & PCEG

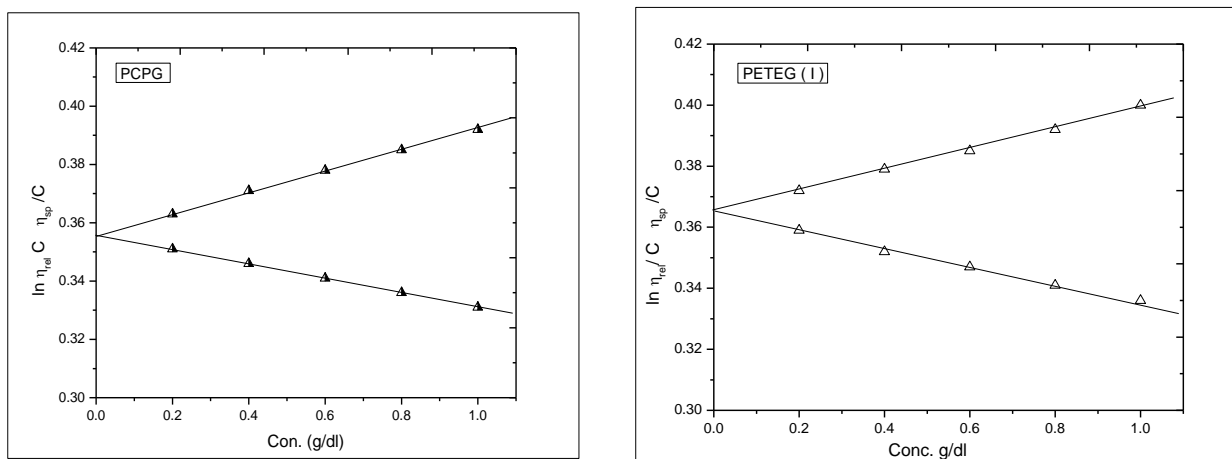
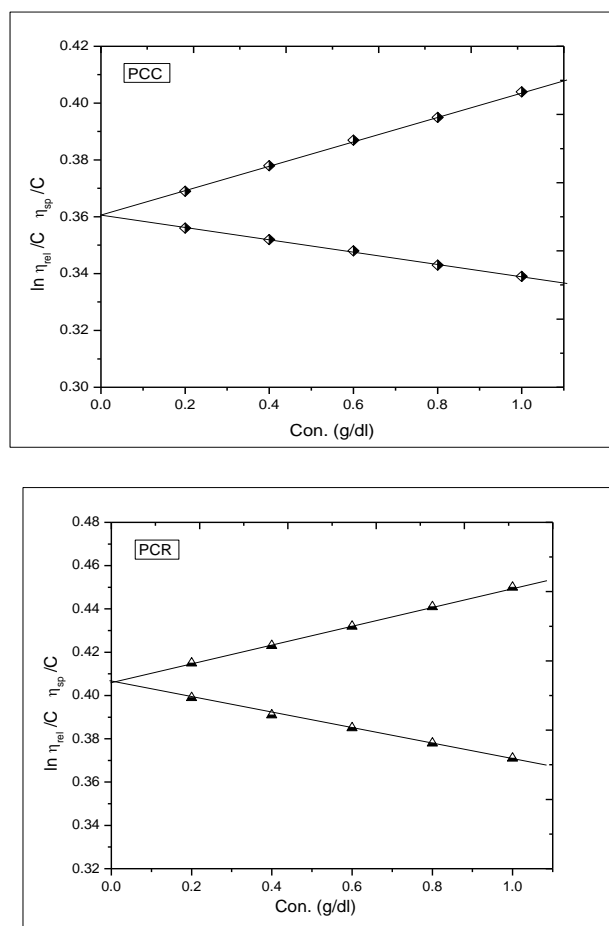
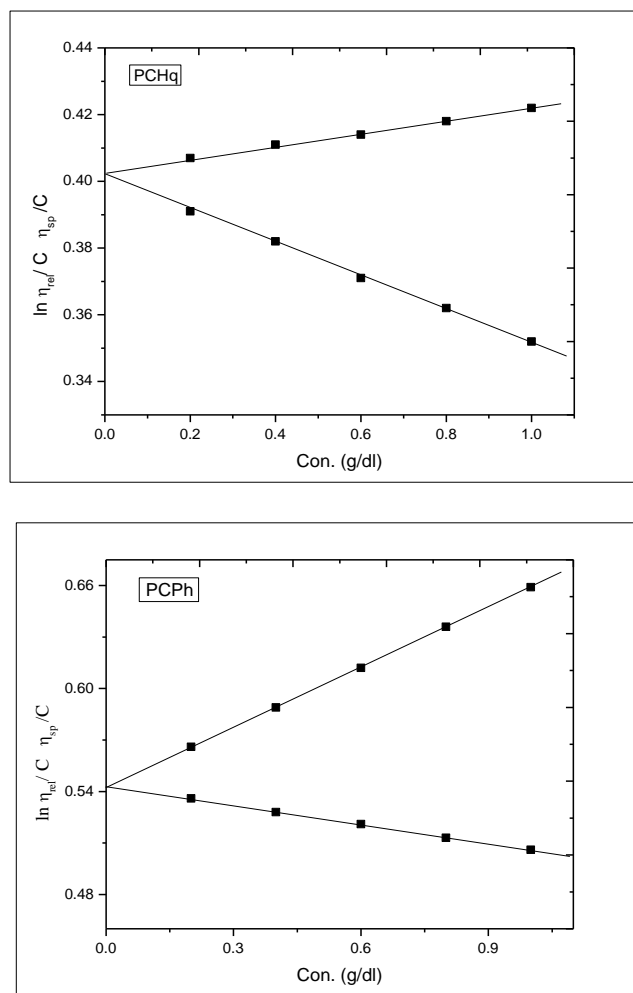
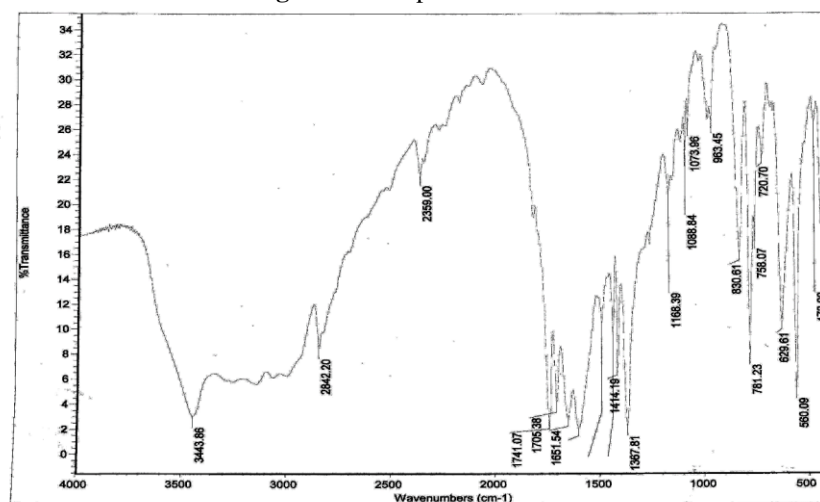
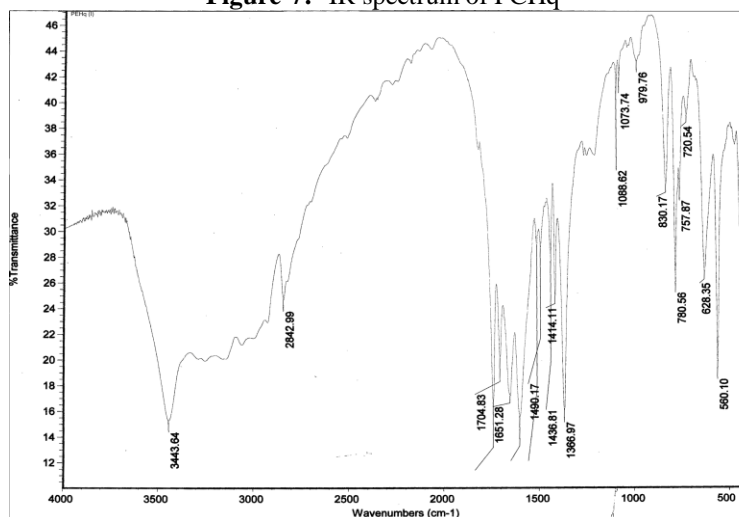
Figure-3:- Huggins & Kraemer plot for intrinsic viscosity of PCPG & PCTEG**Figure-4:-** Huggins & Kraemer plot for intrinsic viscosity of PCC & PCR

Figure-5:- Huggins & Kraemer plot for intrinsic viscosity of PCHq & PCPh**(6) Infrared spectra:-**

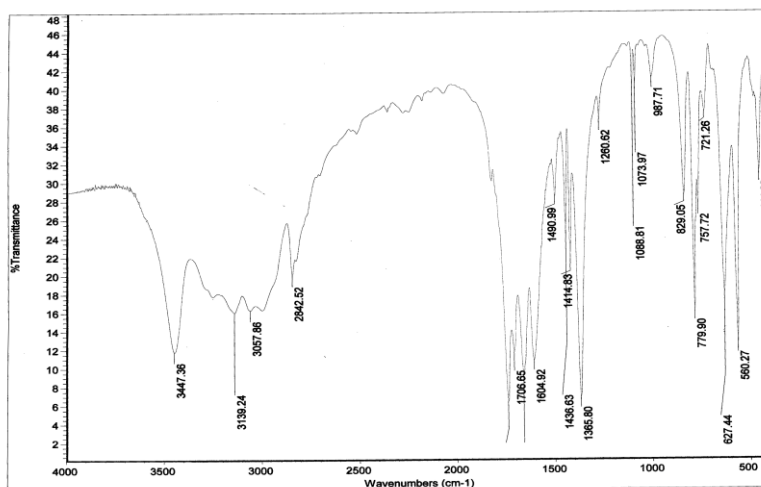
The IR spectra of synthesized polycyanurates are shown in **Figures-6 to 10**. IR spectra of the polyesters a broad band, which is a characteristic of bonded -OH group, extends from 3020 to 3680 cm^{-1} with a maximum around 3420–3450 cm^{-1} , most probably due to -OH bond of end -COOH group. The presence of *s*-triazine ring is supported by the appearance of a band at 1440–1510 cm^{-1} , which is due to in-plane bending vibration of *s*-triazine ring. In spectra of all the polyesters band observed, at 1105–1200 cm^{-1} symmetric, which is attributed to C-O-C stretching. The band at 1310-1360 cm^{-1} is of aromatic C-N stretching linkage (N- containing six member ring). The band observed at around 1260-1300 cm^{-1} is attributed to symmetric stretching vibration of C-O-C (ether) linkage. Band obtain at 1360-1400 cm^{-1} is of C-H bending vibration of -CH₃ group. The homopolyesters involving the aromatic diols in their backbone exhibit bands in the region of 610–670 cm^{-1} , which may be due to out of plane bending vibrations of C-H bands of aromatic rings. The band observed at 595 cm^{-1} in the spectrum of PCEG is attributed to the vibration of aliphatic chain.

Figure 6:- IR spectrum of PCR

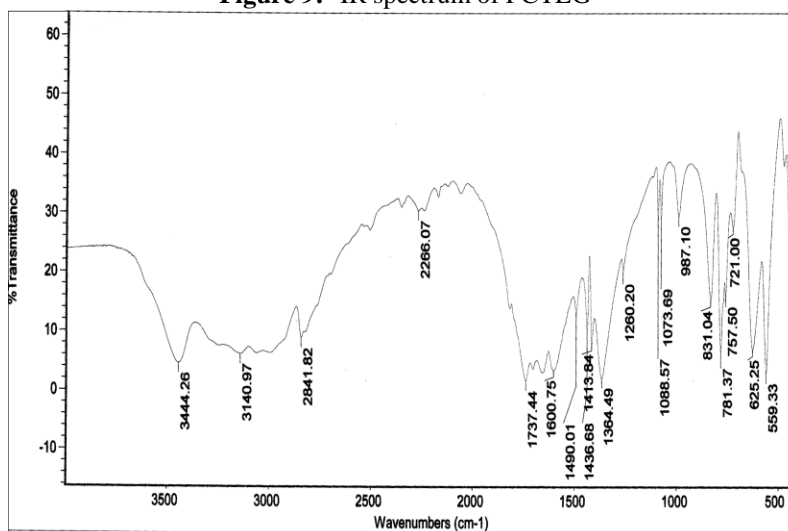
The IR spectral data of PCR in cm^{-1} [Figure-6]: 758 (Out of plane bending vibration of C-H bond of aromatic ring), 720 (m-substituted phenyl ring), 830 (Out of plane vibration of *s*-triazine ring), 1073 (Vibration of aryl ether linkage symmetric), 1367 (Aromatic C-N stretching vibration), 1414 (C-H bending vibration of $-\text{CH}_3$ group), 1510 (In plane vibration of *s*-triazine ring), 3443 (Stretching vibration of $-\text{OH}$ group).

Figure-7:- IR spectrum of PCHq

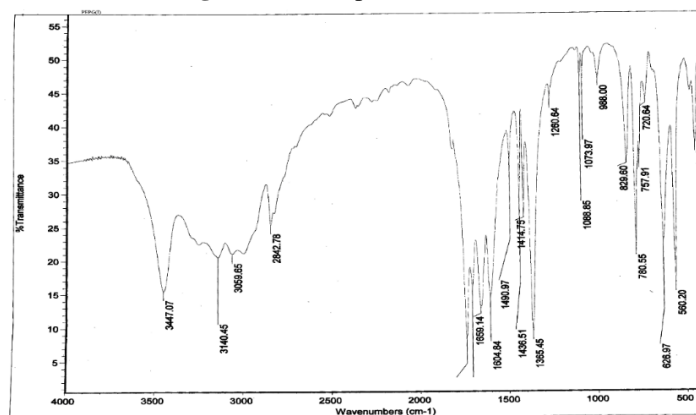
The IR spectral data of PCHq in cm^{-1} [Figure-7]: 757 (Out of plane bending vib. of C-H bond of aromatic ring), 830 (Out of plane vib. of *s*-triazine ring), 1073 (Vibration of aryl ether linkage symmetric), 1360 (Aromatic C-N stretching vibration), 1436 (C-H bending vibration of $-\text{CH}_3$ group), 1490 (In plane vibration of *s*-triazine ring), 3443 (stretching vibration of $-\text{OH}$ group).

Figure 8:- IR spectrum of PCEG

The IR spectral data of PCEG in cm^{-1} [Figure-8]: 757 (Out of plane bending vibration of C-H bond of aromatic ring), 721 (C-H bending vibration of $(\text{CH}_2)_n$), 829 (Out of plane vibration of *s*-triazine ring), 1088 (Vibration of aryl ether linkage symmetric), 1260 (Vibration of aryl ether linkage asymmetric), 1365 (Aromatic C-N stretching vibration), 1414 (C-H bending vibration of $-\text{CH}_3$ group), 1490 (In plane vibration of *s*- triazine ring), 3447 (stretching vibration of $-\text{OH}$ group).

Figure 9:- IR spectrum of PCTEG

The IR spectral data of PCTEG in cm^{-1} [Figure-9]: 757 (Out of plane bending vibration of C-H bond of aromatic ring), 721 (C-H bending vibration of $(\text{CH}_2)_n$), 831 (Out of plane vibration of *s*-triazine ring), 1088 (Vibration of aryl ether linkage symmetric), 1260 (Vibration of aryl ether linkage asymmetric), 1364 (Aromatic C-N stretching vibration), 1413 (C-H bending vibration of $-\text{CH}_3$ group), 1490 (In plane vibration of *s*-triazine ring), 3444 (stretching vibration of $-\text{OH}$ group).

Figure-10:- IR spectrum of PCPG

The IR spectral data of PCPG in cm^{-1} [Figure-10]: 757 (Out of plane bending vibration of C-H bond of aromatic ring), 720 (C-H bending vibration of $(\text{CH}_2)_n$), 829 (Out of plane vibration of *s*-triazine ring), 1088 (Vibration of aryl ether linkage symmetric), 1260 (Vibration of aryl ether linkage asymmetric), 1365 (Aromatic C-N stretching vibration), 1414 (C-H bending vibration of $-\text{CH}_3$ group), 1490 (In plane vibration of *s*-triazine ring), 2842 (C-H stretching vibration of $-\text{CH}_2$ group), 3447 (stretching vibration of $-\text{OH}$ group).

(4) Thermo Gravimetric Analysis (TGA):-

All the thermograms of polycyanurates have been obtain on the 'Perkin- Elmer Pyris-1 TGA' at a constant heating rate of $10^\circ\text{C}/\text{minute}$ in the temperature range from ambient temperature to about 600°C . TGA thermograms obtain at a heating rate of $10^\circ\text{C}/\text{min}$. Figures 11, 12 and 13 have been analyzed as per the graphical methods proposed by Broido, Horowitz & Metzger.

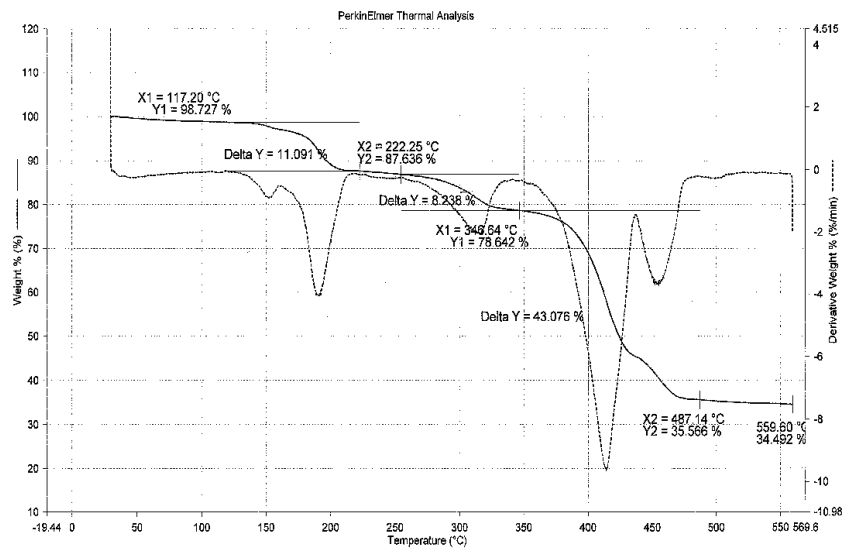
Figure 11:- Thermogram of PCEG

Figure 12:- Thermogram of PCPG

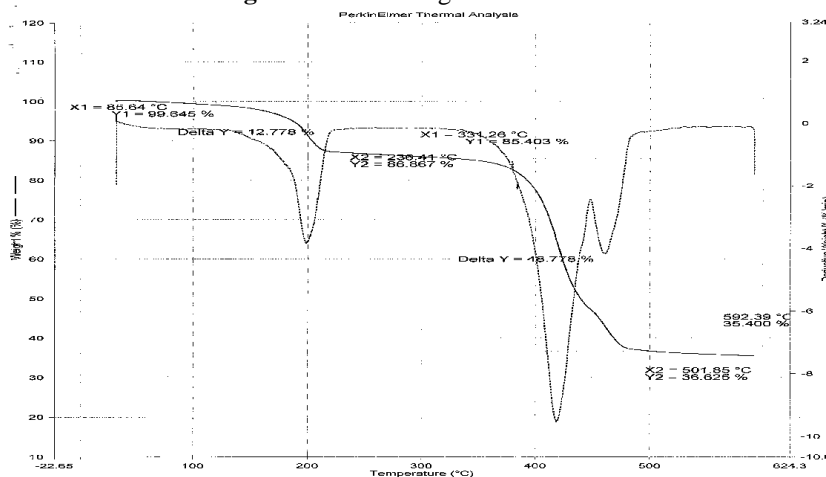


Figure13:- Thermogram of PCBPS

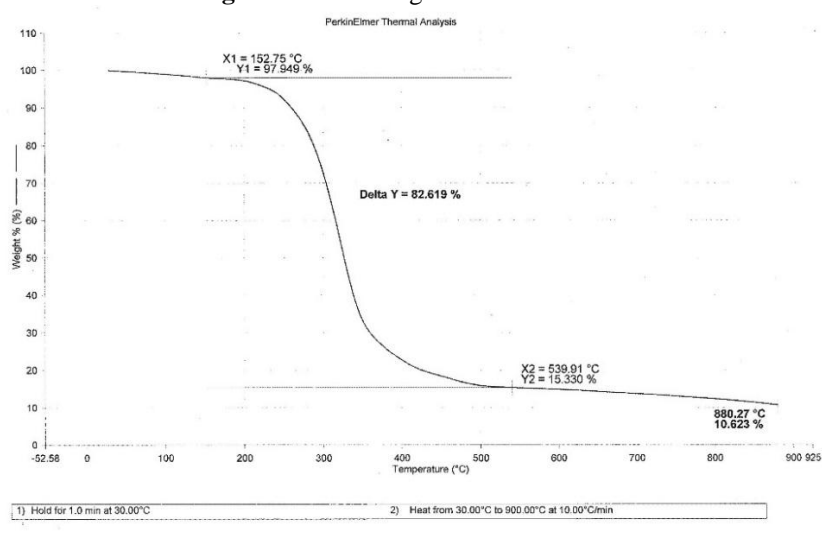


Table-5:- Thermal stability of polycyanurates:

Polymer	T_0	T_{10}	T_{max}		T_s
			Step I	Step II	
PCEG	145	200	190	410	430
PCPG	150	200	200	410	440
PCBPS	190	250	300	-	305

T_0 = Initial decomposition temperature.

T_{10} = Temperature for 10% weight loss.

T_{max} = Temperature for maximum rate of decomposition.

T_s = Half volatilization temperature.

PCEG: PCEG decomposes in two distinct weight loss steps. The polymer begins to decompose at about 190 °C. The first step decomposition encompassing a temperature range 175 - 210 °C involving about 11.24 % weight loss. The second step involves about 22.98 % weight loss over a temperature range 330–500 °C. After that the sample decomposes up to 560 °C leaving about 11.09 % residue.

PCPG: PCPG decomposes in two distinct weight loss steps. The polymer begins to decompose at about 200 °C. The first step decomposition encompassing a temperature range 150-215 °C involving about 11.24 % weight loss. The

second step involves about 50.00 % weight loss over a temperature range 350-485 °C. After that the sample decomposes up to 592 °C leaving about 35.40 % residue.

PCBPS: The thermal degradation of PCBPS exhibits in one distinct step. The polymer begins to decompose at about 220 °C. The decomposition is marked with a rapid weight loss in the temperature range 220-540 °C during which the polymer samples losses 82.7% of its weight. The maximum rate of weight loss occurs at 305 °C. After that the samples decomposes up to 800 °C leaving about 10.62 % residue.

The thermal stability of polycyanurates on the basis of initial decomposition temperature T_0 is as PCEG > PCPG > PCBPS.

Broido and Horowitz & Metzger methods are exemplified for PCEG in **Tables 6 and 7** respectively while for PCPG is shown in **Tables 8 and 9** and the corresponding plots are shown in **Figures 14-15** and **16-17**. The plots for PCBPS is shown in **Figures- 18 & 19**. [23-24]

Activation energy calculated by Broido and Horowitz & Metzger method is shown in **Table-10**.

Table-6: Application of Broido method to thermogram of PCEG

T °C	% Wt.	$Y = \frac{W_t - W_\infty}{W_0 - W_\infty}$	1/ Y	ln ln (1/Y)	T K	1000/ T (K ⁻¹)
380	76.10	0.6351	1.5745	-0.7897	653	1.5313
390	73.70	0.5985	1.6708	-0.6668	663	1.5082
400	69.20	0.5298	1.8875	-0.4537	673	1.4858
410	62.13	0.4219	2.3702	-0.1473	683	1.4641
420	53.05	0.2833	3.5298	0.2321	693	1.4430
430	47.04	0.1915	5.2219	0.5025	703	1.4224
440	44.95	0.1596	6.2656	0.6070	713	1.4025

Table-7:- Application of Horowitz- Metzger method to thermogram of PCEG

T °C	% Wt.	1 - α	1/ 1 - α	ln ln (1/1- α)	T K	Θ
380	76.10	0.6351	1.5745	-0.7897	653	-30
390	73.70	0.5985	1.6708	-0.6668	663	-20
400	69.20	0.5298	1.8875	-0.4537	673	-10
410	62.13	0.4219	2.3702	-0.1473	683	00
420	53.05	0.2833	3.5298	0.2321	693	10
430	47.04	0.1915	5.2219	0.5025	703	20
440	44.95	0.1596	6.2656	0.6070	713	30

Table-8:- Application of Broido method to thermogram of PCPG

T °C	% Wt.	$Y = \frac{W_t - W_\infty}{W_0 - W_\infty}$	1/ Y	ln ln (1/Y)	T K	1000/ T (K ⁻¹)
380	82.31	0.7208	1.3873	-1.1165	653	1.5313
390	80.06	0.6853	1.4592	-0.9731	663	1.5082
400	76.50	0.6292	1.5893	-0.7693	673	1.4858
410	70.40	0.5329	1.8765	-0.4629	683	1.4641
420	61.28	0.3890	2.5706	-0.0574	693	1.4430
430	53.61	0.2680	3.7313	0.2751	703	1.4224
440	49.01	0.1954	5.1177	0.4902	713	1.4025

Table-9:- Application of Horowitz- Metzger method to thermogram of PCPG

T °C	% Wt.	1 - α	1/ 1 - α	ln ln (1/1- α)	T K	Θ
380	82.31	0.7208	1.3873	-1.1165	653	-30
390	80.06	0.6853	1.4592	-0.9731	663	-20
400	76.50	0.6292	1.5893	-0.7693	673	-10
410	70.40	0.5329	1.8765	-0.4629	683	00
420	61.28	0.3890	2.5706	-0.0574	693	10
430	53.61	0.2680	3.7313	0.2751	703	20
440	49.01	0.1954	5.1177	0.4902	713	30

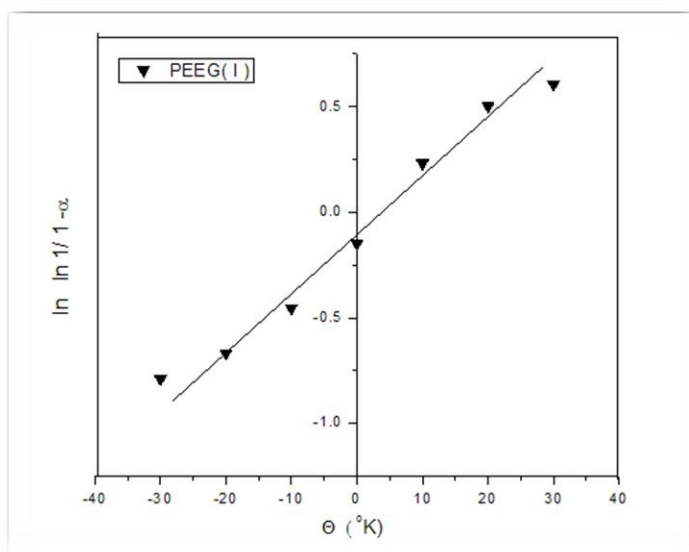
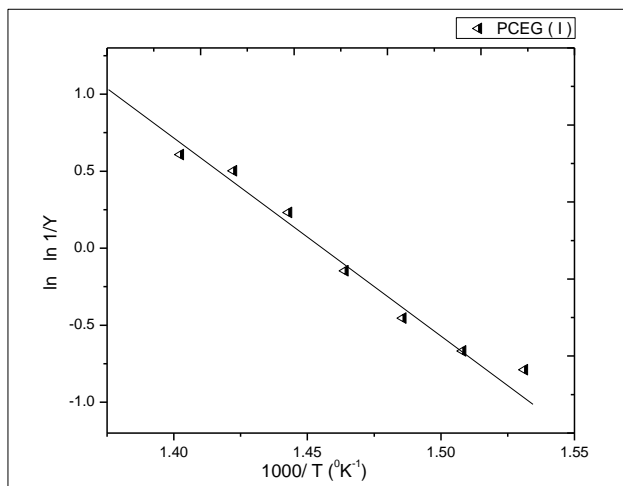
Figure 14:- Brodio plot for PCEG**Figure 15:-** Horowitz- Metzger plot for PCEG

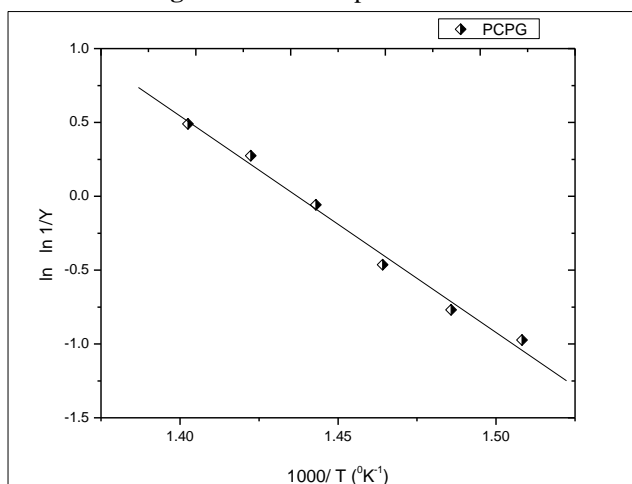
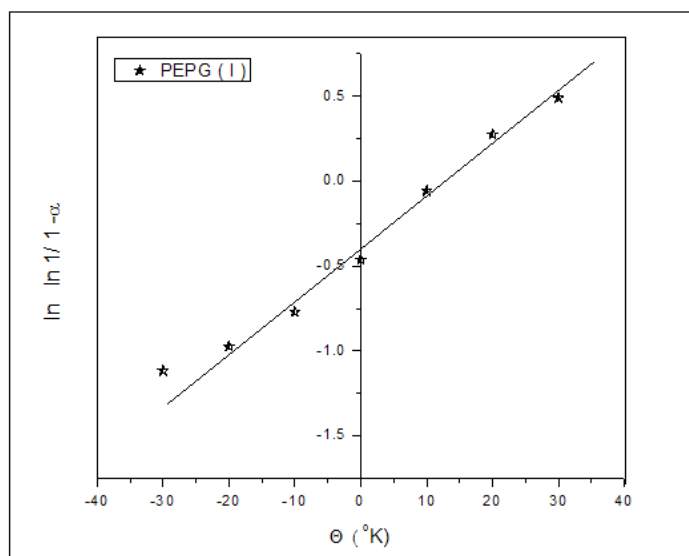
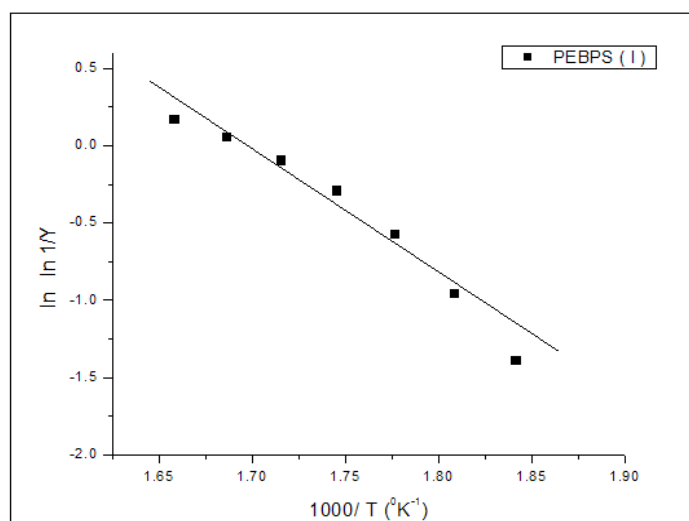
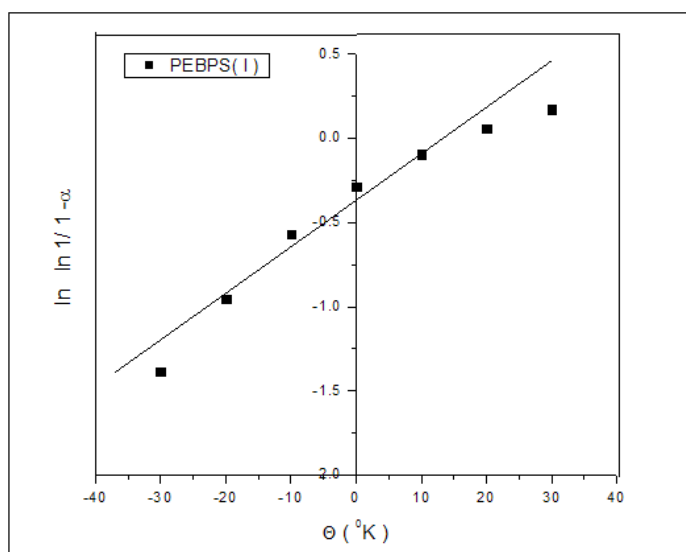
Figure16:- Broido plot for PCPG**Figure 17:-** Horowitz- Metzger plot for PCPG**Figure 18:-** Broido plot for PCBPS

Figure 19:- Horowitz- Metzger plot for PCBPS**Table-10:-** Activation energy calculated by Broido and Horowitz & Metzger method

Polymer code	Broido		Horowitz & Metzger		
	Slope	Ea (K.cal./mole)	Slope	Ts	Ea (K.cal./mole)
PCEG	-16.0	31.79	0.030	703	29.45
PCPG	-12.5	26.82	0.029	713	29.29
PCBPS	-6.0	11.92	0.023	578	15.26

(6) ^1H NMR SPECTROSCOPY:-

High resolution (400 MHz) ^1H -NMR spectra of solution of representative homopolyester sample were measured in deuterateddimethylsulfoxide ($\text{DMSO}-d_6$) using TMS as an internal reference.

The data of ^1H -NMR spectra of polycyanurates PCR in δ ppm: 7.24 (1H, t, Ar-CH), 6.56 (1H, d, Ar-CH), 6.49 (1H, d, Ar-CH), 6.41 (1H, s, Ar-CH), 3.14 (4H, t, Methylene $-\text{CH}_2$), 2.35 (4H, t, Methylene $-\text{CH}_2$), 2.20 (3H, s, $\text{N}-\text{CH}_3$).

The data of ^1H -NMR spectra of polycyanurates PCHq in δ ppm: 7.10 (2H, d, Ar-CH), 6.95 (2H, d, Ar-CH), 3.15 (4H, t, Methylene $-\text{CH}_2$), 2.34 (4H, t, Methylene $-\text{CH}_2$), 2.21 (3H, s, $\text{N}-\text{CH}_3$).

The data of ^1H -NMR spectra of polycyanurates PCEG in δ ppm: 4.30 (2H, t, Aliphatic $-\text{CH}_2$), 3.75 (2H, t, Aliphatic $-\text{CH}_2$), 3.13 (4H, t, Methylene $-\text{CH}_2$), 2.36 (4H, t, Methylene $-\text{CH}_2$), 2.20 (3H, s, $\text{N}-\text{CH}_3$).

The data of ^1H -NMR spectra of polycyanurates PCTEG in δ ppm: 4.31 (2H, t, Aliphatic $-\text{CH}_2$), 3.76 (2H, t, Aliphatic $-\text{CH}_2$), 3.45-3.55 (8H, m, Aliphatic $-\text{CH}_2$), 3.15 (4H, t, Methylene $-\text{CH}_2$), 2.35 (4H, t, Methylene $-\text{CH}_2$), 2.22 (3H, s, $\text{N}-\text{CH}_3$).

The data of ^1H -NMR spectra of polycyanurates PCPG in δ ppm: 4.4-3.7 (3H, m, Aliphatic- CH_2), 3.13 (4H, t, Methylene $-\text{CH}_2$), 2.34 (4H, t, Methylene $-\text{CH}_2$), 2.20 (3H, s, $\text{N}-\text{CH}_3$), 1.33 (3H, d, Methyl $-\text{CH}-\text{CH}_3$).

(7) Result and Discussion:-

Methylated solvents are found to be good solvents for all the polycyanurates. It is also noticed that solubility increases with temperature and those polycyanurates that have partial solubility at 25 $^{\circ}\text{C}$ get dissolved at higher temperature. All the polyesters are soluble in polar aprotic solvents like DMF and DMSO. DMF is found to be best solvent for all the polycyanurates. The density of polycyanurates are measured pycnometrically, the highest density is 1.259 g/cm^3 is found for PCPh while lowest density is 1.114 g/cm^3 found for PCEG. Intrinsic viscosity, reduced viscosity and inherent viscosity for all the polycyanurates at various concentrations were determined by using Huggins & Kraemer method at 25 ± 1 $^{\circ}\text{C}$ temperature. The Intrinsic viscosity of the polyesters synthesized from MPDCT and various diols varies from 0.542 for PCPh to 0.350 for PCEG. The polycyanurates are found to stable more than 400 $^{\circ}\text{C}$ temperature thus it can be used for high temperature applications. Activation energy calculated for

PCEG, PCPG and PCBPS by Broido and Horowitz & Metzger method is found to be 29.45, 29.29 and 15.26 K.cal./mole.

(8) SYMBOLS AND ABBREVIATIONS:

Ea	: Activation energy.
MPDCT	: 2-(N-methyl piperazine)-4, 6-dichloro-s-triazine.
PCPh	: Polycyanurate of Phenolphthalein.
PCC	: Polycyanurate of Catechol.
PCBPS	: Polycyanurate of Bisphenol-S.
PCR	: Polycyanurate of Resorcinol.
PCHq	: Polycyanurate of Hydroquinone.
PCBPA	: Polycyanurate of Bisphenol-A.
PCBPC	: Polycyanurate of Bisphenol-C.
PCTEG	: Polycyanurate of Triethylene Glycol.
PCPG	: Polycyanurate of Propylene Glycol.
PCEG	: Polycyanurate of Ethylene Glycol.

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