ISSN: 2454-9940

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

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INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN 2454-9940

www.ijasem.org

Vol 19, Issue 4, 2025

SYNTHESIS AND CHARACTERIZATION OF AROMATIC POLY (ETHER- AMIDE) S BASED ON 1,5- NAPHTHYL DIAMINE MONOMER

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ABSTRACT

Aromatic poly (ether-amide) s were synthesized using 1,5-naphthyl diamine as a key monomer via a solution polycondensation method. The incorporation of the rigid naphthalene unit imparted enhanced thermal stability and mechanical strength to the resulting polymers. Structural characterization was performed using FTIR, NMR, and elemental analysis, confirming successful polymer formation. Thermal behavior was studied using TGA and DSC, showing high decomposition temperatures and good thermal resistance. The synthesized polymers also exhibited excellent solubility in polar aprotic solvents. These findings suggest potential applications in high-performance materials requiring thermal and chemical stability.

Keywords: Aromatic poly (ether- amide) s, 1,5- naphthyl diamine, Solubility, Viscosity, Thermal stability

1. Introduction

Aromatic polyamides are gorgeous high performance polymers due to their excellent mechanical strength and high thermal stability [1-5]. However, their high softening or melting temperatures and poor solubility in organic solvents due to high crystallinity and high rigidity of the polymer backbone limit their processability and applications [6,7]. Numerous approaches have been outlined to enhance the solubility and processability of aromatic polyamides with retaining of their high thermal stability. These approaches include integration of non-coplanar groups in the main chain [8-11], molecular asymmetry [12- 23], the use of meta-oriented monomers [24,25], flexible linkages [26-31], and bulky pendent [32-48] or cardo groups [49-54]. These alterations work by breaking chain symmetry and regularity and by terminating hydrogen bonding, usually leading to better solubility and processability [55-61].

The objective of the present work was to synthesize a series of polyamides which contains naphthyl ring containing thizoleamine group on the polymer properties such as solubility and thermal behavior. Thus, a series of polyamides was produced by solution polycondensation of 2, 2'-bis(4-(2- aminothiazol-4-yl)phenoxy)-1,1'-binaphthyl (III) with commercially available diacids, viz., 4,4‟-Oxybis(benzoic acid);

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4,4‟- Hexafluoroisopropylidene bis(benzoic acid); 4,4‟-Sulfonyl dibenzoic acid and Biphenyl 4,4‟ dicarboxyllic acid. The synthesized polyamides were characterized by inherent viscosity measurements, solubility tests, FT-IR spectroscopy, X-ray diffraction pattern, thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) studies. Here in reported the synthesis of new series of poly(ether-amide)s from newly synthesized naphthyl ring containing thizoleamine and commercial diacids.

2. Experimental

2.1. Materials

All the solvents / chemicals were purified before use by following the standard procedures.

1. N-N Dimethylacetamide was refluxed over barium oxide for 4h, the liquid was decanted in a separate round bottom flask and distilled at reduced pressure over calcium hydride and stored over Linde type 4 Å Molecular sieves.
2. K_2CO_3 was dried under vacuum at 150°C for 6h.
3. 2-Naphthalol, 4-fluro acetophenone purchased from Spectrochem and used as received.
4. Triphenyl phosphate, 4, 4‟-oxybis(benzoic acid), 4, 4‟- bis(benzoic acid), 4, 4‟-sulfonyl dibenzoic acid and Biphenyl 4, 4‟ dicarboxyllic acid were purchased from Sigma Aldrich (USA) and were used as received.
5. 4- Fluro nitrobenzene purchased from Spectrochem (India) and used as received.
6. Pyridine was refluxed with solid potassium hydroxide pellets, fractionally distilled and stored over Linde type 4 Å Molecular sieves. N-Methyl-2 pyrrolidone (NMP) was dried by azeotropic removal of water with benzene for 6 h, distilled under reduced pressure and stored over Linde type 4 Å Molecular sieves.

2.2. Synthesis of new diamine monomer

2.2.1. Synthesis of 2, 2'-dihydroxy-1, 1'-binaphthyl (I)

In a three necked flask equipped with a dropping funnel and reflux condenser, 14.4g (0.1 mol) of 2-naphthol and 600 mL of water were placed and heated to boil. To the boiling liquid containing 2-naphthol in suspension; a solution of 28 g (0.1 mol) crystallized iron (III) chloride in 60 mL water was added. While addition of iron (III) chloride solution, oily drops of 2-naphthol was observed. Further reaction mixture was boiled till oily drops were disappeared and the 2, 2'-Dihydroxy-1,1 -binaphthyl (I) separates out in flasks boiled for 10 minutes. The hot suspension was filtered through the previously warmed

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Buckner funnel; the crude product was washed with boiled water and dried well. The 2, 2'-dihydroxy-1,1-binaphthyl was recrystallized from toluene (about 150 mL) to get colorless crystals. Yield: 13.12 g (92.25 %). M. P.: 217°C.

2.2.2. Synthesis of 2, 2'-bis(4-acetylphenoxy)-1,1'-binaphthyl (II)

In a 500 mL three neck round bottom flask equipped with calcium chloride guard tube, thermo well, N_2 gas inlet were placed 14.3g 2,2'-dihydroxy-1,1binaphthyl(0.05 mol) and 13.814 g 4-fluoroacetophenone (0.1 mol) in 125 mL N,N-dimethyl acetamide (DMAc), then 13.821 g of anhydrous K_2CO_3 was added. The resulting reaction mixture was refluxed for 5 h. The progress of reaction was studied by TLC method. After completion, reaction mixture was cooled to room temperature and water was added in it for precipitating the product from solution. Finally the product was isolated by filtration, washed with water and finally dried under vacuum. Yield: 21.61 g (82.75 %) M.P.: 130°C IR: 3033, 2974, 1696, 1594, 1403, 1222, 1071, 1062, 815,774 cm^{-1}.

2.2.3. Synthesis of 2, 2'-bis (4-(2- aminothiazol-4-yl)phenoxy)-1,1'-binaphthyl (III)

In a 100 mL three neck round bottom flask added compound (I) 0.4 g (0.001 mol) and iodine 0.252 g (0.003mol), Thiourea 1.2 g (0.006mol) and the mixture was stirred in THF at reflux for 48 h. Then poured the solution with stirring in water, the yellow solid was obtained. Product was recrystallized in ethanol. Yield: 11.80 g (81.49 %) M.P.: 165°C. IR: 3300, 3275, 3091, 3010, 1607, 1509, 1376, 1219, 1157, 1014, 827,781 cm^{-1}. ^1H NMR (d6-DMSO): δ = 8.14 (d, 4H), 7.92 (d, 2H), 7.49 (t, 2H), 7.32 (t, 4H), 7.29 (d, 4H), 6.81(d, 4H), 6.09 (d, 2H), 3.93 (s, 4H). ^{13}C NMR (d6- DMSO): δ= 168.95, 151.48, 147.68, 129.32, 125.51, 124.81, 124.21, 123.26, 122.18, 121.77, 120.83, 119.84, 117.17, 114.46, 113.93, 113.80, 103.80. Mass Spectra m/e (m+1) = 635.

2.2.4. Synthesis of poly (ether-amides)s from 2, 2'-bis(4-(2- aminothiazol-4- yl) phenoxy)-1,1'-binaphthyl (III)

In a 100 mL three neck round bottom flask equipped with reflux condenser, magnetic stirrer, calcium chloride guard tube and nitrogen gas inlet were placed 0. 634 g (0.001mol) 2, 2'-bis(4-(2- aminothiazol-4-yl)phenoxy)-1,1'-binaphthyl (III) ,0.258g (1mmol) 4,4‟‟-dicarboxydiphenyl ether(ODCA), 0.115g lithium chloride [5 wt % based on solvent N- methyl pyrrolidone (NMP) and pyridine mixture] and 0.744g (0.63mL, 2.4mmol) triphenyl phosphite (TPP), 0.5mL pyridine and 2mL NMP. The mixture was stirred well and temperature was slowly raised to 100°C over a period of 30 min. The mixture was heated at 100°C for 3h under nitrogen. After cooling, the resulting viscous solution was poured into rapidly stirred 200 mL of methanol. The precipitated polymer (PEA-i) was filtered, washed with methanol and dried. The polymer was purified by dissolving in N, N- dimethylformamide (DMF) and reprecipitating in

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methanol. It was filtered, washed with methanol and dried under vacuum at 100°C for 6 h. The yield was 99% and the viscosity of polymer in DMF was 0.55 dL/g. The polyamides PEA-ii to PEA -v were synthesized with varying diacids by similar procedure.

3. Results and discussion

Aromatic polyamides have received attention concerning to the production of high performance materials due to their outstanding chemical resistance, thermal stability, mechanical and electrical properties. However their applications are limited because of their poor solubility in organic solvents and tremendously high glass transition temperatures that make them very hard to be processed by spin coating or thermoforming methods. Abundant effort has been made to create structurally improved aromatic polymers having enhanced solubility and processability with retention of their high thermal stability. It is well-known that the solubility of polymers is often improved when flexible bonds such as [-O-, -CH_2-,-SO_2-, -C(CF_3-)2], bulky pendent groups are used along the polymer backbone. If the moiety is cautiously chosen, it is possible to enhance solubility without sacrificing thermal and mechanical properties to any great extent.

In this chapter, synthesis and characterization of four new polyamides containing naphthyl moieties in the main chain was reported from the polycondensation reaction of 2, 2'-bis(4-(2-aminothiazol-4-yl)phenoxy)-1,1'-binaphthyl (III) with commercially available diacids, viz., 4,4‟-oxybis(benzoic acid), 4,4‟-hexafluoroisopropylidene bis(benzoic acid), 4,4‟-sulfonyl dibenzoic acid and Biphenyl 4,4‟ dicarboxylic acid by using N-methyl-2- pyrrolidone (NMP), triphenylphosphite and pyridine as condensing agents. These polymers have naphthyl moiety, and ether linkage in the main chain for improving solubility in organic solvents compared to aromatic polyamide.

3.1. Synthesis of 2, 2'-bis(4-(2- aminothiazol-4-yl)phenoxy)-1,1'-binaphthyl (III)

New diamine 2, 2'-bis(4-(2- aminothiazol-4-yl)phenoxy)-1,1'-binaphthyl (III) were successfully synthesized in several steps starting from naphthol (Scheme- 2C.1). Scheme 2C. 1. Synthesis of 2, 2'-bis(4-(2- aminothiazol-4-yl)phenoxy)-1,1'-binaphthyl(III).

The 2, 2'-dihydroxy-1, 1‟-binaphthyl (I) was synthesized by reacting 2-naphthol in presence of crystallized iron (III) chloride as catalyst. The 2, 2‟-bis(4-acetophenone)-1, 1- binaphthyl (II) was obtained by reacting 2, 2'-dihydroxy-1, 1‟-binaphthyl with 4- Fluoroacetophenone and potassium carbonate as catalyst in DMAc. The structure of (II) was characterized by infrared spectroscopy.

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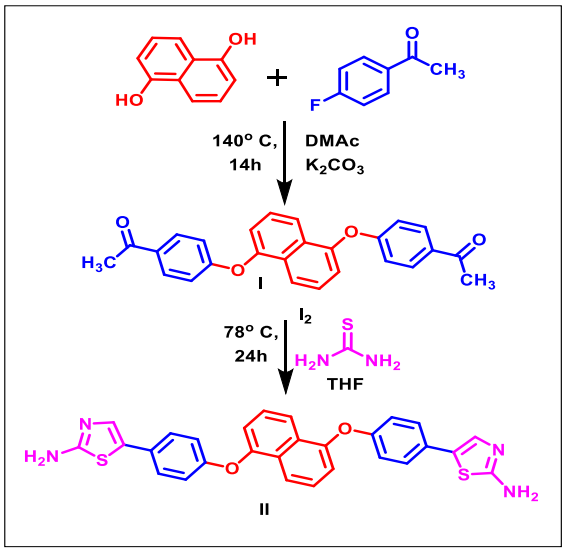

Scheme 1: Synthesis of 2, 2'-bis(4-(2- aminothiazol-4-yl)phenoxy)-1,1'-binaphthyl (III).

The infrared spectrum of (II) (**Fig.2**) showed strong absorption bands at 3033 cm^{-1} and 2974 cm^{-1}corresponding to aromatic and aliphatic C-H stretching vibrations. Spectrum also showed absorption near 1403 cm^{-1}due to C-H bending vibration. Absorption at 1696 cm^{-1} of carbonyl (C=O) stretching absorption was corresponding to acetyl carbonyl moiety. The absorption bands in the region 1222 $cm^{-1}$and 1071 cm^{-1} showed aromatic and aliphatic C-O-C stretch.

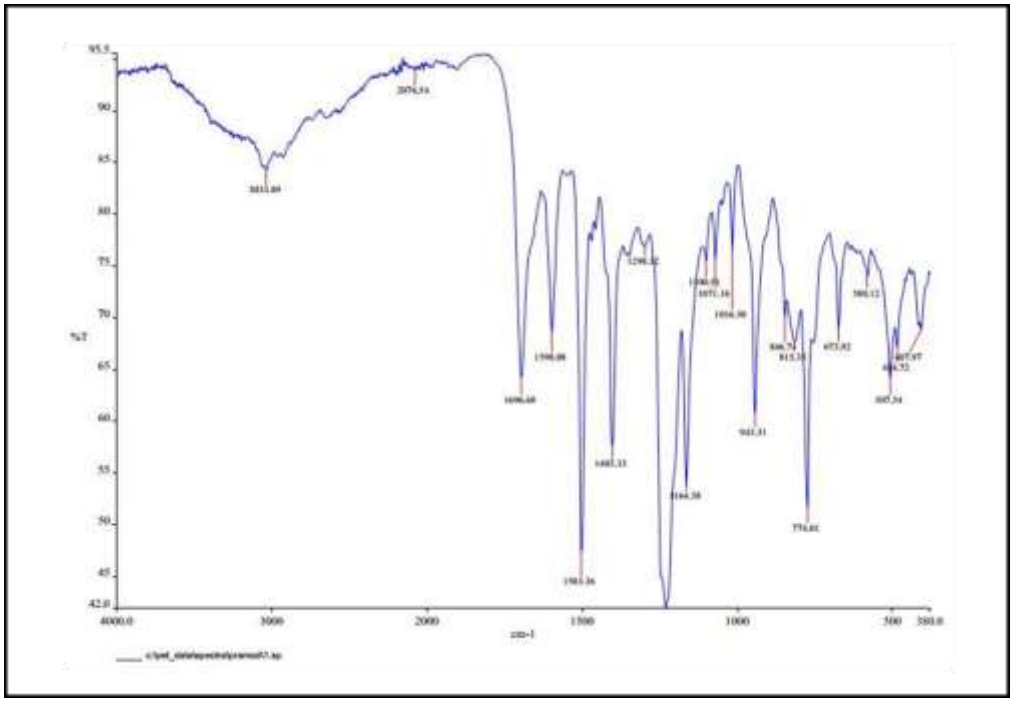

Fig. 2: FT-IR spectrum of 2, 2'-bis(4-acetylphenoxy)-1,1'-binaphthyl (II).

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The newly synthesized thiazole amine monomer, 2,2′-bis(4-(2-aminothiazol-4-yl)phenoxy)-1,1′-binaphthyl (III), exhibited characteristic absorption bands confirming the presence of functional groups as designed. A prominent and broad absorption band near 3300 cm^{-1} corresponds to the N–H stretching vibration of the $–NH_2$ group, indicating the presence of primary amine functionality. Additionally, sharp peaks at 3275 cm^{-1} (asymmetric N–H stretching) and 3091 cm^{-1} (symmetric N–H stretching) further support the incorporation of the amine group. The C–O–C ether linkage within the phenoxy-naphthyl backbone was evidenced by absorption bands at 1219 cm^{-1} and 1157 cm^{-1}, confirming successful connectivity between the naphthyl and phenyl units. Furthermore, a distinct band at 3010 cm^{-1} was attributed to aromatic C–H stretching of the naphthyl moiety, verifying the aromatic backbone. These IR findings, in combination with NMR and mass spectral data, strongly substantiate the successful synthesis and structural integrity of the target monomer.

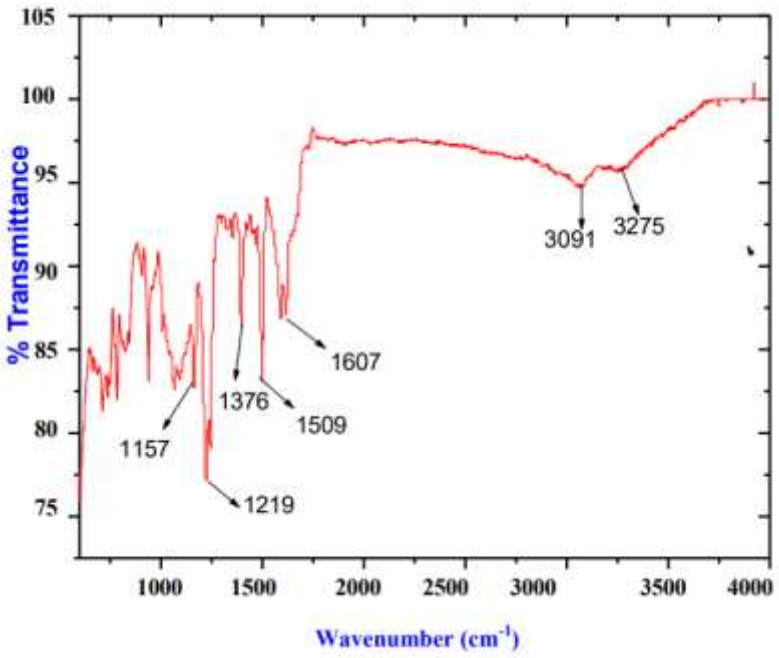

Fig.3. FT-IR spectrum of 2, 2'-bis(4-(2- aminothiazol-4-yl)phenoxy)-1,1'- binaphthyl (III)

The proton NMR spectrum (Fig. 4) of 2,2′-bis(4-(2-aminothiazol-4-yl)phenoxy)-1,1′-binaphthyl (III) provides clear evidence for the presence of functional groups and structural features in the synthesized compound. A prominent singlet at δ 3.93 ppm corresponds to the amine ($–NH_2$) protons, confirming the incorporation of the aminothiazole moiety. The aromatic region of the spectrum exhibits multiple signals between δ 7.29 and 6.81 ppm, integrating for eight protons, which are attributed to the phenylene ring protons. Additionally, characteristic signals observed at δ 8.14, 7.92, 7.49, and 7.32 ppm (accounting for 12 protons) are assigned to the naphthalene protons, indicating the presence of the rigid binaphthyl unit in

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the polymer backbone. Furthermore, a distinct singlet at δ 6.09 ppm is attributed to the methylene (–CH) group attached to the aromatic ring, supporting the successful linkage of the phenoxy and naphthalene units. The distribution and chemical shifts of these signals are consistent with the expected structure, demonstrating successful synthesis and confirming the structural integrity of the designed monomer.

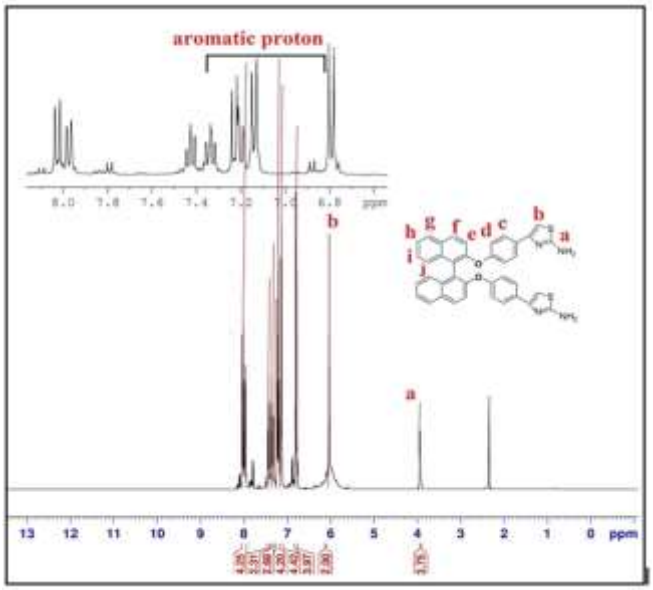

Fig.4.^{1}H-NMR of 2, 2'-bis(4-(2- aminothiazol-4-yl)phenoxy)-1,1'-binaphthyl (III)

The ^{13}C NMR spectrum **(Fig. 5)** of 2,2′-bis(4-(2-aminothiazol-4-yl)phenoxy)-1,1′-binaphthyl (III) provides detailed insights into the carbon framework of the compound, confirming its structural features and connectivity. The carbon directly attached to the amino group (C–NH_2) appeared at δ 168.95 ppm, which is characteristic of a highly deshielded environment due to the electron-withdrawing effect of the amino substituent and adjacent heteroatoms.The quaternary carbons of the aromatic rings and heterocyclic units exhibited signals at δ 151.48, 147.68, 129.32, 125.51, 123.26, and 119.84 ppm, indicating their non-protonated nature and conjugated electronic environment within the rigid binaphthyl and phenoxy systems. Additionally, the CH carbons associated with aromatic protons were observed at δ 124.82, 124.21, 123.27, 121.78, 120.83, 119.85, 114.46, and 113.93 ppm, which are consistent with typical chemical shifts for sp^2-hybridized carbons in aromatic rings.

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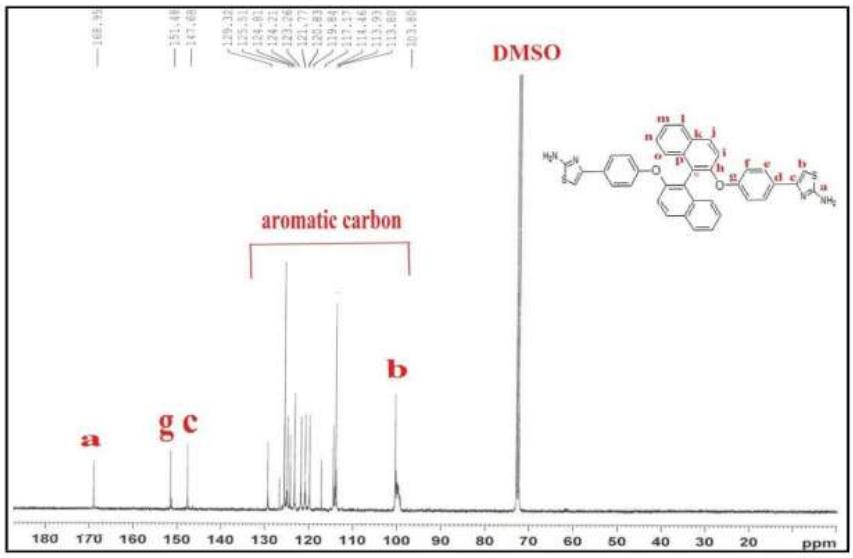

Fig.5. ^{13}C-NMR of 2, 2'-bis(4-(2- aminothiazol-4-yl)phenoxy)-1,1'-binaphthyl (III).

The mass spectrum of 2, 2'-bis(4-(2- aminothiazol-4-yl)phenoxy)-1,1'- binaphthyl (III) in (Fig.2C.5.) showed molecular ion peak at m/e (m+1) at 635 corresponding to molecular weight of 2, 2'-bis(4-(2-aminothiazol-4-yl)phenoxy)-1,1'- binaphthyl (III)

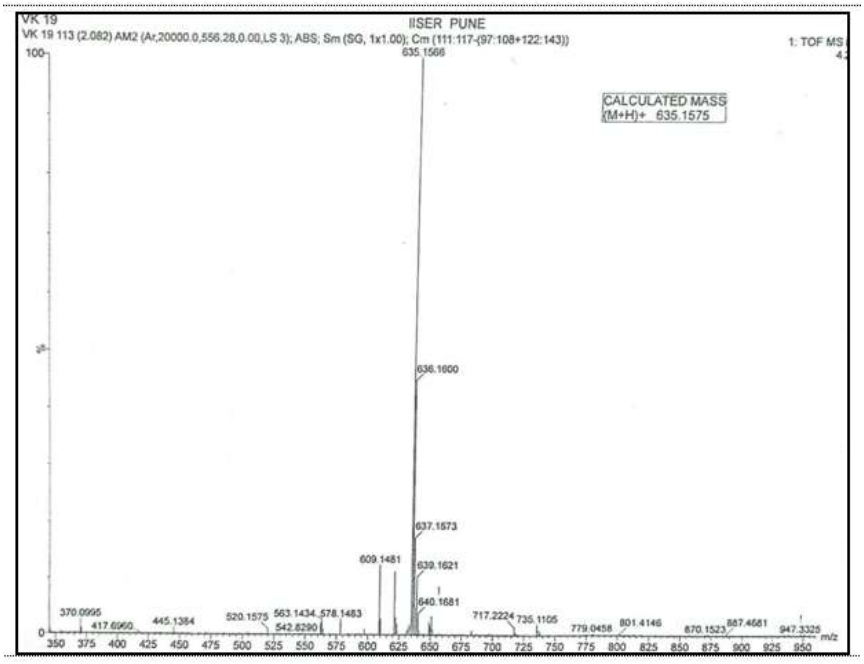

Fig.6. Mass spectrum of 2, 2'-bis(4-(2- aminothiazol-4-yl)phenoxy)-1,1'-binaphthyl (III).

From all above spectral characterization data, it confirmed that, 2, 2'-bis(4-(2- aminothiazol-4-yl)phenoxy)-1,1'-binaphthyl (III) diamine monomer was formed.

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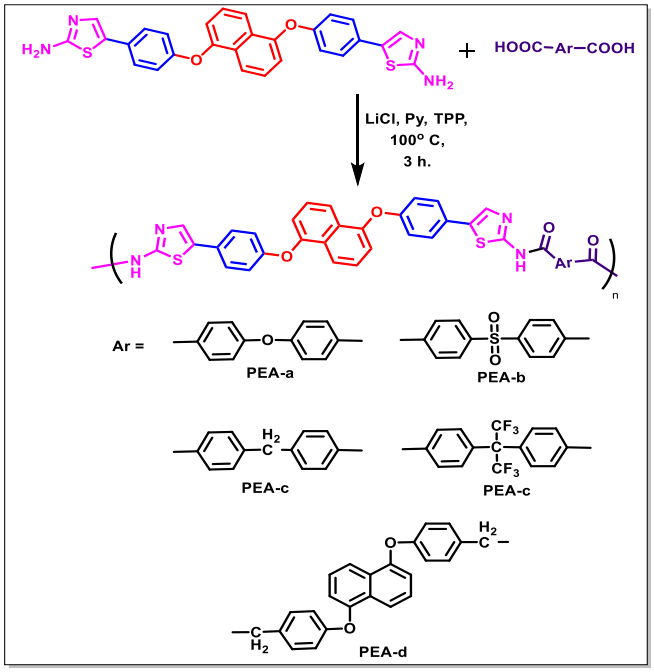
3.2. Synthesis of poly(ether-amide)s from 1, 5-bis (4-(2- aminothiazol-4-yl)phenoxy) naphthalene (II)

As outlined in **Scheme 3.2**, a series of new aromatic polyamides was synthesized by phosphorylation polycondensation of 1, 5-bis (4-(2- aminothiazol-4-yl)phenoxy) naphthalene (II) with various aromatic diacids in NMP solution containing lithium chloride using triphenyl phosphite and pyridine as condensing agents.



Scheme 2. Synthesis of poly (ether-amide)s from of 1, 5-bis (4-(2- aminothiazol-4- yl)phenoxy) naphthalene (II).

The direct polycondensation technique reported by Yamazaki et al is a well-accepted and very valuable laboratory method for the synthesis of polyamides [164-166]. This method includes the one-pot polycondensation of aromatic diamines with aromatic diacids in the presence of an aryl phosphite such as triphenyl phosphite and an organic base such as pyridine. The addition of inorganic salts such as LiCl increases the solubility of polymer and maximizes attainable molecular weights. The advantage of this technique is that, it avoids the use of moisture-sensitive diacid chlorides. The polycondensation reactions were carried out at 100°C for 3h. The polymerizations were homogeneous throughout the reaction and afforded viscous polymer solutions. The results of polymerization are summarized in **Table 1**.

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Table 1. Yield and viscosity of poly (ether-amide)s obtained from 1, 5-bis (4-(2- aminothiazol-4-yl)phenoxy) naphthalene (II) and diacid.

Polymer	Diacids	Yield %	Inherent Viscosity (dL/g [a])
PEA-a	ODBA	99	0.52
PEA-b	SDBA	98	0.49
PEA-c	MDBA	96	0.48
PEA-d	6-FDBA	99	0.51
PEA-e	Diacid-II	99	0.68

[a]Inherent viscosity was measured at a concentration of 0.5 dL/g in **DMF** at 30°C

Inherent viscosities of polyamides were in the range 0.48-0.68 dL/g indicating the formation of medium to reasonably high molecular weight polymers. Tough, transparent and flexible films of polyamides could be cast from their DMF solutions.

Structural characterization

The formations of polymer were confirmed by FT-IR spectroscopy. Figure (**Fig. 7)** shows the FTIR spectra of PEAs derived from 1, 5-bis (4-(2- aminothiazol-4- yl)phenoxy) naphthalene (II) and 4,4‟-oxybis(benzoic acid. Polyamide formation was characterized by the –NH stretching frequency as a broad band around 3289 cm^{-1}. Polyamide formation was characterized by the-NH bending frequency band around 1524 cm^{-1}. Due to the hydrogen bonding, the C=O stretching vibration band shifted to lower wave number and appeared at 1632 cm^{-1}.

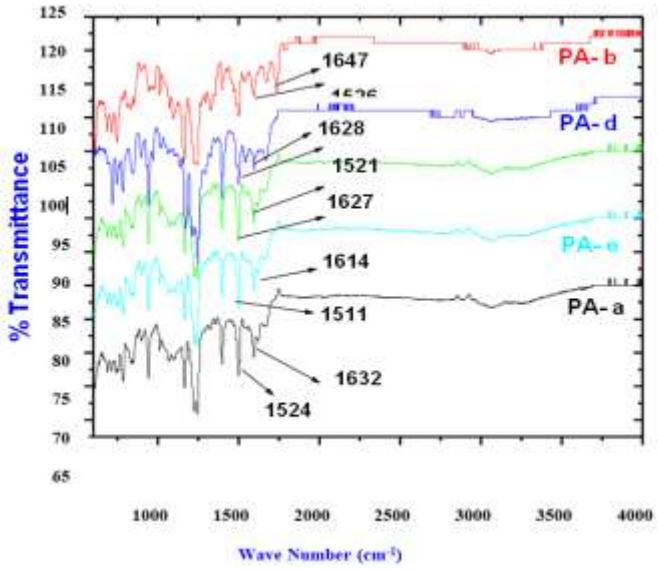

Fig 7. IR spectrum of PEA-a to PEA-e obtained from 1, 5-bis (4-(2- aminothiazol-4-yl)phenoxy) naphthalene (II) and diacid.

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FT-IR Spectrum poly (ether - amide) PEA-c is shown in (**Fig.7)** that showed similar pattern of all absorption bands characteristic of poly ether amide. The characteristic absorption bands of formation was characterized by the –NH stretching frequency as a broad band around 3291 cm^{-1}. Polyamide formation was characterized by the –NH bending frequency band around 1511 cm^{-1}. Due to the hydrogen bonding, the C=O stretching vibration band shifted to lower wave number and appeared at 1627 cm^{-1}.

FT-IR Spectrum poly (ether - amide) PEA-d is shown in (**Fig.7)** that showed similar pattern of all absorption bands characteristic of poly ether amide. The characteristic absorption bands of formation was characterized by the –NH stretching frequency as a broad band around 3274 cm^{-1}. Polyamide formation was characterized by the –NH bending frequency band around 1521 cm^{-1}. Due to the hydrogen bonding, the C=O stretching vibration band shifted to lower wave number and appeared at 1628 cm^{-1}.

FT-IR spectrum poly (ether - amide) PA-e is shown in **Fig. 6** they showed similar pattern of all absorption bands characteristic of poly ether amide. The characteristic absorption bands of formation were characterized by the –NH stretching frequency as a broad band around 3301 cm^{-1}. Polyamide formation was characterized by the –NH bending frequency band around 1526 cm^{-1}. Due to the hydrogen bonding, the C=O stretching vibration band shifted to lower wave number and appeared at 1647 cm^{-1}.

3.3. Properties of poly(ether-amide) Solubility of polyamides

Solubility of polyamides was tested in various organic solvents at 3 wt % concentration and data is summarized in **Table 2D.2**.

Table-2. Solubility behavior of poly (ether-amide)s obtained from 1, 5-bis (4-(2-aminothiazol-4-yl)phenoxy) naphthalene (II) and diacid.

Solvent	PEA-a	PEA-b	PEA-c	PEA-d	PEA-e
DMAc	++	++	++	++	++
DMSO	++	++	++	++	++
DMF	++	++	++	++	++
THF	++	++	++	++	++
DCM	--	--	--	--	--
m- Cresol	++	++	++	++	++
Pyridine	++	++	++	++	++
H_2SO_4	++	++	++	++	++

(++) Soluble at room temperature,(+) soluble on heating,(+-) partially soluble,(--) insoluble,

[a] Solubility measured at a polymer concentration of 3% (w/v)

Table 2. Shows the solubility behavior of poly (ether amides)s. All poly (ether- amide)s showed excellent solubility in Polar aprotic solvent such as DMF, DMAc, DMSO, NMP, m-cresol,

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and in common organic solvent as THF and in H_2SO_4 either at room temperature or upon heating. Enhance solubility behaviour of poly(ether-amide)s was attributed to incorporation of naphthyl moiety and ether linkage along the polymer backbone.

Physical properties of poly (ether-amide)s

Thermal properties

Thermal behaviour of polymers was evaluated by means of dynamic thermogravimetric and differential scanning calorimetry **Table 3.** Incorporate the thermal data such as glass transition temperature (T_g), initial decomposition temperature (T_i), temperature for 10 % Wt. loss (T_{10}) and residual weight at 900°C.

Table 3. Physical properties of poly (ether-amide)s obtained from 1, 5-bis (4-(2- aminothiazol-4-yl)phenoxy) naphthalene (II) and diacid.

Polymer	T_i (°C)	T_{10} (°C)	Tg (°C)	Residual wt% at 900°C
PEA-a	315	468	191	52
PEA-b	305	417	192	50
PEA-c	345	425	198	51
PEA-d	323	431	162	42
PEA-e	365	448	159	49

T_i – Initial decomposition temperature. T_{10} –
Temperature of 10% decomposition.

Tg- Glass transition temperature determined by DSC at a heating rate of 10°C /min**.**

[a]Temperature at which onset of decomposition was recorded by TGA at **a** heating rate of 10°C /min.

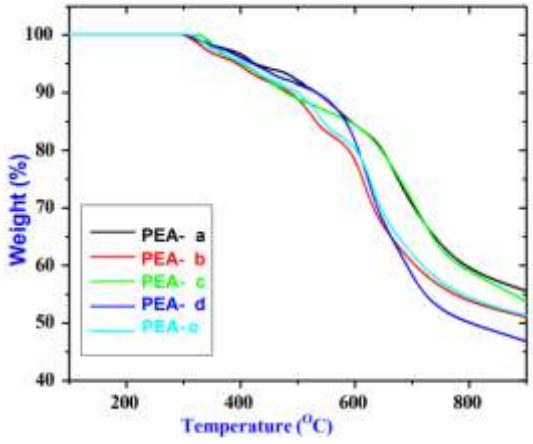

Fig 8. TGA curve of polyamides PEA-a to PEA-e obtained from 1, 5-bis (4-(2- aminothiazol-4-

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yl)phenoxy) naphthalene (II) and diacid.

Thermal stability of polyamides was determined by thermogravimetric analysis (TGA) at a heating rate of 10°C /min under nitrogen atmosphere. TG curves of polyamides are shown in Fig.7. T_d values obtained from TG curves for polyamides were in the range 417-468°C indicating their good thermal stability, which could obviously be attributed to the presence of aliphatic methyl groups. The weight residue of polyamides when heated to 900°C in nitrogen was in the range 42-52%.

Glass transition temperature (Tg) of the polyamides was evaluated by differential scanning calorimetry (DSC). Tg Values were obtained from second heating scans of polyamide samples at a heating rate of 10°C / minute. DSC curves are reproduced in **Fig. 8** and Tg values are incorporated in **Table 3**.

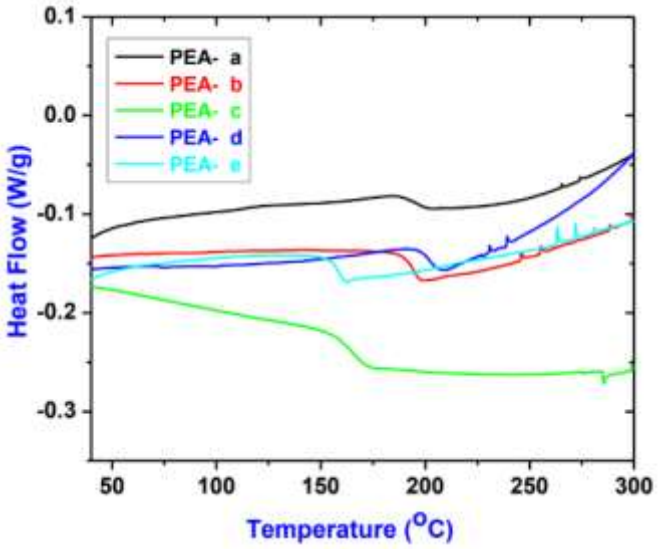

Fig 9. DSC curve of polyamides PEA-a to PEA-e obtained from 1, 5-bis (4- (2- aminothiazol-4-yl)phenoxy) naphthalene (II) and diacid.

T_g of polyamides containing naphthyl moiety were in the range 159°C-198°C. The increasing order of T_g corresponds to an increase in the rigidity of the diacid. The polyamide PEA-V shows lowest T_g value (159°C) due to bulky naphthyl substituents of diacid which hinder the chain packing and increase the free volume. The PEA-3 exhibited highest Tg value (198°C) among the series of polyamides.

X-Ray diffractograms of polyamides derived from of 1, 5-bis (4- (2- aminothiazol- 4-yl)phenoxy) naphthalene (II) and aromatic diacids are shown in **Fig.10**.

ISSN 2454-9940
www.ijasem.org
Vol 19, Issue 4, 2025

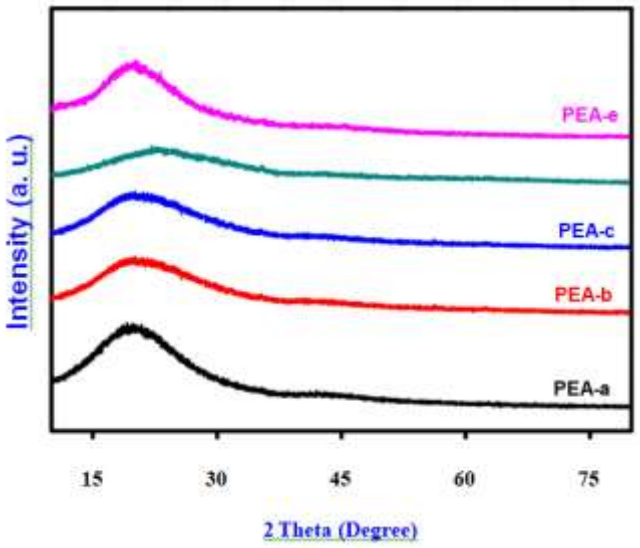

Fig 10. XRD curve of poly(ether-amide)s PEA-a to PEA-e obtained from 1, 5-bis (4- (2- aminothiazol-4-yl)phenoxy) naphthalene (II) and diacid

X-Ray diffractograms of all polymers exhibited a broad halo in the wide angle region (at about $2\theta \approx 20^0$) indicating that all the polymers were semicrystaline. This result could be explained in terms of the presence of the naphthyl group and ether linkage in the polymer backbone which hindered packing of the polymer chains and decreased the intermolecular forces, subsequently causing a decrease in crystallinity

4. Conclusion

A series of novel polyamides incorporating a naphthyl moiety were successfully synthesized through the direct polycondensation of 1,5-bis(4-(2-aminothiazol-4-yl)phenoxy)naphthalene (II) with various aromatic diacids. The inherent viscosities of the resulting polyamides were observed to be in the range of 0.48–0.68 dL/g, indicating the formation of polymers with medium to reasonably high molecular weights. These polyamides exhibited excellent solubility in polar aprotic solvents such as DMF, DMAc, DMSO, NMP, and m-cresol, either at room temperature or upon mild heating. This enhanced solubility can be attributed to the presence of the bulky naphthyl group and ether linkages in the polymer backbone, which reduce intermolecular interactions and increase chain flexibility. Wide-angle X-ray diffraction (WAXD) analysis confirmed that these polyamides possess a semi-crystalline nature, reflecting an ordered yet flexible polymer chain arrangement. Thermal analysis demonstrated their good thermal stability, with T_{10} values (temperature at 10% weight loss) in the range of 417-468 °C, making them suitable for high-temperature applications. Additionally, glass transition temperatures (Tg) were found to lie between 159–198 °C, suggesting a rigid polymer backbone with excellent dimensional stability. These findings collectively indicate that the introduction of naphthyl and ether functionalities significantly improves the

solubility, processability, and thermal resistance of the synthesized polyamides, making them promising candidates for advanced high-performance materials.

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