

New Antimicrobial Schiff base Polymers derived from 6, 6-Methylenebis (1-Napthaldehyde)

Moina Akhtar Mughal, Akhtar Mughal, Zeenat M. Ali, Ghulam Zuhra Memon,
Mohammad Yar Khuhawar, Hussain Saleem

Abstract:

This paper presents new antimicrobial schiff base polymers derived from 6, 6-Methylenebis (1-Napthaldehyde). Four new Schiff based Polymers (SBPs) Poly Methylenebis(1-napthaldehyde) Thiourea (PMBNTU), Poly Methylenebis(1-napthaldehyde) 1, 2-Phenylenediimine (PMBNPh), Poly Methylenebis(1-napthaldehyde) Semicarbazide (PMBNS) and Poly Methylenebis(1-napthaldehyde) Thiosemicarbazide (PMBNTS), were prepared from bis(1-napthaldehyde) through polycondensation of a monomer methylenebis napthaldehyde with diamines in 1:1 molar ratio. The monomer was prepared by a general method by Marvel and Torkoy by treating it with 1,3,5-trioxane by addition of H_2SO_4 and CH_3COOH respectively. The solubility level of reported polymers was found poor in organic solvents, and attributed to its quality of being a hindrance. The structure of Schiff bases was confirmed by CHN, FTIR, UV-Visible Spectroscopy, TGA/DTA and Viscosity measurements. All the Schiff base polymers revealed a qualitative change or a shift in band position as compared to monomer due to conversion of Carbonyl to Azomethine group. An observable increase was found in the values of reduced and intrinsic viscosities than the corresponding monomer that could be due to the formation of polymers. The monomer and the prepared Schiff base polymers possessed significant antimicrobial activities against various microorganisms.

Keywords: Antimicrobial, Schiff Base Polymers, Viscosity, Thermogravimetry, Differential Thermal Analysis.

1. INTRODUCTION

Synthesis of new Schiff base polymers using polycondensation technique for monomers with diamino compounds, such as poly[6,6-methylenebis(1-napthaldehyde)1,2-phenylenediimine] (PMBNPh), poly[6,6-methylenebis(1-napthaldehyde) Thiourea] (PMBNTu), poly[6,6-methylenebis(1-napthaldehyde) Semicarbazone] (PMBNS) and poly[6,6-methylenebis(1-napthaldehyde) Thiosemicarbazone] (PMBNTS)[1-4]. polymers that show conjugation among $-C=C-$ and $-C=N-$ bonds have been a field of interest, because these groups are present in main chains and attracted scientists, involved in the related field. A number of researchers have reported that Schiff base polymers demonstrate antimicrobial activity for bacteria, fungi and yeast. Researchers reviewed the fundamentals of antimicrobial polymers on surfaces as well as in solutions and explained methods to save humans from microbes [5-6]. Scientists have studied Schiff based complexes and metal ions in connection to intermediaries between antimicrobial and antitumor [7-11]. The monomer is prepared by a general method. [12]. The present study reports the synthesis of four Schiff base polymers through polycondensation of diamines with monomer.

2. EXPERIMENTAL SETUP:

1-napthaldehyde, 1,2-phenylenediamine,(Fluka, Switzerland) Thiourea, semicarbazide, Thiosemicarbazide(E,Merck ,Germany). Monomer was prepared as:

2.1 Synthesis of Monomer

Eighty (gms), sixty nine (mls) of alpha napthaldehyde was poured into CH_3COOH (glacial) 45-50 (ml) within the temperature range 91-94°C, in an inert atmosphere. In this mixture a solution of 1,3,5 trioxane seven (gms), liquefied in 0.5 ml and 2.5ml of Sulphuric and CH_3COOH acid (glacial) at the temperature range 91-95 °C. The agitation of this mixture continued for twenty four hours. The recovered reaction mixture was then poured into 1L of H_2O (distilled) and again kept for precipitation for further 10-12 hours. The oily product was neutralized with ten percent

NaHCO₃. The solid product recovered after 12 hours was washed and filtered and were bubbled in acetone for twenty five minutes. The precipitates were kept in oven for eight hours at seventy degree. The melting point recorded was >three hundred. The percentage (%) yield was 62.5.

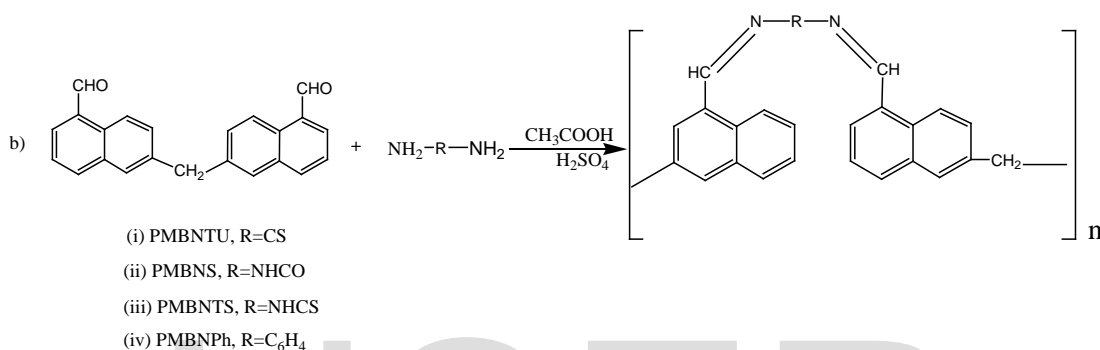
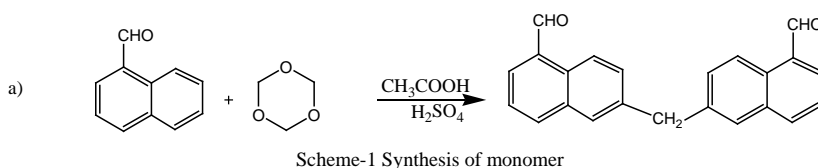


FIG 1

2.2 Preparation of Polymeric Schiff bases

6,6-methylenebis(1-naphthaldehyde) (3.24g) dissolved in DMF (30mL), was refluxed till complete dissolution of monomer, it was stirred with 1,2-phenylenediamine (1.08g) dissolved in DMF (5mL), Thio urea (0.76g) in DMF (4mL), Semicarbazide (0.74g) in DMF (4mL) and Thiosemicarbazide (0.911g) in DMF (5-6mL). The reaction mixture was refluxed in an oil bath for the period of 22-24 h. The product along with the solvent was concentrated to its half volume, till it precipitated into dark brown crystals in case of PMBNPh, brownish precipitate in case of PMBNTU, blackish brown precipitate for PMBNS and blackish precipitate for PMBNTS respectively. The precipitate recovered were filtered, and recrystallized from the ethylalcohol. These were dried in oven at the temperature of 80-90°C for 6-7 h.

The decomposition point recorded was >550 °C. % Yield for polymers PMBNPh, PMBNS, PMBNTS, PMBNTU were 61.72, 86.41, 75.2, and 80.5%.

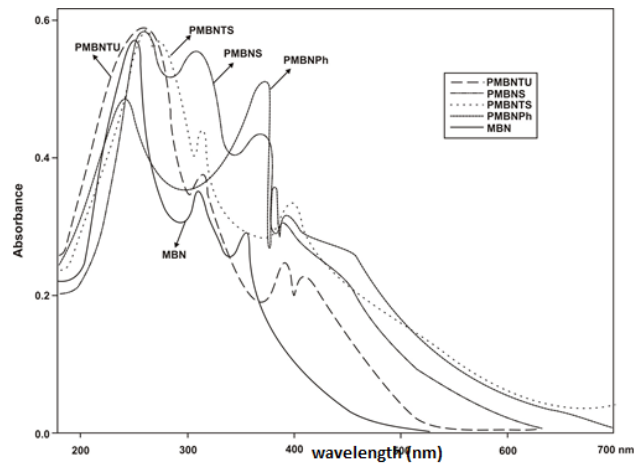


FIG 2

IJSER

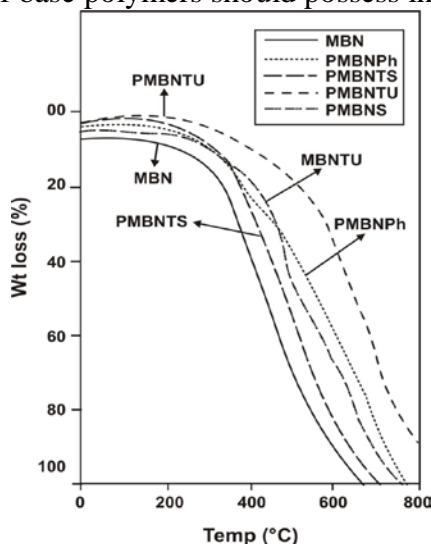
2.3 Characterization

The elemental microanalysis was recorded at HEJ, research institute of chemistry, University of Karachi, Pakistan. Infrared spectra results were taken on using Nicolet Avatar 330 FT-IR (Thermo Nicolet Electron Corporation USA) with attenuated total reflectance (ATR) accessory (smart partner) ranging 4000 - 600 cm^{-1} . Studies regarding UV/VIS- pectrophotometer were done with dimethylformamide using double beam Hitachi 220 spectrophotometer (Hitachi, Japan) within range of 180-700nm. Thermogravimetric analysis and Differential Thermal Analysis were carried out by Perkin Elmer Pyris Diamond TGA/DTA thermal analyzer from ambient to 800 $^{\circ}\text{C}$ temperature with flushing of pure nitrogen gas 5ml/min. In crucible 2mg sample taken each time, pure alumina reference material selected and heated at 20 $^{\circ}\text{C}/\text{min}$.



FIG 3: Wave number

Viscosity of monomer and Schiff base polymer were recorded at temperature range of 283-323K. The viscosity intrinsic $[\eta]$ increase with increase in weight of polymer and vice versa. Therefore Schiff base polymers should possess intrinsic viscosity higher than its dialdehyde.



TGA of Schiff base Polymers

FIG 4

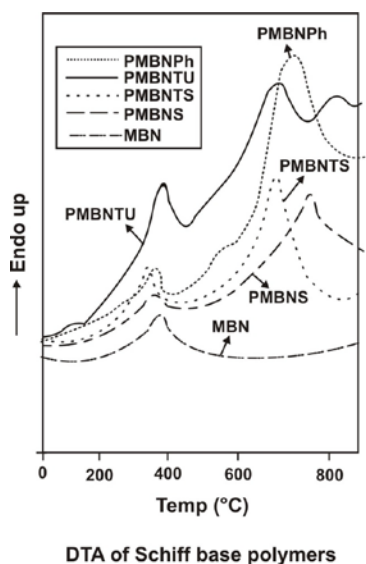


FIG 5

The $[\eta]$ is obtained by extrapolating η_{red} to zero concentration satisfying Huggins equation. The thermodynamic parameters, ΔG_v , ΔH_v and ΔS_v were calculated using equations; $\Delta G_v = 2.303 RT \log (\eta/10^{-3})$, $\Delta H_v = \text{Slope} \times R$, and $\Delta S_v = \Delta H_v - \Delta G_v / T$ respectively. The monomer and synthesized Schiff base polymers were screened against number of antifungal and antibacterial microorganisms. *A. Niger*, *Aspergillus flavus*, and *candida albicans*, were examined for antifungal study and *Escherichia Coli*, *Bacillus Cirroflgellosus*, and *Staphylococcus aureus*, *shigella flexneri* and *Micrococcus flavus* were examined for antibacterial study using agar well diffusion technique. Miconazole (Antifungal) and Tetracycline (Antibacterial) both used to control the positive and negative controls. A sterilized cork borer that was 22-24mm in diameter was used to dig the wells in culture plates. A micropipette was used to fill the wells with sample solutions. The suggested concentration was 1mg/ml. Whereas the control wells filled by DMF and antibacterial reference antifungal drugs for negative and positive controls.

3. RESULTS AND DISCUSSION

The monomer was synthesized by using a general method .The results of C.H.N analysis were in good agreement with the expected values, and support the formation of polymers.

Table 1: C H N ELEMENTAL MICROANALYSIS

COMPOUNDS	CALCULATED%			EXPERIMENTAL%		
	C	H	N	C	H	N
6,6-methylenebis(1-napthaldehyde) (MBN)	85.16	4.9		86.80	5.21	
Poly 6,6-methylenebis(1 Napthaldehyde) Thiourea (PMBNTU)	75.01	3.99	6.66	74.99	4.44	5.90
Poly 6,6-methylenebis(1-napthaldehyde) 1,2-Phenylenediimine) (PMBNPh)	86.25	5.90	8.50	86.39	5.89	8.00
Poly6,6-methylenebis(1-napthaldehyde) semicarbazone (PMBNS)	80.71	4.50	9.90	79.80	4.25	8.90
Poly6,6-methylenebis(1-napthaldehyde) Thiosemicarbazone (PMBNTS)	77.90	4.39	10.55	78.50	4.00	9.85

All the polymers show less or partial solubility in most of the organic solvents used. **Table 2.** Recrystallization, leading to low yield was accomplished. The FTIR of the monomer, indicated a strong confirmatory peak of carbonyl group $\nu_{C=O}$ at 1700cm^{-1} , which was not present in PMBNTU, PMBNPh, PMBNS, PMBNTS respectively, where as bands of medium to strong

intensity was observed within 1620-1660 cm^{-1} due to $\nu\text{C}=\text{N}$ vibrations, with regard to polymers of Schiff base considered as compulsory peak for confirmation purposes.

TABLE 2: Solubility^{a,b} of MBN and Schiff base Polymers in various solvents

Compounds	H ₂ O	CH ₃ OH	C ₂ H ₅ OH	CHCl ₃	Acetone	n-hexane	ETHER	DMF
MBN	-	-	-	-	±	-	-	±
PMBNTU	-	-	±	±	±	-	-	±
PMBNPh	-	-	±	±	±	-	-	+
PMBNS	-	-	±	±	±	-	-	±
PMBNTS	-	-	±	±	±	-	-	±

a 0.05g compounds in 10ml solvent at 30°C

b (+) Soluble, (±) Partially Soluble, (-) Insoluble

The results of spectroscopic studies are shown in **Table 3**. The monomer showed 3 peaks at 251,315 and 353 nm with molar absorptivity 19011, 11890 and 7320 $\text{Lmol}^{-1}\text{cm}^{-1}$ respectively, but the polymers PMBNTU indicate four bands. The values of $[\eta]$ were observed ranging 0.411-0.424 and 0.310-0.438dl/g for polymers derived from monomer. The intrinsic viscosity $[\eta]$ for monomer was calculated through the same parameter derived for Schiff base polymers and was observed in the range 0.1940-0.3000 dl/g, which is quiet evident owing lower values as compared to polymers. The relationship between the reduced viscosity and concentration of the monomer and the polymers in DMF is showed linearity, agreeing to huggin's equation. The increased value of polymer viscosity as compared to dialdehyde supports its formation **Table 4**.

Table 3 Results of spectroscopic studies in DMF as solvent

COMPOUND	λ_{max} nm	(ϵ)
1. MBN	251	19011 $\text{Lmol}^{-1}\text{cm}^{-1}$
	315	11890 $\text{Lmol}^{-1}\text{cm}^{-1}$
	353	7320 $\text{Lmol}^{-1}\text{cm}^{-1}$
	λ nm ϵ 1%	
2. PMBNPh	249	(279.2)
	372	(221)
	380	(125)
	390	(105.5)
3. PMBNTU	258	(312.8)
	315	(233.3)
	399	(112.4)
	405	(106.5)
4. PMBNS	259	(229)
	278	(106.2)
	307	(67)
	390	(110.5)
5. PMBNTS	261	(344.4)
	278	(99.2)
	312	(118)
	399	(100.1)

The absolute viscosity (η_{abs}) for dialdehydes MBN is in the range 0.2807-0.1689m.N.s/m² and for polymers PMBNTU, PMBNPh, PMBNS, and PMBNTS, were in the range 0.252-0.477, 0.265-0.515, 0.266-0.512 and 0.271-0.522 m.N.S/m² respectively.

Table 4: Intrinsic Viscosity values of MBN and Schiff base polymers (dl/g)

Compound	283	293	303	313	323
MBN	0.3000	0.2660	0.2410	0.2110	0.1940
PMBNTU	0.424	0.380	0.363	0.334	0.316

PMBNPh	0.460	0.412	0.337	0.314	0.310
PMBNS	0.438	0.388	0.316	0.292	0.288
PMBNTS	0.565	0.513	0.440	0.417	0.411

The viscosity absolute of dialdehyde MBN and polymer increases against rise in concentration and decreases against rise in temperature, as η proportional to density of solution $\eta = \sigma \beta t$ therefore augmentation of viscosity against concentration might be owing to increase in solution density. Factors contributing regarding rise of η against concentration such as; values of ΔG_v , (free energy viscous flow) is considered using following equation $\Delta G_v = 2.303 RT \log (\eta/10^{-3})$.

Table 5 TGA Endotherm

Characterization	MBN	PMBNTU	PMBNPh	PMBNS	PMBNTS
1. primary wt loss Temp	36% 200-489°C	11% 239-308 °C	20% 229-368 °C	19% 231-399 °C	3.4% 198-298 °C
2. sec wt loss Temp	27% 489-595 °C	14% 409-559 °C	96% 799-800 °C	-	-
3. Tertiary wt loss Temp	33% 590-800 °C	84% 800	100% 748 °C	100% 685 °C	
4. Max rate of loss	600 °C	689 °C	669 °C	499 °C	500 °C

Here ΔG_v values for Schiff base polymer and monomer in DMF at various temperatures and concentrations are; 13.635-13.818 kJmol^{-1} for MBN and 14.412-15.119, 14.529-15.132, 14.585-15.247 and 14.628-15.898 kJmol^{-1} for the polymer PMBNTU, PMBNPh, PMBNS, and PMBNTS respectively. The values increase with increase in temperature and concentration. The increase of ΔG_v with concentration indicates that in dilute solutions the associations among molecules are weaker therefore could be controlled for the duration of flow process, but against higher concentrations the associations are strong and are least disturbed for the duration of flow process so values remain above.

Table 6 DTA Endotherm °C

Characterization	MBN	PMBNTU	PMBNPh	PMBNS	PMBNTS
1.	310	400	390	386	380
2.	—	680	710	730	495
3.	—	798	—	—	—

Value of ΔH_v (heat of activation of viscous flow) for MBN are 11.626-11.409 mol^{-1} higher than the respective Schiff base polymers PMBNTU, PMBNPh, PMBNS, and PMBNTS. were in the range 11.138-11.295, 11.123-11.311, 11.113-11.231 and 11.232- 11.244 kJmol^{-1} . The values are lower for polymers as compared to dialdehyde MBN may be due to crowding of polymeric molecules.

Table 7 [A] Antimicrobial activity of MBN and Schiff base Polymers (Antibacterial)

Compound	Zone of inhibition(mm) 50 $\mu\text{g/mL}^{-1}$				
	M.Flavus	S.aureus	B.cirroflgellosus	S.flexneri	E.coli
MBN	++	++	+	-	+
PMBNPh	+++	++++	++	+++	+++
PMBNS	++++	++	++++	+++	+++
PMBNTS	++++	+	+++	++	+++

PMBNTU	+++	++	+++	+++	++++
Tetracycline^a	-	+	+	-	+++

^a Standard drug +ve control antibacterial activity

-	= inactive	5 mm
+	= weakly active	8 – 10 mm
++	= moderately active	11 – 15 mm
+++	= highly active	16 – 20 mm
++++	= most active	21 – 24 mm

Table: 7[B] Antimicrobial activity of MBN and Schiff base Polymer (Antifungal)

Compound	Zone of inhibition(mm) 50µg/mL ⁻¹		
	C.albicans	A.flavus	A.niger
MBN	+	+	-
PMBNPh	+++	++++	++
PMBNS	+++	++++	+++
PMBNTS	++++	++	++
PMBNTU	+	++	+++
Miconazole^b	-	+++	++

^b standard drug –ve control antifungal activity

-	= inactive	5 mm
+	= weakly active	8 – 10 mm
++	= moderately active	11 – 15 mm
+++	= highly active	16 – 20 mm
++++	= most active	21 – 24 mm

The positive values of ΔH_v show process of degradation in orientation of macromolecules of and structure occurs for the duration of flow. ΔS_v values of dialdehyde MBN are -0.00710....-0.00745 and those for polymers PMBNTU, PMBNPh, PMBNS and PMBNTS are -0.0132....-0.0132, -0.0131....0.0136, -0.0118....0.0123 and -0.0117....0.0126 J/k. The -ve sign of ΔS_v regarding polymeric Schiff base indicate that the same are opened and spread owing to uncoiling of polymers in solutions. The biological studies revealed the facts that the monomer possessed the biological activity but the polymers showed enhancement in antibacterial and antifungal activities. The monomer MBN exhibited (15, 15, 10, 5, and 10 mm), the polymers PMBNPh, PMBNS, PMBNTU and PMBNTS showing (20, 24, 15, 20 and 20mm), (24, 15, 24, 20 and 20mm), (20, 15, 20, 20 and 24mm) and (24, 10, 20, 15 and 20 mm) zone of inhibition against the bacteria; Micrococcus flavus, Staphylococcus aureus, Bacillus Cirroflgellosus, S.fiexneri, and Escherichia Coli. The polymer PMBNS exhibited the highest antibacterial activity against the reported bacteria. For antifungal studies the monomer MBN exhibited (10, 10 and 5 mm), the polymers PMBNPh, PMBNS, PMBNTU and PMBNTS exhibited (20, 24 and 15mm), (20, 24 and 20mm), (10, 15 and 24 mm) and (24, 15, and 15 mm). However polymer PMBNS exhibited the highest antifungal activity among the other Schiff base polymers.

4. CONCLUSIONS

Four new Schiff base polymers have been synthesized and characterized by elemental microanalysis, spectroscopic and viscosity measurements. The polymers indicate low solubilities and indicate high thermal stability. The monomer possessed significant antimicrobial activity whereas enhancement in activity was observed in the Schiff base polymers.

References

- [1] O. Catanescu, M.Grigoaras, g colotin, A.Dobreanu, N. Hurduc and C.I Simionescu, European polymer Journal, 37, 2213 (2001).

- [2] S. Samal R. R Das, R. K. Dey and S. Acharya, *Journal of Applied polymer science*,77, 967 (1999).
- [3] S. Banerjee,C Saxena, P. K. Gutch and D .C. Gupta, *European polymer Journal*, 32, 661 (1996).
- [4] W Sun, X. Gao and F . Lu, *Journal of Applied polymer science*,64,2309 (1997).
- [5] Gregory N.Tew,Dahui Liu,Bin Chens,Robert J.Dorrrksens,Justin Kaplan,Patrick J .carroll, Micheal L.Kleins, and William F.Degrado, "De Novo design of biomimetic antimicrobial polymers"PNAS 99(8) 5110, (2002).
- [6] F. siedenbiedel, and Joer g C .Tiller;" Antimicrobial Polymers in Solution and on Surfaces: Overview and Functional Principles Polymers 4(1) 46-71; 44227 Dortmund, Germany (2012).
- [7] D. H. Brown, W. E. Smith, J. W. Teape, A . J . lewis,"Anti-inflammatory effects of some copper complexes", *J . Med. Chem.* 23, 729 (1980).
- [8] A. Scozzafava, L. Menabuoni, F. Miincione, G. Miincione, C . T. Supuran,"Carbonic anhydrase inhibitors: synthesis of sulfonamides incorporating dtpa tails and of their zinc complexes with powerful topical antiglaucoma properties", *Bioorg. Med.Chem. Lett.* 11(4), 575 (2001).
- [9] A. Scozzafava, C. T. Supuran,"Carbonic Anhydrase and Matrix metallo proteinase inhibitors:sulfonylated Amino acid hydroximates with MMP inhibitory properties Act as efficient inhibitors of Ca *J. Med. Chem.* 43, 3677 (2000).
- [10] G. Alzuet, J . Casanova, J. Borrás, S. G. Granda , A. G. Rodríguez, C. T. Supuran, "Copper complexes modelling the interaction between benzolamide and Cu-substituted carbonic anhydrase. Crystal structure of Cu(bz)(NH₃)₄ complex *Inorg. Chim. Acta* 273, 334 (1998).
- [11] C. T. Supuran, A. Scozzafava, Carbonic anhydrase inhibitors-part 94.1,3,4 Thiadiazole-2-sulfonamide derivatives as antitumor agents" *Eur . J . Med Chem.* 35, 867 (2000).
- [12] Marvel, C.S and Tarkey,n.,*J .Am.Chem.Soc.* 1958,80:832

IJSER