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Synthesis of 4,4 Dihydroxybiphenyl-Carbohydrazide-Formaldehyde Copolymer and Its Characterization

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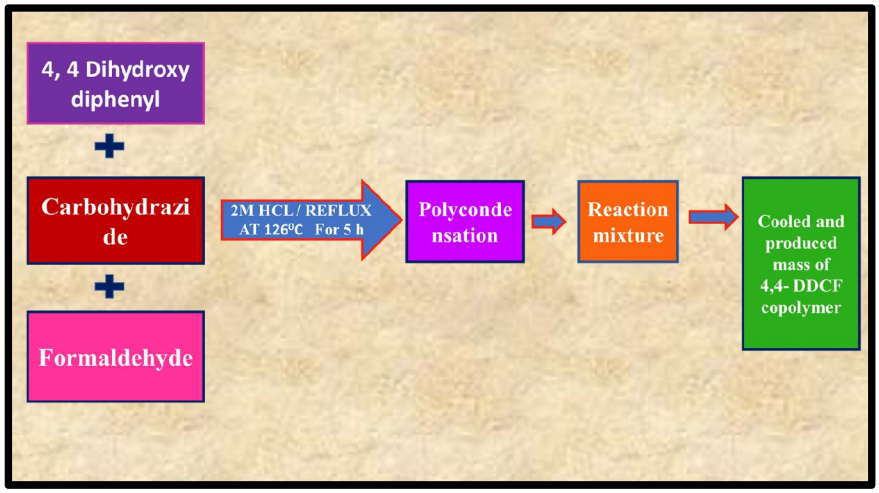
Abstract: *The novel copolymer 4,4'-DBCF was synthesized by the condensation of of 4,4'-dihydroxydiphenyl, carbohydrazide, and formaldehyde in the presence of acid catalyst with using 1:1:2 molar ratio of reacting monomers. Copolymer composition has been determined on the basis of their elemental analysis and no. average molecular weight of copolymer was determined by gel permission chromatography method The viscosity of the copolymer in dimethyl sulfoxide (DMSO) was measured to determine its unique functions and constants. The structure of the copolymer was determined by examining its infrared spectra. Further examination of 4,4 DDCF was carried out using techniques such as nuclear magnetic resonance (NMR) spectroscopy, ultraviolet-visible (UV-Vis) spectroscopy, and atomic analysis. Scanning electron microscopy was also used by researchers to examine the morphology of the copolymer.*

Keywords: Polycondensation, Copolymer, Dihydroxydiphenyl, Carbohydrazide, Synthesis, Characterization



Schematic representation of Synthesis of copolymer 4,4 DBCF

I. INTRODUCTION

Copolymers have high molecular weights and are made up of small repeating units held together by strong covalent bonds.. Copolymer synthesis is an important subject of study in polymer science because it allows for the tailoring of polymers for specific purposes. Polymers are becoming increasingly popular because to their versatility and uniqueness.

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Copolymers are suitable for packaging, adhesives, and coatings in electrical sensors and semiconductors due to their thermal stability and ability to produce materials.

C. Kohod and coworker prepared a yellow colour copolymer which was synthesized from 8-HQ5-SAHMDAF blended by gathering (0.2 mol) 8-hydroxyquinoline5-sulfonic acid, (0.1 mol) hexamethylenediamine and (0.3 mol) formaldehyde at 124^0C in an oil bath for 5 hrs [1]. Megha Rangari and et.al. had done thermal degradation studies of high-performance copolymer resin of 8-HQAF derived from 8-hydroxyquinoline, acrylamide and furfural with 2M HCl in the molar ratio in an oil bath at a temperature of 122 ^{o}C also they made composite from synthesized copolymer.[2] Applications of ion chelation exchange capability and antibacterial properties had been studied of synthesized copolymer derived from o-cresol-formaldehyde-catechol by Jayathilake and coworkers [3]

By condensing 2 amino 6-nitrobenzothiazole, formaldehyde, and melamine in the presence of 2M HCl as a catalyst at 122°C in an oil bath for 5 hours, Gupta and colleagues created BMF-IV copolymer. A yellow solid product was sorted out.[4] The copolymer 8-HQ-5-SAGF, or 8-Hydroxyquinoline-5-sulphonic acid-guanidine-formaldehyde copolymer, was described by Rathod and his colleague using the polycondensation process in a 1:1:2 molar ratio. This 8-HQ-5-SAGF copolymer resin was examined using a Perkin Elmer TGA/DTA thermal analyzer. This copolymer was subjected to elemental analysis using the Perkin Elmer 789N QP-2010 device.[5] By polycondensation in a melt of guanidine hydrochloride and hexamethylene diamine at a specific temperature, Okladnikova and colleagues synthesized Polyhexamethylene guanidine hydrochloride (PHMGhch). PHMGhch's superior antibacterial activity and gelation properties make it a promising polymer for medical applications.[6]

Y. U. Rathode and colleagues investigated the photoluminescence of a copolymer and its copolymer/carbon composite utilizing phthalic acid and formaldehyde in combination with 8-hydroxyquinoline5-sulphonic acid.[7] Akshay and colleagues studied a multifunctional copolymer made by a controlled polycondensation technique that combined formaldehyde, acrylamide, and 8-hydroxyquinoline. Fourier-transform infrared (FT-IR) spectroscopy, UV–visible spectroscopy, and proton nuclear magnetic resonance were used to characterize the structure and confirm that all functional moieties were successfully integrated into the polymer framework.[8] The copolymer resin 4-HBAF was created by combining 4-hydroxybenzoic acid, adipamide and formaldehyde in molar ratio with hydrochloric acid as a catalyst reported by Thakare and Gurnule[9]

Using HCl as a catalyst to eliminate hexavalent chromium ions, Vilayatkar and Sudip Mondal created a polymer resin from 8-hydroxy quinoline (8-HQ), thiourea, and formaldehyde in a 1:1:2 mol ratio[10]. Wasudeo B. Gurnule and Yashpal U. Rathod evaluated thermal properties of terpolymer (8-HQ-5-SAAF) synthesized using 8 hydroxyquinoline-5-sulphonic acid, anthranilic acid and formaldehyde via the poly condensation method[11]. The thermal decomposition behavior of HMBPDANF-II has been synthesized by condensation of 2-hydroxy, 4-methoxybenzophenone and 1, 5 diaminonaphthalene with formaldehyde in the presence of hydrochloric acid as a catalyst in molar proportion of reactants.This copolymer had been carried out by using TGA in static nitrogen atmosphere at a heating rate of 10 0C/min.[12]

Using benzoyl peroxide (BP) as an initiator, Yousef Wadouh and coworkars synthesized a co-polymer (styrene/allyl-2.3.4.6-tetra-O-acetyl-β-D-glucopyranoside) from glucose in four steps by addition polymerization in accordance with the radical process. Allyl-2.3.4.6-tetra-O-acetyl-β-D-glucopyranoside monomer was first synthesized in three steps and the reaction was monitored by HPLC, FT-IR, and TLC. In the fourth step, the monomer was polymerized with styrene, and FT-IR and NMR spectroscopy were used to determine its structure [13-15].Using the polycondensation process, Nandekar and Gurnule created p-HBSF-I copolymer from p-hydroxybenzoic acid, semicarbazide, and formaldehyde. Using an agar well diffusion method, p-HBSF-I copolymer was employed for antibacterial and antifungal investigations.[16-18]

This communication describes the synthesis and characterization of a novel copolymer produced from 4,4′-dihydroxybiphenyl, carbohydrazide, and formaldehyde (4,4-DBCF) using polycondensation. Characterization incorporates spectral investigations, scanning electron microscopy, and X-Ray Diffraction to analyze surface characteristics of copolymers.

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Experimental

Materials

Central Scientific Company, Nagpur supplied 4,4′-dihydroxybiphenyl, carbohydrazide, and formaldehyde. Solvents, including hydrochloric acid and dimethyl sulfoxide, were also obtained from Central Scientific Company in Nagpur. All chemicals used were of analytical grade and utilized exactly as received.

Synthesis of novel copolymer

The novel copolymer was manufactured using polycondensation of monomers such as 4,4 dihydroxydiphenyl, carbohydrazide, and formaldehyde in 1:1:2 molar ratios using 2M HCL and refluxed for five hours at 126^{0}C.The reaction mixture was then cooled and rinsed with warm water and ethanol before being filtered to remove unreacted monomers and contaminants. Finally, the copolymer was dried in the air. The proposed reaction scheme is given in figure 1.

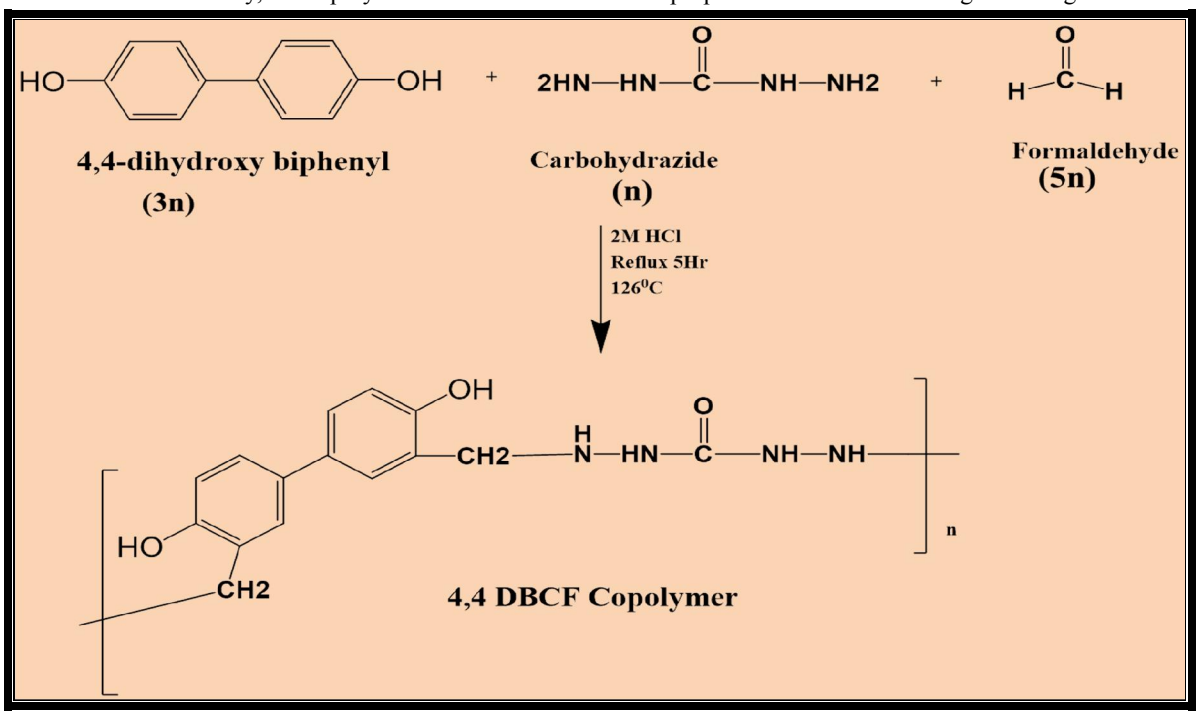

Fig.1: Synthesis of 4,4 DBCF copolymer

Characterization

Using a twin beam spectrophotometer equipped with an automatic pen chart recorder, the UV-visible spectra were recorded at room temperature in dimethylsulphoxide between 190 and 850 nm. The Cary 630 Agilent Technology FT-IR Spectrophotometer was used to perform FT-IR spectra in the 4000-650 cm-1 range. Using DMSO as a solvent, the copolymer's 1H-NMR spectrum was captured using a Varian 400 MHz NMR Spectrophotometer. All of the analytical and spectral investigations for the produced copolymer resin were documented at Sprint Testing Solutions, Parel, Mumbai, India.

II. RESULTS AND DISCUSSIONS

It was discovered that the produced copolymer had a yellowish colour. The copolymer is insoluble all other inorganic and organic solvents, but soluble in solvents like dimethyl sulphoxide (DMSO), dimethylformamide (DMF), and partially soluble in tetrahydrofuran (THF).

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FT-IR Spectra

The FTIR spectra of 4,4 DBCF copolymer is shown in the figure. The broad band appeared at 3202 cm^1 and 3023 cm^1 may be due to O-H stretching of phenolic group and N-H stretching of hydrazide group exhibiting intermolecular hydrogen bonding. [19]The peak appeared at 1607 cm^1 due to C=O stretching or C=N stretching indicate amide linkage from carbohydrazide . the strong peack at 1467 cm^1 indicate C-H stretching confirmed presence of aromatic ring.The medium band at 1347 cm^1 suggested -NH-NH- the hydrazide linkage of carbohydrazide. The strong band observed at1202 cm^1 indicate C-O stretching phenolic –OH group. The peak observed at 1110 cm^1 suggested presence of methylene bridge -(CH_2)- in the copolymer chain.[20,21]

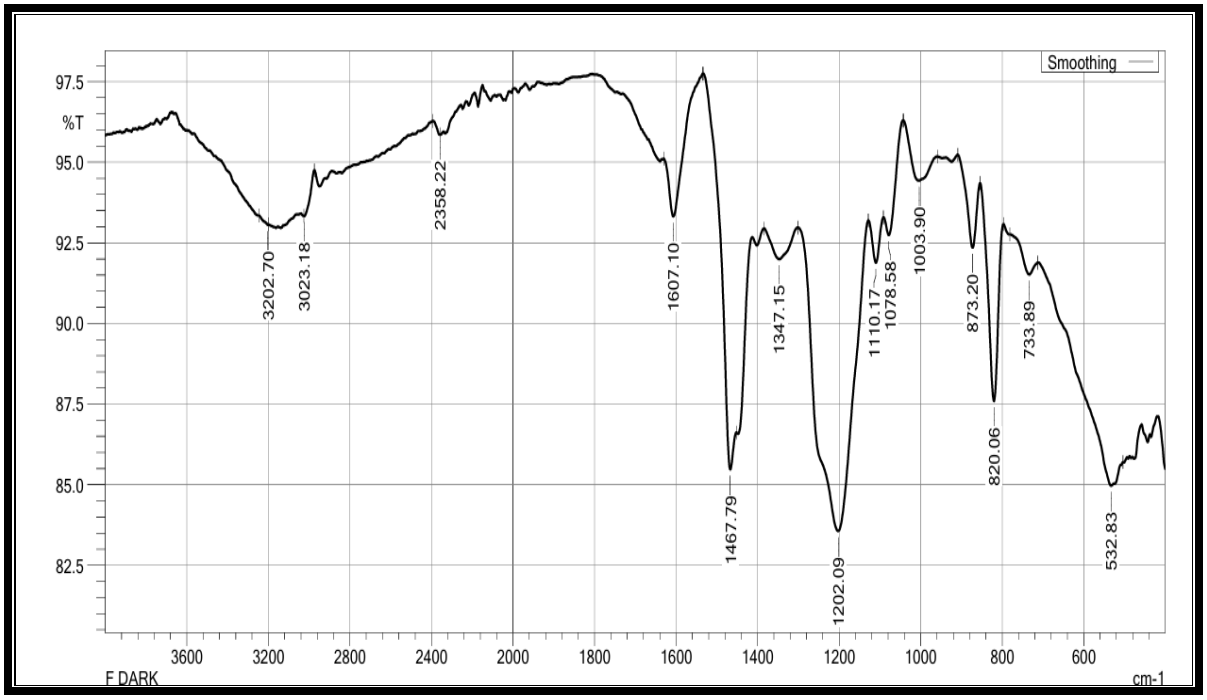

Fig. 2:-FT-IR Spectra of 4,4 DBCF copolymer

^{1}H-NMR

The H^1 NMR of copolymer 4,4 DBCF is introduced in the figure 3. NMR Spectra shows the presence of methylene proton of the Ar-CH2-NH bridge has attributed to singlet signal in the region of 3.32 ppm.[22-24] A Singlet proton in the region 2.50 ppm might be because of proton near to -NH-CO- hydrazide environment due to high degree of polymerization there is absence of aromatic proton which is generally appears at 6.7 -8 ppm region .Also due to strong intermolecular hydrogen bonding there is missing of OH and NH proton. [25,26]

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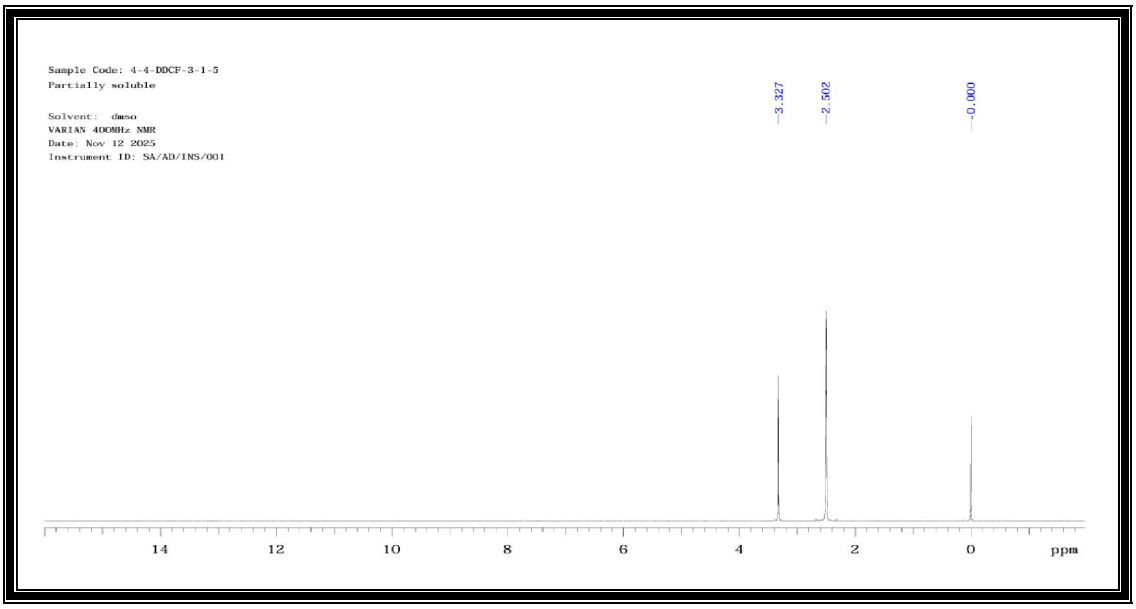

Fig 3: Proton NMR of Copolymer 4, 4 DBCF

X-Ray Diffraction

The X-ray diffraction pattern of 4,4 DBCF copolymer shows an amorphous material's characteristic broad diffuse peak centered around 2θ = 18–22°. The copolymer's lack of long-range crystalline organization is indicated by the absence of distinct and strong Bragg reflections. This wide halo indicates that the substance is non-crystalline and is caused by the copolymer chains' jumbled arrangement.

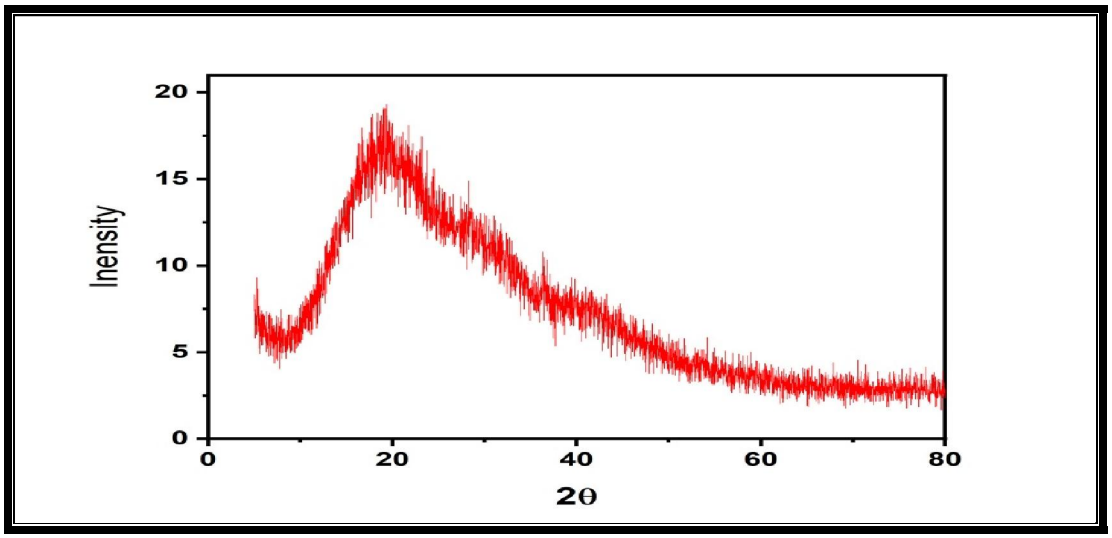

Fig 4: X-Ray diffraction of 4,4 DBCF copolymer

Scanning Electron Microscopy of 4,4 DBCF copolymer

The SEM analysis has greatly aided in material characterization, surface property recognition, and particle size determination.[27-28] Scanning electron microscopy was used to analyze the morphology of the copolymer 4,4 DBCF, as seen in Fig. 5.The copolymer was discovered to be more amorphous than crystalline based on the photos. The copolymer exhibits a more amorphous character with a close-packed surface having deep pits and the reactivity of active

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sites buried in the copolymer matrix [29-30] The absence of regular structures and clearly defined grain boundaries suggests that the material lacks long-range molecular order. This morphological characteristic implies that the copolymer is amorphous. Additionally, the creation of a strongly crosslinked polymer network is supported by the fused and randomly distributed structure. These findings align with X-ray diffraction data, which further validate the copolymer's amorphous nature.

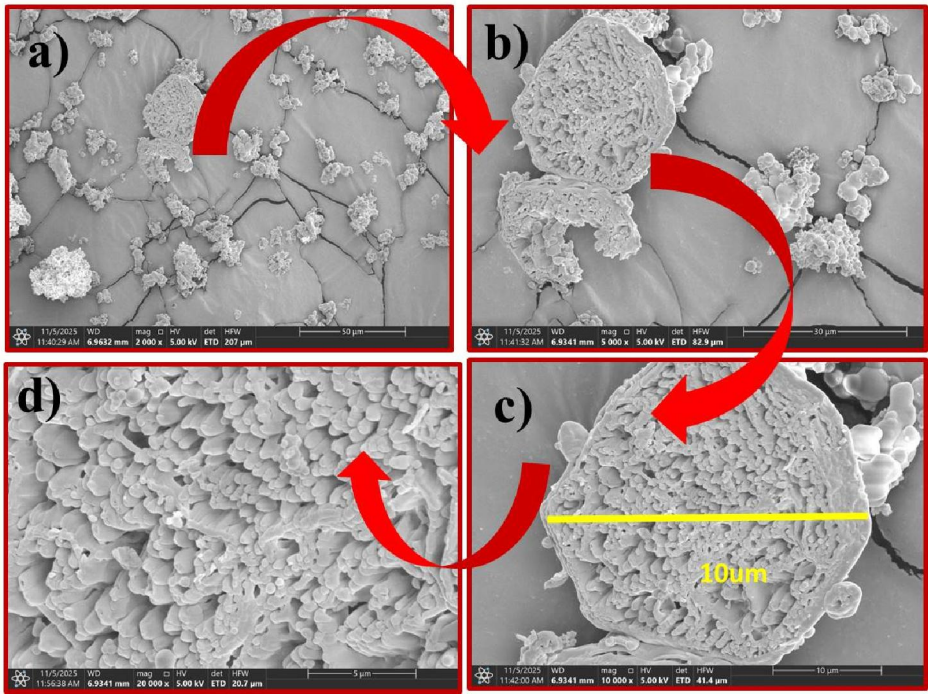

Fig. 5: Scanning electron microscopoy Micrograph of 4,4 DBCF copolymer

III. CONCLUSION

The copolymer synthesized from 4,4 Dihydroxy biphenyl ,Carbohydrazide and formaldehyde in 3:1:5 ratio usig 2 M HCl as catalyst in an oil bath at 120^0C. The structure of copolymer 4,4 DBCF wasconfirmed by FT-IR 1H –NMR spectral studies. Scanning electron microscopy shows the morphology of copolymer that the copolymer was more amorphous in nature than crystalline .this amorphous nature also confirmed by X-ray diffraction study. These all are confirmed that these new monomer prepared a novel copolymer.

REFERENCES

1. Chetana Kohad and Wasudeo Gurnule ‘Synthesis, Characterization and Photoluminescence Studies of Organic Copolymer Resin’ Materials Today: Proceedings 15 (2019) 438–446
2. Megha Rangari, S S Rahangdaleb, Seema Shrivastava , Yashpal Rathodd, Prajkta U Waghee & Wasudeo B Gurnule, ‘Thermal Degradation Studies of High-Performance Copolymer Resin Derived From 8-Hydroxyquinoline, Acrylamide and Furfural’ Indian Journal of Engineering & Materials Sciences Vol. 30, December 2023, pp. 816-822 DOI: 10.56042/ijems.v30i6.4517 *
3. N.H.A.M. Jayathilake, S. Arasaretnam and C. Mahendranathan, ‘Synthesis, characterisation, ion chelation exchange capability and antibacterial properties of the o-cresol-formaldehyde-catechol-based copolymer’ Vingnanam Journal of Science, Vol.17 (2), December 2022 https://doi.org/10.4038/vingnanam.v17i2.4217

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4. P G Gupta, R H Gupta, W B Gurnule, S N Rao, & Y U Rathod 'Synthesis, Characterization, and Photoluminescence Properties of 2-amino 6-nitrobenzothiazole-Melamine-Formaldehyde Copolymer-Charcoal Composite' Indian Journal of Engineering & Materials Sciences Vol. 30, December 2023, pp. 838-844 DOI: 10.56042/ijems.v30i6.4529
5. Y U Rathod, S B Zanje and W B Gurnule. 'Hydroxyquinoline copolymers synthesis, characterization and thermal degradation studies International Conference on Research Frontiers in Sciences (ICRFS 2021) Journal of Physics: Conference Series 1913 (2021) 012061 IOP Publishing doi:10.1088/1742-6596/1913/1/012061
6. V O Okladnikova, O S Ochirov, M N Grigor'eva, S A Stelmakh and D M Mognonov 'Obtaining a copolymer of polyhexamethylene guanidine hydrochloride and polyvinyl alcohol' Journal of Physics: Conference Series 1989 (2021) 012002 IOP Publishing doi:10.1088/1742-6596/1989/1/012002
7. Yashpal U. Rathod , Vikram U. Pandit , Devidas S. Bhagat ,Wasudeo B. Gurnule 'Synthesis of copolymer and its composites with carbon and their photoluminescence studies'Volume 53, Part 1, 2022, Pages 123-129
8. Akshay A. Akare1, W. B. Gurnule, D. M. Chafle 'Multifunctional Copolymer Synthesis Using 8-Hydroxyquinoline: Thermal, Spectroscopic, and Surface Morphological Analysis' JOURNAL OF APPLIED BIOANALYSIS, December 2025 p. 907-918 10.53555/jab.v11si16.2688 (ISSN 2405-710X) Vol. 11, No. 16s
9. Mangesh B. Thakrea and Wasudeo B. Gurnule'Synthesis and Characterisation of New Copolymer Resin Derived from 4-Hydroxybenzoic Acid and Adipamide' Materials Today: Proceedings 15 (2019) 516–525 ICMAM-2018
10. Nitin D. Vilayatkar , Pralhad K. Rahangdale , Sudhir M. Maskey , Aniruddha Mondal , Sudhir S. Bhuyar , Manjiri S. Nagmote , Sudip Mondal 'Synthesis and characterization of terpolymeric resin for removal of hexavalent chromium' Mat. Tod. Proce. 29 (3) 776-780 (2020)
11. Wasudeo B. Gurnule and Yashpal U. Rathod , 'Synthesis, Characterization and Thermal Behaviour Studies of Terpolymer Resin Derived from 8-Hydroxyquinoline- 5-Sulphonic Acid and Anthranilic Acid' Current Applied Polymer Science, 2021, 4, !.76..809
12. Sanjiokumar S. Rahangdale, Narayan C. Das, Kiran S. Vajpai and Wasudeo B. Gurnule 'Synthesis, Characterization And Thermal Degradation Study Of Copolymer Resin- Ii: Resulting From 2-Hydroxy, 4-Methoxybenzophenone, 1, 5 Diaminonaphthalene And Formaldehyde' I J R B A T, Issue (VIII), Vol. I, Jan 2020: 194-204
13. Yousef Wadouh Rana Ghenem Warda Khalil Mohammad Keshe, 'Synthesis and Characterization of Co-Polymer (Styrene / Allyl 2,3,4,6-tetra-O acetyl-β-D- glucopyranoside) and Studying some of its thermal properties'Baghdad Science Journal Published 2023, 20(5): 1655-1683 DOI: https://dx.doi.org/10.21123/bsj.2023.7378
14. Narayan C. Das, Kiran S. Vajpai, A. P. Ganorkar and Wasudeo B. Gurnule, 'Synthesis, Characterization and Morphology of Organic Copolymer Resin-III Resulting from 1,5 Diaminonaphthalene, 2,4 Dihydroxypropiophenone and Formaldehyde' (IJARSCT) Volume 12, Issue 4, December 2021
15. Soliman Mehawed Abdellatif Soliman, Mohamed Fathi Sanadc and Ahmed Esmail Shalan 'Synthesis, characterization and antimicrobial activity applications of grafted copolymer alginate g-poly(N-vinyl ' imidazole)†' *RSC Adv.,2021, 11, 11541–11548
16. Kamlakar Nandekar and Wasudeo Gurnule, 'Synthesis and antimicrobial study of copolymer resins derived from p-hydroxybenzoic acid, semicarbazide and formaldehyde' (ICRFS 2021) Journal of Physics: 1913 (2021) 012063 IOP Publishing doi:10.1088/1742-6596/1913/1/012063 1
17. Punam G. Gupta1, R. H. Gupta2, W. B. Gurnule, 'Synthesis, Characterization, and Electrical Properties of Copolymer Derived from 2-Amino 6 nitrobenzo- thiazole, Dithiooxamide and Formaldehyde' (IJARSCT) Volume 12, Issue 4, December 2021, 312-321 DOI: 10.48175/IJARSCT-2396

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ISSN: 2581-9429
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Impact Factor: 8.2

18. W.B. Gurnule [a] Kiran S. Vajpai , R.V. Mankar , C.G. Kohad 'Photoluminescence studies of copolymer metal complexes with 8-hydroxyquinoline, hexamethylenediamine and formaldehyde' Materials Today: Proceedings volume 29, Part 4, 2020, Pages 974-980 https://doi.org/10.1016/j.matpr.2020.04.175
19. W. B. Gurnule, N. C. Das, S. Vajpai et al., 'Synthesis, characterization and thermal degradation study of copolymer resin', Materials Today: Proceedings, 2020 page 1-6 https://doi.org/10.1016/j.matpr.2020.04.828
20. S. B. Rahardjo, M. K. Widowati, Y. A. Rasyda, S.D. Marliyana 'Synthesis, Characterization And Antibacterial Studies Of Aminobenzothiazole Derivative And ITS COPPER(II) COMPLEX'
21. Rasayan J. Chem., 14(3), 2116-2124(2021) http://doi.org/10.31788/RJC.2021.1436378 S.P. Chakole, Y.U. Rathod, V.U. Pandit , Wasudeo B. Gurnule., 'Synthesis, characterization and thermal behavior of 2,20-dihydroxybiphenyl formaldehyde-phenylenediamine copolymer, Materials Today: Proceedings, 1-5 https://doi.org/10.1016/j.matpr.2021.12.395
22. Wasudeo B. Gurnule and Narayan Das, 'Kinetic Study of Non-Isothermal Decomposition of Copolymer Resin Derived from 2, 4-Dihydroxypropiophenone, 1, 5 Diaminonaph- thalene and Formaldehyde' Materials Today: Proceedings 15 (2019) 611–619
23. Damini Shedmake, Jyotsna V. Khobragade and W. B. Gurnule, 'Synthesis, Characterization And Antimicrobial Activity Of Copolymer Metal Complexes And Their Thermal Studies' I J R B A T, Issue (XI) Vol (II) May 2023 : 67-79
24. Kamlakar Nandekar and Wasudeo Gurnule, 'Synthesis and antimicrobial study of copolymer resins derived from p-hydroxybenzoic acid, semicarbazide and formaldehyde' (ICRFS 2021) Journal of Physics: Conference Series 1913 (2021) 012063 IOP Publishing doi:10.1088/1742-6596/1913/1/012063
25. Kamlakar Nandekar and Wasudeo Gurnule Shehla Mushtaq, Nasir M. Ahmad ,Azhar Mahmood andMudassir Iqbal, 'Antibacterial Amphiphilic Copolymers of Dimethylamino Ethyl Methacrylate and Methyl Methacrylate to Control Biofilm Adhesion for Antifouling Applications' Polymers 2021, 1-13, Polymers 2021, 1-13, 216. https://doi.org/10.3390/polym13020216
26. Nakan, U.; Bieerkehazhi, S.; Tolkyn, B.; Mun, G.A.; Assanov, M.; Nursultanov, M.E.; Rakhmetullayeva, R.K.; Toshtay, K.; Negim, E.-S.; Ydyrys, A.
27. 'Synthesis, Characterization and Antibacterial Application of Copolymers Based on N,N-Dimethyl Acrylamide and Acrylic Acid'. Materials 2021, 1-14, 6191. https://doi.org/10.3390/ma14206191
28. W. B. Gurnule, K. S. Vajpai, R. V. Mankar et , 'Photoluminescence studies of copolymer metal complexes with 8-hydroxyquino line, hexamethylenediamine and formaldehyde,Materials Today: Proceedings, 1-7 https://doi.org/10.1016/j.matpr.2020.04.175
29. W. B. Gurnule, Y. U. Rathod, A. D. Belsare , 'Thermal degradation and antibacterial study of transition metal complexes derived from novel terpolymer ligand', Materials Today: Proceedings, 1-6 https://doi.org/10.1016/j.matpr.2020.04.708
30. M. M. Yeole and Seema Shrivastava and W. B. Gurnule, '-Synthesis and characterization of copolymer resin derived from 4-methyl acetophenone, phenyl hydrazine andformaldehyde Der Pharma Chemica, 2015, 7(5):124-129 (http://derpharmachemica.com/archive.html)
31. P.A. Mishra, Y.U. Rathod, V.U. Pandit et al., Thermal degradation studies of 2-hydroxy-4-methoxy acetophenone, guanidine and formaldehyde copolymer, Materials Today: Proceedings,1-5 2021 https://doi.org/10.1016/j.matpr.2021.12.383