The Rubrics
JOURNAL OF INTERDISCIPLINARY STUDIES

ISSN 2454-1974
Volume 7 Issue 8, November 2025
Website: https://therubrics.in

RESEARCH ARTICLE

Review on different methods for the synthesis of polyindole

D. J. Bhagat

Nehru Mahavidyalaya (Arts, Science and Commerce), Nerparsopant, Maharashtra, India;

djbhagat247@gmail.com

Accepted version published on 5 November 2025

ABSTRACT

In this review different synthesis methods of polyindole have been verified, such as sonochemical polymerization, template synthesis, chemical synthesis, solution polymerization, microemulsion polymerization. This review suggested that the particle size and yield of synthesis can be depends upon the synthesis technique used prepared the polyindole as per literature survey. Moreover, the medium also affect the yield. Researchers used various oxidant as well as different solvent like aqueous or organic media to make a solution for synthesis.

Keywords: Polyindole, Polymerization, Characterization

FULL PAPER

Introduction

In the last few decades heterocyclic conducting polymer has extensive research interest worldwide due to their physical properties. Polymers are traditionally regarded as electrical insulators. However, a new class of polymers known as intrinsically conducting polymers or electro active conjugated polymers has emerged during the past two decades. These novel materials with interesting properties have attracted the whole scientific community, including polymer and synthetic chemists. Such materials exhibit interesting electrical and optical

properties. This has led to the wide use of polymer electrolytes and polyelectrolytes in electrochemical systems, optical devices, sensors and rechargeable batteries [1].

Polymer composites of conductive polymers such as polyacetylene, polypyrrole, polythiophene and polyaniline have also been reported. Among conducting polymers, polyindole has been one of the least studied polymers. There is more research expectation on polyindole in future because of its physical and electrical properties that have led to several applications such as solid state and electronics devices. Since polyindole has high redox activity, good thermal stability, slow degradation rate in comparison with those of polyaniline and polypyrrole and air stable electrical conductivity [1-2]. The polyindole is a promising candidate, which is used in electronics devices and active materials for batteries. Literature survey suggests conducting polymers are promising in all solid state electrochemical power sources such as rechargeable batteries, organic solar cells, fuel cells, printing electronic circuit, organic light emitting diode, super capacitor, chemical sensors and biosensors, flexible transparent displays, electromagnetic-shielding [3-8].

Here the existing literature reviewed for this study, various synthesis methods of PIN have been verified, such as sonochemical polymerization, template synthesis, chemical synthesis, solution polymerization, microemulsion polymerization.

Results and discussion

The various synthesis techniques utilized to prepare PIN are detailed below.

1. Sonochemical synthesis of polyindole:

For the chemical oxidative polymerization of indole, oxididizing agent like $(NH_4)_2S_2O_8$ were used and in acidic media it simply acts as an oxidant [9]. In some cases, at some stage in polymer development acid protons are formed. Additionally, Lewis acids, such as $FeCl_3$, are used as oxidizing agent in chemical oxidative polymerization [9, 10].

Soylu et al. synthesized polyindole using Cu(ClO4)2·6H2O in neutral, protonic acidic, and Lewis acidic media. In the synthesis of polymers, various polymerization mixtures were prepared including indole, $Cu(ClO_4)_2·6H_2O$, $HClO_4$ and BF_3 [11].

2. Template synthesis of polyindole:

Template synthesis is most widely used and effortless method of nanostructure formations. This technique has been utilized to synthesized conducting polymer nanotubes through both chemical and electrochemical polymerisation. In the template technique the polymerization starts on the surface

of the template, resulting core shell structures. In template synthesis required material with vital shape is prepared inside pores of template and after that template is dissolved, leaving the material with shape of pores of template [12-15]. Template-based techniques have paying attention as a possible technology enabling to control length and diameter of nanowires [16-19].

3. Chemical synthesis of polyindole:

The polymerization of indole monomer through chemical oxidative polymerization approach is a very easy and convenient method. Also, the yield percentage is very high. In chemical route aqueous or organic solvents were used as media for synthesis. The polymerization of indole with various oxidants such as $CuCl_2$, KIO_3 [20, 10], $FeCl_3$ [20, 21-23, 24, 10, 25-27], ammonium persulphate [103,104] was reported. The selection of oxidants strongly affects the morphology and transport properties. The tuning of optimum PIN yield was dependent on monomer to oxidant ratio in chemical synthesis technique. The polyindole was synthesized chemically using oxidant $FeCl_3$ in organic media. The polymerisation process was done under nitrogen atmosphere. The immaculate polymer was collected by filtration and then washed with hot distilled water. Finally the precipitate dried in vacuum oven [21, 23]. The produce polymer was recovered with 78% yield [22].

4. Solution polymerization of indole:

PIN has also been prepared through solution polymerisation technique. In general the processability of PIN is very poor. Therefore, the PIN prepared through a solution polymerization procedure has superior processability because it is already in a solution. Indole has been chemically polymerised in various solvents such as phenol, nitromethne [20], acetonitrile [20,28,29], xylne [21], chloroform [30], dichloromethane [20,31], ethanol [20,32], methanol, also in aqueous media [32,33] and electropolymerized in solvents like, methanol [34], acetonitrile [35,36], also in aqueous media [37,38].

5. Microemulsion polymerization of indole:

A microemulsion is controlled micro-heterogeneous method which provides a huge interfacial area and is usually less sticky. To balance the method water, oil and surfactant, and moreover frequently a co-surfactant are used as stabilizer in this polymerisation method.

To detect the direction behaviour of the surfactants, microemulsion is a most ideal technique; also it is molecularly well-organized method [39, 40]. To

synthesized polymer particles in the size range over 5–100 nm, there is most efficient and recognized technique of polymerization is the microemulsion. This technique has paying lots of attention in the past few decades [41–43]. PIN has also been produced through the microemulsion technique with Cetyltrimethyl ammonium bromide (CTAB) was employed as a surfactant and ammonium persulphate used as oxidant [44]. Chen et al. synthesized substituted 3H-indole probe molecules reside in the AOT-based water-in-oil microemulsion [45]. In above discussion five simple polymerization of indole methods are briefly discussed.

Conclusion

The literature survey provide in results and discussions concluded that the synthesis methods such as sonochemical polymerization, template synthesis, chemical synthesis, solution polymerization, microemulsion polymerization can prepared the polyindole successfully. Also, size of particle and yield can be depends on the media and synthesis methods.

References

1. O. M. Folarin, E. R. Sadiku, A. Maity; Int. J. Phys. Sci. 6 (2011) 4869-4882.
2. J. H. He, Polym. 45 (2004) 9067-9070.
3. J. R. MacCallum, C. A. Vincent, Polymer electrolyte reviews, Elsevier Appl. Sci. Publisher, London, 1&2, 1987 &1989.
4. X. L. Wang, A. Mei, M. Li, Y. H. Lin, Ce. Wen. Nana, J. Appl. Phys. 102 (2007) 054907.
5. H. S. Nalwa, Handbook of Nanostructured Materials and Nanotechnology, (Academic Press: New York, NY, USA, 5, 2000.
6. Lange, Ulrich, Roznyatovskaya, V. Nataliya, Mirsky, M. Vladimir, Analytica Chimica Acta 614 (2008) 1.
7. Z. Cai, M. Geng, Z. Tang, J. Mater. Sci. 39 (2004) 4001.
8. L. Fan, Z. Dang, G. Wei, Ce. Wen. Nan, M. Li, Mater. Sci. Eng. B 99 (2003) 340.
9. G. Rajasudha, D. Rajeswari, B. Lavanya, R. Saraswathi, S. Annapoorni, N. C. Mehra, Colloid Polym. Sci. 283 (2005) 575-582.
10. D. Billaud, E. B. Maarouf, E. Harmecart, Mat. Res. Bull. 29 (1994) 1239-1246.

11. O. Soylu, S. Uzun, M. Can, The investigation of acid effect on chemical polymerization of indole, Colloid. Polym. Sci. 289 (2011) 903-909.
12. S. Xiong, Q. Wang, H. Xia, Synth. Met. 146 (2004) 37-42.
13. Demoustier-Champagne S, Duchet J, Legras R. Synth. Met. 101 (1999) 20-21.
14. M. Delvaux, J. Duchet, P. Y. Stavaux, R. Legras, S. Demoustier-Champagne. Synth. Met. 113 (2000) 275-280.
15. J. Mativetsky, W. R. Datars, Solid State Commun. 122 (2002)151-154.
16. R. V. Parthasarathy, C. R. Martin, Chem. Mater. 6 (1994) 1627-1632.
17. J. Choi, G. Sauer, K. Nielsch, R. B. Wehrspohn, U. Gosele, Chem. Mater. 15 (2003) 776-779.
18. G. Sauer, G. Brehm, S. Schneider, K. Nielsch, R.B. Wehrspohn, J. Choi,et al. Highly ordered mono crystalline silver nano wire arrays. J. Appl. Phys. 91 (2002) 3243-3247.
19. J. Choi, G. Sauer, P. Goring, K. Nielsch, R. B. Wehrspohn, U. Gosele, J. Mater. Chem. 13 (2003) 1100-1103.
20. D. Billaud, E. B. Maarouf, E. Harmecart, Synth. Met. 69 (1995) 571-572.
21. B. Sari, N. Yavas, M. Makulogullari, O. Erol, H. I. Unal, Synthesis, electrorheology and creep behavior of polyindole/polyethylene composites, Reactive Functional Polym. 69 (2009) 808-815.
22. N. B. Tayalan, B. Sari, H. I. Unal, Preparation of Conducting Poly(vinyl chloride)/Polyindole Composites and Freestanding Films via Chemical Polymerization, J. Polym. Sci.: Part B: Polym. Phys. 48 (2010) 1290-1298.
23. O. Eraldemir, B. Sari, A Gok, H. I. Unal, Synthesis and Characterization of Polyindole/Poly(vinylacetate) Conducting Composites, J. Macromol. Sci. Part A: Pure and Appl. Chem. 45 (2008) 205-211.
24. V. Q. Trung, D. N. Huyen, Synthesis, properties and application of polyindole/TiO_2 nanocomposites, J. Phys. Conference Series 187 (2009) 012058.
25. C. Zhijiang, Y. Guang, Synthesis of polyindole and its evaluation for Li-ion battery applications, Synth. Met. 160 (2010) 1902–1905.

26. K. Oz, M. Yavuz, H. Yilmaz, H. I. Unal, B. Sari, Electrorheological properties and creep behavior of polyindole/poly(vinyl acetate) composite suspensions, J. Mater. Sci. 43 (2008) 1451-1459.
27. K. Koyuncu, H. I. Unal, O. Y. Gumus, O. Erol, B. Sari, T. Ergin, Electro kinetic and electrorheological properties of poly(vinylchloride)/polyindole conducting composites, Polym. Adv. Technol. (2011) 2068(1-9).
28. G. Rajasudha, H. Shankar, P. Thangadurai, N. Boukos, V. Narayanan, A. Stephen, Preparation and characterization of polyindole–ZnO composite polymer electrolyte with $LiClO_4$, Springer-Verlag. Ionics 16 (2010) 839-848.
29. D. Sazou, The dynamical behavior of the electrochemical polymerization of indole on Fe in acetonitrile–water mixtures, Synth. Met. 130 (2002) 45-54.
30. L. Joshi, R. Prakash, One-pot synthesis of Polyindole–Au nanocomposite and its nanoscale electrical properties, Mater. Lett. 65 (2011) 3016-3019.
31. B. Gupta, D. S. Chauhan, R. Prakash, Controlled morphology of conducting polymers: Formation of nanorods and microspheres of polyindole, Mater. Chem. Phys. 120 (2010) 625-630.
32. V. Q. Trung, D. N. Huyen, Synthesis, properties and application of polyindole/TiO_2 nanocomposites, J. Phys. Conference Series 187 (2009) 012058.
33. P. Rejani, B. Beena, Structural and Optical Properties of Polyindole-Manganese Oxide Nanocomposite, Indian J. Adv. Chem. Sci. 2 (2013) 95-99.
34. P. S. Abthagir, R. Saraswathi, Electronic properties of polyindole and polycarbazole Schottky diodes, Org. Electro. 5 (2004) 299-308.
35. H. Talbi, E. B. Maarouf, B. Humbert, M. Alnot, J. J. Ehrhardt, J. Ghanbaja, D. Billaud, Spectroscopic Studies of electrochemically dope polyinole, J. Phys. Chem. Solids. 57 (1996) 1145-1151.
36. E. B. Maarouf, D. Billaud, E. Hannecart, Mater. Res. Bull. 29 (1994) 637-643.
37. M. Ghita, D. W. M. Arrigan, Electroanalysis, Electrochemical Overoxidation of Polyindole and Its Cation Permselective Behavior,16 (2004) 979-987.
38. M. Saraji, A. Bagheri, Electropolymerization of indole and study of electrochemical behavior of the polymer in aqueous solutionsSynth. Met. 98 (1998) 57-63.

39. Yan F, Zheng C, Zhai X, Zhao D. Preparation and characterization of polyacrylamide in cationic microemulsion, J Appl. Polym. Sci. 67 (1998) 747-754.

40. Roy S, Devi S. Mechanism of microemulsion polymerization of methyl methacrylate: experimental evidence, J. Appl. Polym. Sci. 62 (1996) 1509-1516.

41. Barton J. Free-radical polymerization in inverse microemulsions, Prog. Polym. Sci. 21 (1996) 399-438.

42. Chi W. A simple model for the structure of spherical microemulsions, Macromolecules 27 (1994) 298-299.

43. Dreja M, Pyckhout-Hintzen W, Tieke B. Copolymerization behaviour and structure of styrene and polymerizable surfactants in three-component cationic microemulsion. Macromolecules 31 (1998) 272-280.

44. S. An, T. Abdiryim, Y. Ding, I. Nurulla, A comparative study of the microemulsion and interfacial polymerization for polyindole, Mater. Lett. 62 (2008) 935-938.

45. Y. Chen, T. Xu, X. Shen, H. Gao, How do the novel substituted 3H-indole probe molecules reside in the AOT-based water-in-oil microemulsion? An investigation by absorption and fluorescence spectroscopy, J. Photochem. Photobiol. A: Chem. 169 (2005) 123-129.