

RESEARCH ARTICLE

Review on Electrically active polymer polyindole and its co-polymers

D. J. Bhagat

Nehru Mahavidyalaya (Arts, Science and Commerce), Nerparsopant, Maharashtra, India;
djbhagat247@gmail.com

Accepted version published on 5 January 2026

ABSTRACT

This review basically focused on the synthesis of electrically active polymer polyindole and its copolymers. Basically, polyindole and its copolymers were prepared through electro-chemical co-polymerization method. This developed polymeric materials characterized and deeply studied through techniques like, SEM, TG-DTA CV, FTIR, UV-VIS, DSC, XRD, etc.

Keywords: Polyindole, Polymerization, Characterization

FULL PAPER

In general, four major types of electrically active polymers are present with dissimilar degrees of conductivity. The first and largely used group of conducting Polymer is composites wherein an insulating polymer matrix is filled with conductive fillers. The conductive fillers such as carbon or metal are in the form of particulate or fibrous to impart high conductivity. The ionically conducting polymers are second group of polymers. Now, the source of electrical conductivity is outcome of the group of ions present in the polymer [1]. An example of such a polymer composites are polyindole oxides such as polyindole-ZnO, polyindole-CuO, polyindole-NiO, etc in which lithium ions are mobile. These types of polymers have application in the battery industry [2-4].

The redox polymers are the third group of polymers. These polymers contain immobilized redox/electro active centers. Though, these centers are not essentially in contact with one another, however being capable of conduct charge through transport of electron from one to another center during the eminent “hopping” mechanism. During conduction, electrons tunnel through potential barrier from one to another redox center. To raise the possibility of such tunnelling the polymer requires having a huge number of redox centers [1].

The conjugated polymers are fourth and last group of conducting polymers. These consist of discontinuous single and double bonds, forming an extensive π -network. The main cause of conductivity in these polymers is movement of electrons within this π -frame work. Though, the level of conductivity is enhanced by dopant intended for these polymers. The conductivity of filled conducting polymers is a function of various concentrations such as matrix and filler, viscosity of polymer, polymer types, filler distribution and dispersion in the polymer matrix [5–8]. To reach a percolation threshold there is requirements of superior doping of spherical metal fillers [9]. The literature survey suggests that researchers not only interested to develop the conducting polymers but also they have interest to develop the copolymer materials which shows the properties of both conducting polymers. So in this article we try to study the development in copolymers and characterization. The various researchers are made their research on electrically active polymers and their co-polymers and it briefly discussed below.

Results and Discussions

The number of researchers were developed the polyindole with copolymers and studied its various properties and stabilities as discussed below, Gopi *et al.*, prepared poly(indole-co-thiopene) copolymer coatings on low nickel stainless steel via electrochemical method and characterized through cyclic voltammetry (CV), Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM) [10]. Dhanalaksmi *et al.*, synthesized conducting copolymer poly(pyrrole-co-indole) and its electro activity by electrochemical polymerization method and characterized via ^1H NMR, FTIR, CV, SEM, EDAX, UV-VIS, for the confirmation of successful synthesis of desired material [11]. Sarac *et al.*, synthesized the 5, 2 thio-phenyl-indole co-monomer (5, 2 In-Th) in order to understand electrochemical polymerization behaviour on carbon fiber electrode and confirm the preparation via characterization like, UV-VIS, FTIR, AFM, CV [12]. Xu *et al.*, copolymerized indole and 3, 4 thylene-dioxy-thiophene in acetonitrile containing LiClO_4 through the electro-chemical co-polymerization and characterized by UV-VIS, SEM, CV, FTIR, TGA to confirm structure and to check the thermal stability

and electrochemical behaviour of prepared material [13]. Wan *et al.*, developed PIN by the cooperation of pyrrole unit via electro-chemical co-polymerization and characterized via FTIR, CV for structural confirmation as well as to verify the electrical stability [14]. Gupta *et al.*, fabricated Schottky diode via electro-chemical copolymerization of indole and carbazole and characterized via SEM, TGA CV, FTIR, UV-VIS, DSC to verify structure and confirm the thermal as well as electrical stability [15]. Mozaffari *et al.*, developed the Schottky diodes using the poly(pyrrole-co-indole), PPY and PIN doped by various dopant anions as semiconductor layer and different metals with low work function as rectifying contact using electro-chemical co-polymerization technique and studied via SEM, CV to verify surface morphology and to check electrical stability [16]. Wadatkar *et al.*, developed the thiophene-indole conducting copolymers and studied the electrical and complex optical properties and characterized via SEM, UV-Vis, TG-DTA, XRD [17].

Above discussion showed that polyindole and its copolymers were synthesized through electro-chemical co-polymerization technique by maximum the researchers and they studied prepared materials via various characterizations such as SEM, TG-DTA CV, FTIR, UV-VIS, DSC, XRD, etc.

Conclusion

The electro-chemical co-polymerization method is best method to synthesize the polyindole and its copolymers which can be observed from above discussion. The various characterization techniques were used by researchers to characterize the prepared polymeric materials.

References

1. D. L. Wise, G. E. Wnek, D. J. Trantolo, T. M. Cooper, J. D. Gresser, Electrical and optical polymer systems, New York: Marcel Dekker, (1997).
2. G. Rajasudha, L. M. Jayan, D. Dhinasekaran, T. Paramasivam, N. Boukos, V. Narayanan, A. Stephen, Polyindole-CuO composite polymer electrolyte containing LiClO₄ for lithium ion polymer batteries, Springer-Verlag Polym. Bull. 68 (2012) 181.
3. G. Rajasudha, H. Shankar, P. Thangadurai, N. Boukos, V. Narayanan, A. Stephen, Preparation and characterization of polyindole-ZnO composite polymer electrolyte with LiClO₄, Springer-Verlag. Ionics 16 (2010) 839-848.

4. G. Rajasudha, A. P. Nancy, T. Paramasivam, N. Boukos, V. Narayanan, A. Stephen, Synthesis and characterization of polyindole–NiO-based composite polymer electrolyte with LiClO₄, *Int. J. Polym. Mater. Polym. Biomater.* 60 (2011) 877-892.
5. Y. Agari, T. Uno, Thermal conductivity of polymer filled with carbon materials: effect of conductive particle chains on thermal conductivity, *J. Appl. Polym. Sci.* 30 (1985) 2225-35.
6. L. E. Nielsen, The thermal and electrical conductivity of two-phase systems, *Ind. Eng. Chem. Fund.* 13 (1974) 17-20.
7. Nysten B, Issi JP. Composites based on thermally hyperconductive carbon fibres. *Composites*, 21 (1990) 339-343.
8. P. K. Pramanik, D. Khastgir, Conductive nitrile rubber composite containing carbon fillers: studies on mechanical properties and electrical conductivity. *Composites*, 23 (1992) 183-191.
9. S. Bhattacharya, *Metal filled polymers*, New York: Marcel Dekker, (1986).
10. D. Gopi, R. Saraswathy, L. Kavitha, D. K. Kim, Electrochemical synthesis of poly(indole-co-thiophene) on low-nickel stainless steel and its anticorrosive performance in 0.5 mol L⁻¹ H₂SO₄, *Polym. Int.* 63 (2013) 280-289.
11. K. Dhanalakshmi, R. Saraswathi, Electrochemical preparation and characterization of conducting copolymers: Poly(pyrrole-co-indole), *J. Mater. Sci.* 36 (2001) 4107–4115.
12. A. S. Sarac, S. O. Sarioglan, T. Dziomba, E. Sezer, Synthesis and electrocoating of indole-thiophene comonomer on carbon fiber microelectrode, and surface topography by AFM, *Eur. Polym. J.* 43 (2007) 3392–3399.
13. J. Xu, G. Nie, S. Zhang, X. Han, J. Hou, S. Pu, Electrochemical copolymerization of indole and 3,4-ethylenedioxythiophene. *J. Mater. Sci.* 40 (2005) 2867–2873.
14. F. Wan, L. Li, X. Wan, G. Xue, Modification of polyindole by the incorporation of pyrrole unit, *J. Appl. Polym. Sci.* 85 (2002) 814–820.
15. B. Gupta, A. K. Singh, A. A. Melvin, R. Prakash, Influence of monomer concentration on polycarbazole–polyindole (PCz–PIn) copolymer properties: Application in Schottky diode. *Solid State Sci.* 35 (2014) 51–61.
16. S. Mozaffari, M. R. Nateghi, A. Behjat, M. B. Zarandi, Effects of dopants and copolymerization on Schottky barriers of polypyrrole and polyindole/metal interfaces, *Iran. Polym. J.* 21 (2012) 799–808.

- 17.N. S. Wadatkar, S. A. WAguley, Exploring the electrical and complex optical properties of as-synthesized thiophene-indole conducting copolymers, *Heliyon*, 5 (2019).