CONDUCTING POLYMERS

Khushboo[1]*, Anu Kapoor[2]

Abstract: The growth of electrically conducting polymers is increasing day by day when intrinsically insulating organic conjugated polymers are doped with oxidizing and reducing agents. The conductivity is further increased. Later it introduces conducting polymers and conducting mechanism. Different kinds of CPs, their unique properties and synthesis are discussed. The recent achievements detail the morphological spectrum of conducting Nano-materials.

Keywords: Conducting polymers, conducting mechanisms.

[1]*,[2]Department of Physics, University Institute of Sciences, Chandigarh University, Ludhiana-Chandigarh State Highway, Punjab 140413, India

[1]*Email: Khushijangra604@gmail.com
[2]Email: anukapoor.appsci@cumail.in

***Corresponding Author: -** Khushboo
*Email: Khushijangra604@gmail.com

DOI: 10.53555/ecb/2023.12.12.274

INTRODUCTION

Polymers are the substances that are composed of very large molecules called macromolecules that are multiples of simpler chemical units called monomers.

Polymers are natural or synthetic substances, for example, proteins, cellulose or nucleic acids.

Conducting polymers are those polymers which can conduct electricity through themselves. The first highly-conductive organic compounds were the charge transfer complexes polyaniline was first described in the mid-19th century by Henry Letheby. He investigated the electrochemical and chemical oxidation products of aniline in acidic medium. He observed that the reduced form was colorless but the oxidized forms were deep-blue. In 1970, the first polymer was capable of conducting electricity i.e., polyacetylene. It was prepared by Shirakawa, Macdiarmid and Heiger fortify on polyacetylene and then they emerge it with the concept of organic materials behaving not as traditional insulators but like metals or semiconductors, it was exciting because it created a new subject of study for the coming students between chemistry and condensed matter physics and there is a lot more to discover. This review article reviews development in this field, and these methods working so far to improve the electrical conductivity of conducting polymers and applications because of the extra ordinary properties such as electrical characteristics, reversible doping procedures, controllable chemical and electrochemical properties a variety of conducting polymers e. g. polyaniline, polypyrrole, polyacetylene, etc. [1,2]

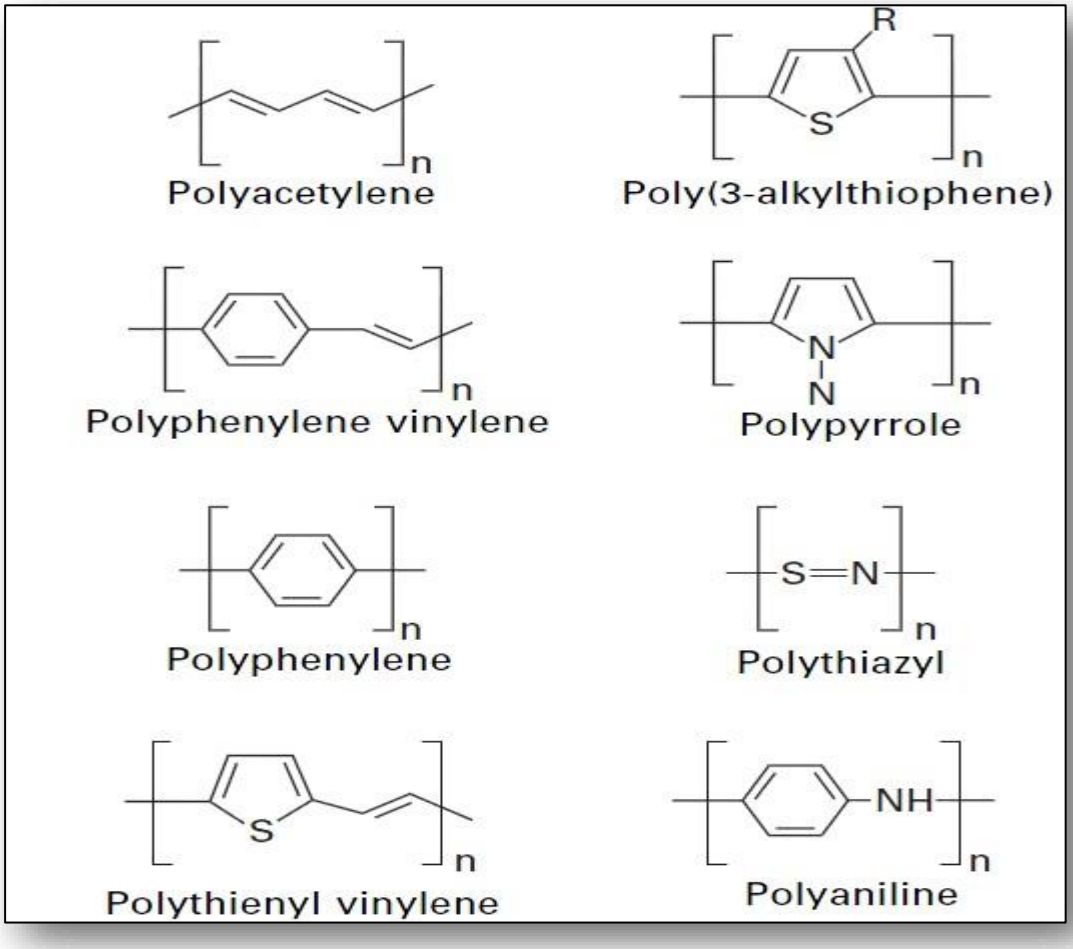


Fig: 1

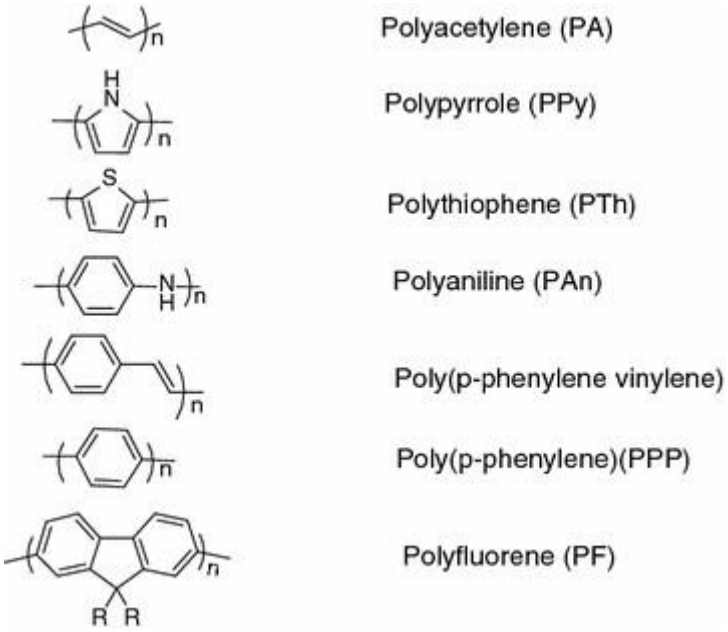


Fig : 2

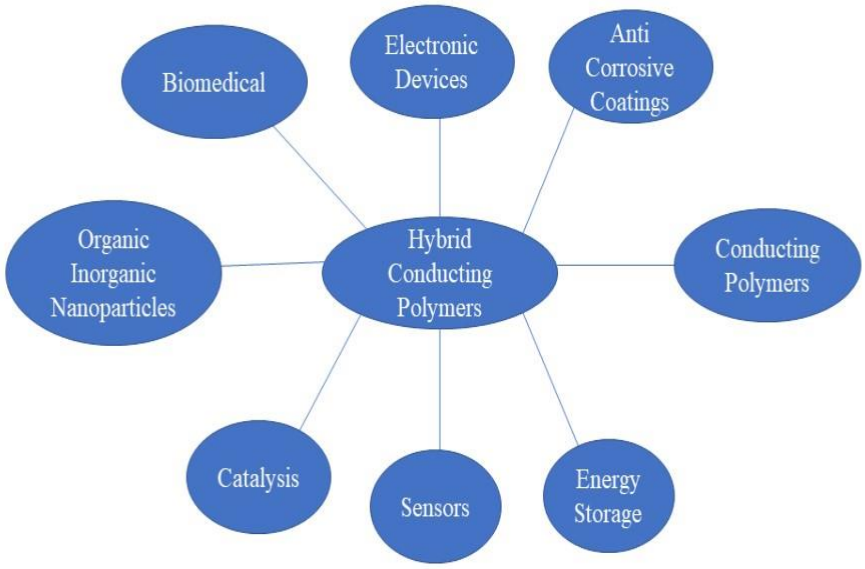


Fig: 3 (Applications of Hybrid Conducting Polymers) PROPERTIES OF CONDUCTING POLYMERS

Conducting polymers exhibits the following properties: conduction, Magnetic wetting, mechanical, optical and microwave absorbing properties.

Some of these is as shown below:

- Conduction Property: The conductivity of polymers depends upon doping percentage. Its conjugation length polymer chains arrangement and the purity of its samples. Polymers produces electronic movement due to its molecular nature. The particles which create a powerful interacting among the charges on the chain attained as result of doping.

Factors affecting the conductivity are: o Density of charge carriers

- Their mobility o Direction
- Presence of doping materials

- Temperature

- Magnetic Property: Conducting polymers have extraordinary magnetic properties. They have technological applications. The magnetic characteristics of nano materials to be merge into polymer matrix, the transition metal oxide nano particles have great importance.
- Optical properties: As conducting polymers have great importance in nano photonic devices, we came to know about their optical properties.
- Mechanical properties: The conducting polymers offers useful information on charge carrying group and unpaired spins, so we get to know about their magnetic properties.
- Microwave absorbing properties: Conducting polymers have lower density, low cost and simple processibility, they are found to show microwave absorbing properties.
- Wettability: For many materials, surface wettability is an important part. It is important to control surface wettability for many applications like self-cleaning windows, waterproof textiles, cookware coatings, optical instruments, etc. [3]

APPLICATIONS

- Supercapacitors: It will help in the voltage range of electrodes.
- Light emitting diodes: When positive and negative electron charge carriers are injected into the organic semiconductor metallic contacts made to opposite sides of the semiconductor films.
- Solar cells: it is used as donor layers, buffer layers and other polymer based nanostructures in binary or ternary devices to influence device performances.
- Electro-Magnetic shielding: The widespread use of communication devices causes a significant increase in EM waves in people's homes. This EM radiation generates the issue of EM Interference (EMI), which not only damages extremely sensitive electrical devices but also has a notable negative impact on human health for one's physical health. By deliberately constructing an EM shield, a specific level of attenuation is extended through the process of EMI shielding. [4–7]

SYNTHESIZING METHODS OF CONDUCTING POLYMERS

Conducting Polymers can be made by one of the following methods:

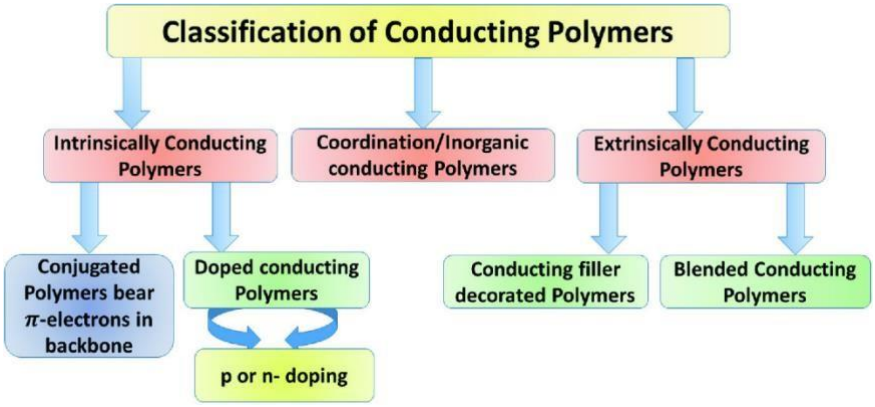
1. Chemical Methods: CPs are chemically synthesized by oxidation or reduction of monomers and polymerization of corresponding monomers. we can get an advantage of mass production at a reasonable price.
2. Electrochemical Method: The electrochemical synthesis is very important as it is cost-effective, simple, reproducible and we can have fabricated films of required thickness and uniformity.
3. Photochemical Method: These are the main procedures of finding polymers in industry and research laboratories. It is a quick and inexpensive method and not destructive to the surroundings. It is useful for the fabrication of some of the conducting polymers.
4. Metathesis Methods: Metathesis is the chemical reaction between two compounds that results in the interchange of one part of each

to form two different compounds. The process involves three categories: ring opening metathesis of cyclo-olefins; metathesis of alkynes, acyclic or cyclic; and metathesis of diolefins.

5. Concentrated Emulsion Method: This method is a hetero phase polymerization procedure which has three segments: water segment, latex particle segment and the monomer droplet segment. The main mechanism in it is a radical polymerization.
6. Inclusion Method: This process manufactures composite materials at atomic or molecular level. So, we can process low dimensionality composite materials with great potential.
7. Solid State Method: It is a procedure in which we lengthen the polymer chain by heat in lack of oxygen and water. We use vacuum or removal with an inert gas to push away the byproducts of the reactions. It enhances mechanical and rheological properties of polymers.
8. Plasma Polymerization: In this method, we prepare thin films from organic and organometallic materials. The films synthesized by this method are pinhole free and highly cross linked, and so they are insoluble, thermally stable, chemically inert and mechanically strong.
9. Pyrolysis Method: It is the chemical decay of organic materials by heating at elevated temperatures. It is used in detection of organic

polymeric substances in plastic and rubber production, dentistry, etc. [8]

CLASSIFICATION OF CONDUCTING POLYMERS



1. Intrinsically conducting polymers
• Conducting polymers having conjugation
• Doped conducting polymers

2. Extrinsically conducting polymers
• Conducting element filled polymers
• Blended conducting polymers

- Intrinsically conducting polymers: The conduction of electricity in this type of polymers is due to conjugation in the backbone of the polymers. The conjugation can be due to either pi-electrons or due to doped ingredients. These polymers are of two types:

o Intrinsic polymers with conjugation: In these types of polymers, due to the presence of double bonds and lone pair of electrons, conduction of electricity takes place.
1. Polyacetylene 2. Polyaniline 3. Poly pyrrole
o Doped conducting polymer: The conjugated polymers which increases the conductance by introducing the (+) charge or (-) charge on its backbone by oxidation or reduction are called doped conducting polymers. The doping process are of two types: 1. P-doping: The polymers are treated with oxidising agents (like Lewis acids or halogens), which oxidises the polymers are creates positively charged sites on polymer backbone, they are acting as good conductors of electricity. It is called p-doping or oxidative doping.
Examples for p-dopants- I_2, Br_2, $AlCl_3$, AsF_5, etc.
2. N-doping: The polymers are treated with reducing agents (like Lewis bases or Alkali metals), which reduces the polymers are creates negatively charged sites on polymer backbone, they are acting as good conductors of electricity. It is called n-doping or Reductive doping.
Examples for n-dopants- Na, K, Lithium naphthalides.

- Extrinsically conducting polymers: These are conducting polymers whose conductivity is due to the presence of external ingredients added to them.

1. Conductive element filled polymers: Here, the polymers are filled with conducting elements such as carbon black, metal oxides, etc. In this, polymers act as the binder to hold the conducting elements together in the solid entity. They are low cost, light in weight, durable and strong. Example-polyacetylene

2. Blended conducting polymer: These polymers are obtained by blending a conducting polymer with the conventional polymers(insulators). These polymers have better physical, chemical and mechanical properties and can be easily processed.

Example- Polyaniline (PANI)

CONCLUSION

This review article describes different types of conducting polymers, synthesizing methods and their applications in various

fields. To realize the importance of conducting polymers, it is very important to increase their processibility, environmental and thermal studies.

REFERENCES

[1] R. Gangopadhyay, A. De, Chemistry of Materials 12 (2000) 608–622.
[2] C.S. Park, C. Lee, O.S. Kwon, Polymers (Basel) 8 (2016).
[3] E. Sezer, F:\1-New Folder Structure\2-Pagination\Els-UK\NOC\Latex-I045052\CH04I045052.Dvi, 2007.

[4] G. Wang, L. Zhang, J. Zhang, Chem Soc Rev 41 (2012) 797–828.
[5] A.C. Grimsdale, K.L. Chan, R.E. Martin, P.G. Jokisz, A.B. Holmes, Chem Rev 109 (2009) 897– 1091.
[6] C.J. Brabec, N.S. Sariciftci, J.C. Hummelen, Plastic Solar Cells**, n.d.
[7] M.K. Vyas, A. Chandra, ACS Appl Mater Interfaces 8 (2016) 18450–18461.
[8] R. Kumar Babasaheb Bhimrao, R. Kumar, S. Singh, B.C. Yadav, D. Nagar, International Advanced Research Journal in Science, Engineering and Technology 2 (2015).