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# Critical Review on Conducting and Nanocomposite Polymeric Membranes for Water Purification

**Monika and Karunendra Singh***

**Amity Institute of Applied Sciences, Applied Chemistry; Amity University, Noida, Uttar Pradesh, India 201307*

**Abstract—***Today the warning by various global agencies related to shortage of safe drinking water around the various parts of world may a serious issue among the society. There is a need to develop reliable and cost effective techniques for water purification for removing toxic metals like lead chromium, mercury, zinc, copper, nickel metals and their oxides because of chronic disorders like breakdown of the immune system, coughing, headaches, hair loss, damage to the nervous system, damage of central nervous system, failure of kidney and brain and sometime it may leads to death. Even the toxic metals may responsible for abnormality in cell growth which causing cancer. There are various membranes are reported like porous inorganic capillary, dense perovskite, ionic liquid, polymer and nanocomposite (i.e. conducting polymer with metal and metal oxides) membranes for the removal of toxic metals. Out of various membranes conducting polymer with various metals , metal oxides, carbon nano tubes (CNT) and graphene oxide (GO) based membranes attracted more because of the unique properties such as stability, electrical conductivity, mechanical properties, electrorheological properties, etc. The piece of work focused on the synthesized various conducting polymer based membranes and their investigation techniques by means of SEM, FTIR and XRD .*

**Keywords***: Conducting polymer,CNT, SEM, FTIR and XRD.*

## 1. INTRODUCTION

The warning issued by the world health organization (WHO) about the shortage of safe drinking water and the increased the cases of water diseases related to water is one of the serious issue . The presence of toxic metals like lead chromium, mercury, zinc, copper, nickel metals and their oxides because of chronic disorders like breakdown of the immune system, coughing, headaches, hair loss, damage to the nervous system, damage of central nervous system, failure of kidney and brain and sometime it may leads to death. Even the toxic metals may responsible for abnormality in cell growth which causing cancer.[1] he researchers find out the easiest way to get pure drinking water by various methods like chemical method (lime and soda , zeolite , ion exchange process) membranes (semi permeable membranes ) of metals and polymers. The development of membrane is the cost effective method to remove toxic metals and impurities from water. But the membranes have some limitations to filter the particular size of impurities and other conditions like the amount of dissolved solids and especially organic impurities like oil and fatty acids may affects the membranes. The polymer science plays and important role in the manufacturing sector by making innovative materials for the mankind specially the membranes. There are various membranes are reported like porous inorganic capillary, dense perovskite, ionic liquid, polymer and nanocomposite (i.e. conducting polymer with metal and metal oxides) membranes for the removal of toxic metals. Out of various membranes conducting polymer with various metals , metal oxides, carbon nano tubes (CNT) and graphene oxide (GO) based membranes attracted more because of the unique properties such as stability, electrical conductivity, mechanical properties, electrorheological properties, etc. The conducting polymers i.e polypyrrole, poly(p-phenylene), poly(phenylacetylene), poly(p-phenylenesulphide), polythiophene, polyfuran, polyaniline, polyisothianaphthene and their derivatives plays an important role in the membrane synthesis as compared to the conventional synthesis because these materials consolidate with the electrical switching properties with light weight, workability etc.

## 2. MEMBRANES

Membrane is a thin layer of organic and inorganic material that separate substances when a driving force is applied across the membrane. It can be used to remove not only the toxic metal and metal oxides but may also be used to remove biological impurities like bacteria, microorganisms etc. There are various important advantages are there for utilizing the membrane technology in industries as well as household such as no phase changes, easy to scale up, simple in operation, no or very less energy required, low cost, required less space etc. [2] The simple polymeric membrane have limits of a trade-off relationship between selectivity and permeability, and also low anti-fouling property [3] There are various membranes are reported like porous inorganic capillary, dense perovskite, ionic liquid, polymer and nanocomposite (i.e. conducting polymer with metal and metal oxides) membranes for the removal of toxic metals. Out of various membranes conducting polymer with various metals , metal oxides, carbon nano tubes (CNT) and graphene oxide (GO) based membranes attracted more because of the unique properties such as stability, electrical conductivity, mechanical properties, electrorheological properties, etc.

## 3. CONDUCTING POLYMER

Conducting polymers are the third group of candidate materials for supercapacitors due to their good electrical conductivity [4-6] large pseudo capacitance [7-8] and relatively low cost.

There are two types of conducting polymer.

**Intrinsic conjugated polymer**

In this type of conducting polymer, conduction of the electricity is due the conjugation in the backbone of the polymeric chain and this conjugation is because of either pi electrons or the dopant. Intrinsic conducting polymer can be classified into two types

a) **Conjugated conducting polymer:** In the conjugated conducting polymer, conduction is because of the presence of the pi electrons in their backbone. There creates valence and conduction bands all through the backbone of the polymer due to its overlapping of conjugated pi electrons. Conduction takes place after the attaining the required activation energy by thermally and photo chemically

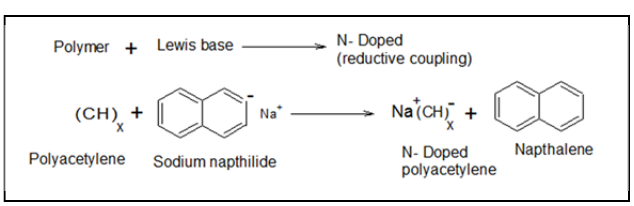
b) **Doped conducting polymer**

I. **P- Doping:** when the conjugated polymer is treated with electron deficient species (lewis acid) like $FeCl_3$ or $I_2$ vapour, there takes place oxidation and the positive charge is created in the molecule. Removal of one electron fron the pi backbone of the conjugated polymer which forms a radical cation (polaron), and on removal of second electron forms bipolaron.

Polymer + Lewis Acid ⟶ P-doped polymer (Oxidative coupling)

$(CH)_x + 3\ I_2 \longrightarrow 2(CH)^+_x\ I_3^-$ Polyacetylene

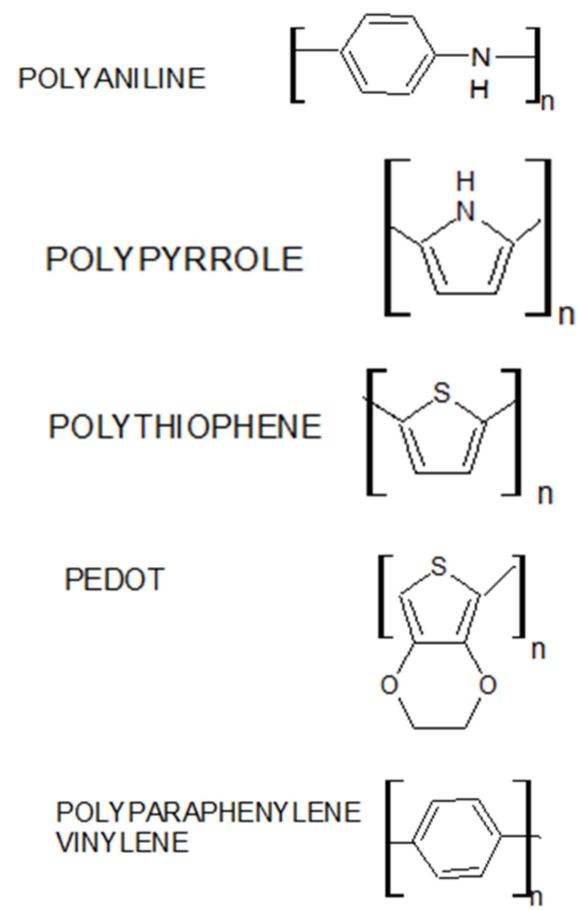
II. **N-Doping:** when the conjugated polymer is treated with the electron rich species (lewis bases) due to the reduction of the polymer (negative charge develops). In bi-polaron, conduction takes place due to the delocalization of the charge.




**Extrinsically conducting polymers:**

The conductivity of these polymers is due to the addition of external ingredients. When carbon black or some metal oxides or metallic fibers are added, the polymer becomes conductive. The minimum concentration of the element required for the conductivity is called percolation threshold. The filler (ingredients) that percolate have more surface area, more porosity and filamentous nature due to which they can enhance the conducting properties. eg; polyphony-lenevinylene, polyacetylene , polythiophene.

Examples of few conducting polymer with their structures:




## 4. NANOCOMPOSITES BASED MEMBRANES

Polymeric nanocomposite membranes are prepared by mixing of nano-sized fillers and polymer matrix to enhance performances such as high permselectivity, fluxes, favorable surface morphology as a result of excellent fouling resistance compared with the pure polymeric matrix membranes [9,10] Many polymers membranes have been reported till date by using nanomaterial and the polymers including Polyvinylidene fluoride (PVDF), polyether-sulfone (PES), polysulfone (PSF), polyvinyl alcohol (PVA), and polyacrylonitrile (PAN) [11,12]

There are two types of lamellar nanocom-posites:

a) **Intercalated polymer nanocomposites:** In the intercalated polymer nanocomposites, there are alternating polymer chains with the inorganic layers in a fixed compositional ratio and have a well defined number of polymer layers in the intralamellar spaces shown in the below figure

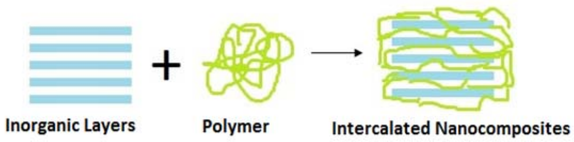



**Fig. 1: Intercalated polymer nanocomposites**

b) **Exfoliated polymer nanocomposites** In exfoliated nanocomposites the number of polymer chains between the layers is almost continuously variable and the layers stand >100 Å apart.

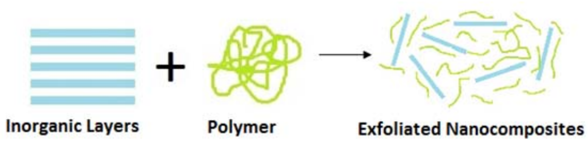



**Fig. 2: Exfoliated polymer nanocomposites**

The intercalated nanocomposites behave like compound because of stoichiometric polymer-layer ratio. This makes them interesting for their electronic and charge transport properties. On the other hand, exfoliated naocomposites have superior mechanical properties.

**Polymer-CNT:**

The incorporation of carbon nanotubes (SWCNT& MWCNT) with polymeric membranes have received widespread interests in construction of new composite membranes for water treatment application because of its good mechanical strength and chemical inertness due to its high specific surface area outstanding water- transport property. [13,14]

**Polymer-Graphene:**

Graphene oxide (GO) has wide application especially in the synthesis of membranes. The incorporation of GO within the polymer matrix not only improves its physical and chemical properties [15,16] but also improves the conductivity of polymer electrolyte membranes and reduce biofouling on the membranes .

## 5. CHARACTERIZATION AND TESTING TECHNIQUES:

The polymeric nanomaterial based membranes have various parameters like hydrophobicity, morphology and the nature of the membrane analytical methods are available. The mechanical strength of the polymeric nanocomposite membrane can be tested by a tensile tester. The structural studies of the resulting polymeric nanocomposite membrane can be carried out by using Fourier-transform infrared spectroscopy (FTIR). The hydrophobicity of the prepared polymeric nanocomposite membrane can be measured by using the sessile drop method by a goniometer. The X-ray diffraction (XRD) and Scanning Electron Microscopy (SEM) preferred to analysis of the morphology and nanostructure of the membrane.

## 6. CONCLUSION

The minimizing the risk of toxic metals from drinking water is possible at reasonable cost and cut down the risk of many diseases. The research in the development of polymeric nanocomposite membrane is quite interesting but still need further research because of few limitations. The manipulation of the polymeric membrane by using various nanomaterials specially graphene oxide and perovskite are the future based membranes.

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