

Polypyrrolenano-Composites For Sensing Application

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Abstract:

Syntheses of conducting polypyrrole (PPYs) based composites prepared with various methods like chemical, electrochemical and plasma polymerization have been discussed in this review. Different-different fillers in the polypyrrole matrix which are responsible for the improvement of PPYs properties for sensing application have also been discussed in detail.

Keywords: Polypyrrole, Composites, Sensor, Application

1.Introduction

Conducting polymers, opening with polyacetylene (PA), is well known polymer to allow electric current through their conjugated backbone when doped with proper dopant. This conjugated polymer was discovered in the year of 1977 by well-known scientists Shirakawa, Mac Diarmid and Heeger, later on got nobel prize in 2001 for this invention [1]. After the discovery of first conducting polymer polyacetylene many other conducting polymers have been discovered namely polythiophene (PTh), polypyrrole (PPy) and polyaniline (PANI)[2]. The conductivity of these conducting polymers is due to the presence of conjugation in their structure which helps for the transportation of charge carriers [3]. Along with electrical conductivity the other properties like magnetic, mechanical, optical properties are also very important for other applications in the field of sensors, fuel cells, supercapacitors, and electromagnetic interference (EMI) shielding etc. [4]. Among all these conjugated polymers

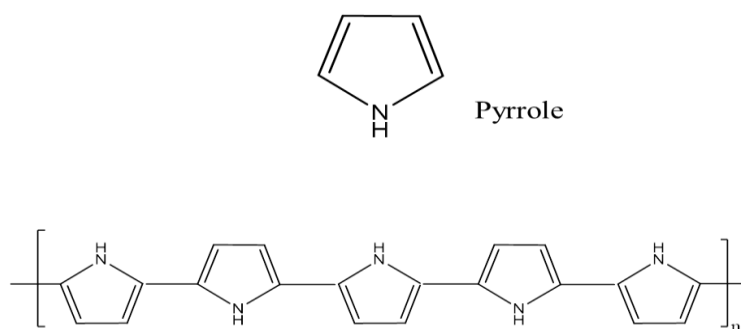


Fig.1: Chemical structures of pyrrole and polypyrrole.

Polypyrrole (**Fig.1**) is one such conducting polymer that nowadays is being used in electronic devices and sensors. The wide interest of scientific community especially in polypyrrole is due to its ease of synthesis, stability, good processing and low cost [3]. Various methods have been used for the synthesis of this polymer like chemical, electrochemical polymerization and plasma polymerization. Electro-polymerization and plasma polymerization methods are expensive for the preparation of polypyrrole. However, chemical oxidative polymerization method is easy to handle, low cost and processability is good so this is the wide use method. The properties of polypyrrole can be improved further by adding suitable filler in its matrix. These fillers can be TiO_2 , CNT and Ag-NiO etc which can improve their properties[5].

In this review paper, we have reported the various methods for the preparation of polypyrrole based composites. Emphases have also been given on the use of these composites in the field of sensing application.

2.0 Methods

2.1 In situ chemical oxidative polymerization method

S.G. Bachhav *et al* considered it to be an appropriate method for the preparation of polymer composite as it allows grafting of polymer on the surface of carbon nanotube (CNT) and hence better interaction and dispersion[6]. According to Anil Kumar *et al* to prepare polymer composite, this method is suitable as good amount of CNT can be easily incorporated into the matrix by the formation of strong bonds. This method involves the addition of oxidizing agent like APS to the solution to allow polymerization[2]. CNTs due to their properties like good thermal, electrical and mechanical properties are appropriate to be used as fillers for the synthesis of polymer nano-composites. The synthesized nano-composites have various applications such as solar cells, fuel cells, super capacitors etc.[6].

2.2 Electrochemical polymerization method

This method involves the use of two or three electrode cells. Two electrode cell comprises of a working and a counter electrode whereas three electrode cell comprises of a working, counter and reference electrode (Ag/AgCl or calomel electrode)[7]. It does not involve the use of any oxidant or surfactant[2]. Potentiostatic, galvanostatic and potentiodynamic methods are used in the electrochemical synthesis of polymer composite having applications in transistors and rechargeable batteries[8].

3.0 Polypyrrole composites

3.1 PPy/TiO₂ Composite

Pi Gueyet *al* have reported composites thin film of titanium dioxide nanoparticles with polypyrrole(TiO₂/PPy) on alumina substrate prepared through in situ photopolymerization method. The fabricated sensor with these composites films used 0.0012g of TiO₂ depicted the least hysteresis and premier sensitivity. Along with sensing they also determined the effect of response, long term stability, and applied frequency. [9].The route for the fabrication of sensor has been shown in **Fig. 2**.

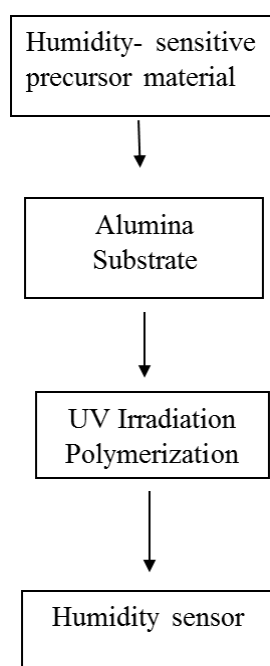


Fig.2: Schematic representation for the manufacture of humidity sensor.

3.2 PPy/CNTComposite

Sadrolhosseini *et al* have prepared PPy/MWCNT composite for sensing heavy metals like Fe (iron), Pb (lead) and Hg (mercury) in the aqueous solution. Surface plasmon resonance method was used by this group for the modification of gold layer. They found that the accuracy of the sensor and sensitivity were improved for ions (in aqueous solution) because of the bonding of Pb, Hg, and Fe. The fabricated sensor was restricted for the concentration about 0.1 parts per million which leads to the shift (0.3° to 0.6°)[10].

3.3 PPy/Ag-NiO Composite

Ramesan *et al* have reported nano-composites of PPy/Ag-NiO prepared with in situ polymerization method. They have used different- different percentage of filler (Ag-NiO nanoparticle) in the matrix of polypyrrole. They have been found that the sensitivity of the prepared composites has higher sensitivity for the ammonia gas as compared to the polypyrrole.[11].

4.0 Applications

According to Navaleet *al* there was a need for a gas sensor to detect harmful gases like NO₂ below its threshold value of 25ppm. Therefore they synthesized PPy thin film based sensor for the detection of NO₂. It was reported that the gas sensor was more selective towards NO₂ gas and exhibited higher response (36%) towards it[12]. According to Cui *et al* a conducting polymer is suitable to be used in gas sensor due to its high sensitivity, reliability. Therefore they formed PPy/TiO₂ based gas sensor. The sensor displayed good sensitivity to various gases even at low concentration (10ppm) and it was also selective towards NH₃[13]. Humidity sensor synthesized by Pi Gueyet *al* also showed good stability, good sensitivity and good performance[9]. PPy/MWCNT based sensor showed better detection of Hg ion over Pb and Fe ions having detection limit of 0.1ppm[10].

5Conclusions

It concluded that polypyrrole is a good choice of conducting polymer owing to its properties like good electric properties, ease of synthesis, stability and many more and these properties can be further improved by the addition of appropriate fillers to it like TiO₂, CNT and NiO. The synthesized composite thus can have application to be used as sensor for the detection of gases like NH₃, NO₂ and heavy metal ions like Hg, Pb and Fe.

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