SYNTHESIS AND GAS SENSING APPLICATION OF CONDUCTING POLYMER-POLYTHIOPHENE NANOCOMPOSITE

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ABSTRACT

Conducting polymer- polythiophene nano composites are mainly synthesized by oxidative polymerization method. It is very simple method by using oxidizing agent at room temperature. The nanoparticles of metal oxides will be synthesized using chemical method. The nanocomposites of polymer-metal oxides will be prepared. The composite show advanced properties for different applications such as solar cell, gas sensor, supercapacitor, transistors, Light Emitting Diode (LED), Radar application, etc .

Keywords: conducting polymer; composite; polythiophene; sensor

I. INTRODUCTION

Polymer consists of large molecules composed of many repeated subunits. Because of their broad range of properties, both synthetic and natural polymer plays an essential role in everyday life. The first conducting polymer is flexible like plastic, but post conductivity in 1977 by three scientists Dhirakawa, Heeger and MacDiarmid. Conducting polymer is a chain of conjugated molecule which consists of sigma bonding to maintain the conductive form of polymer structure. The conducting polymer based on heterocycles such as polythiophene (PTh), polyaniline, polypyrrole etc. PTh is a linear chain of thiophene. PTh derivative is developed by two scientists at Bayer AG research laboratories in Germany in 1980. Polythiophene are recognized by awarding of 2000 Nobel Prize in chemistry to Alan J, Heeger and Hideki Shirakawa. PTh can become conducting when electron is added or removes from the pi conjugated orbital via doping. The molecular formula for thiophene is C_4H_4S. PTh is double bond which are sigma and pie bond [1]. PTh is useful for electrical and physical properties such as solubility, electro-chromic, electrical conductivity, mobility and so on. They also possess lower band gap and better electronic properties such as increased ionization potential and stability. PTh do not possess metallic type conductivity even in doped state. They are commonly used in organic semiconductor. PTh suffer from low conversion, low monomer reactivity, insolubility in common solvent and infusibility [2]. PTh has unique properties such as polymerization, low production cost, large pi conjugated structure, flexibility, high conductivity, ease of doping and good environmental and thermal stability in both doped and undoped states. The conductivity of pure PTh like other conducting polymer is low ($<10^{-5}$ scm^{-10}).

Nanocomposite consists of a polymer having nanoparticles or nanofillers dispered in polymer matrix. It is multiphase solid materials where one, two or three dimensions of less than 100 nanometer or structures having nanoscale or structure having nanometer repeat distances between the different phases that make up the material.The idea behind nanocomposite is use to building block with dimensions in nanometer range to design and create new material. There are three major classifications of nanocomposites such as Ceramic matrix nanocomposite, metal matrix nanocomposite, Polymer matrix nanocomposite[3].There are many application in PTh such as supercapacitors, organic semiconductors, good luminescent, nonlinear optics devices, polymer LED's or smart windows,photoresists,antistatic coating, sensors, batteries, solar cells, electrodes, transistors, printing wire panels and so on [4].

This review deals with the synthesis of conducting polymer-polythiophene nanocomposite and its application as gas sensing.

II. SYNTHESIS METHODS OF CONDUCTING POLYMER

There are many methods of conducting polymer as follow

1) Chemical method
2) Electrochemical method
3) Photochemical method
4) Methathesis method
5) Concentrated emulsion method
6) Inclusion method
7) Solid state method
8) Plasma polymerization method
9) Pyrolysis method

1) Chemical method

Conducting polymer is synthesized by polymerization method like chain or step growth polymerization. It is versatile techniques for preparing large amount of conducting polymer. Chemical polymerization method is the process in which relatively small molecule called monomer combine chemically to produce a very large chain like or network molecule, i.e. it is synthesized chemically by oxidation or reduction of monomer and polymerization of corresponding monomer. There are many advantages such as chance of mass production at reasonable price and so on. There are many unique physical properties such as elasticity, high tensile strength or ability to form fibers that differentiate polymer from substance composed of small molecule [5].

2) Electrochemical method

Electro-polymerization is a standard oxidative method for preparing electrically conducting conjugated polymer. Electrochemical polymerization method are performed in a single compartments cell containing electrochemical bath which is monomer and supporting electrolytic dissolved in perfect solvent. Electro synthesis can be three ways;

a) Potent static (constant potential method).
b) Galvanostatic (current method)
c) Potentiodynamic (potential scanning or cyclic voltametric method)

This method is used three electrode cell which are working electrode, reference electrode, and counter electrode. Working electrode used material such as gold, copper, nickel etc. And also used semiconducting material such as no doped silicon, gallium etc [6].

3) Methathesis method

Methathesis is defined as chemical reaction between those two components that result in the interchange of one part of each to form the two different components. It is divided into three categories

A) ring -opening methathesis of cyclo-olefins.
B) Methathesis of alkynes, a cyclic.
C) Methathesis of diolefins [7].

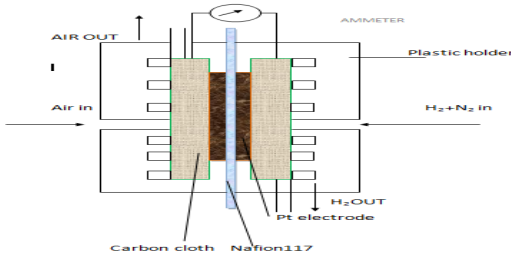

Figure 1: Methathesis method setup

4) Concentrated Emulsion method

It is a heterophase polymerization procedure. There is three segment classified such as water segment, latex particle segment and monomer droplet segment. It is used in radical polymerization. The method with one segment present in arrangement is bulk and solution polymerization where the monomer as solvent and initiator are in identical segment. The synthesized polymer remains soluble either in the monomer or solvent until high modification. This method contains a micelle forming surfactant, a water soluble initiator in a mixture of water insoluble monomer. The emulsion polymerization is a misnomer, the initial point is an emulsion of monomer droplets in water then the manufactured product is a distribution of latex particles [8].

5) Inclusion method

Inclusion polymerization method is generally manufactures of composite material at the atomic or molecular level. This kind of polymerization can unlock the path to unique low dimensionality composite materials with enormous potential .The inclusion of an electro conductive polymer might fabricate a molecular

wire .On the basis of inclusion composite of polymer with organic hosts is synthesis [9].

6) Solid state method

Solid state polymerization is a procedure in which the polymer chain length are enlarged by heat in lack of oxygen and water either by the vacuum or removal with an inert gas to push away by the product of reactions. The reactions controlled by temperature, pressure and the diffusion of by product from the core of the pellet to the shell. It is the key move used after melt polymerization for the intension of enhancing the mechanical and rheological properties of polymer prior to injection blow molding. This method useful in industrial production of bottle grade PET, films and advanced industrial fibers [10].

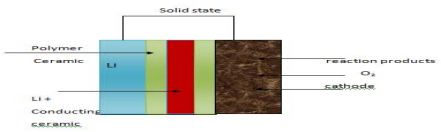

Figure 2: solid state method setup

6) Plasma polymerization method

It is a novel process to manufacture thin film from the group of organic and organ metallic preliminary materials .plasma polymerized films are pinhole free and highly cross linked and are insoluble thermally stable, chemically inert and mechanically strong. This film is extremely coherent and adherent to a range of substrates compressing conventional polymer, glass and metal surface. It is used as perms elective membranes, protective shells, biomedical material, and electronic optical device and adhesion supporters [11].

8) Pyrolysis method

It is described as the chemical decay of organic material by heating to elevated temperature. It has established as a precious process for the investigation and detection of organic polymeric substance in the plastic and the rubber production, density, ecological shelter [12].

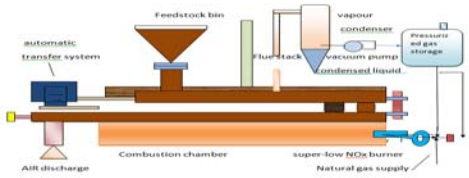

Figure 3: pyrolysis method setup

III Applications

There are many applications in PTh such as PLED, organic semiconductors, good luminescent, polymer LED, printing wire pannels, magnetic recording, quantum electronic devices, photodiodes, memory devices and so on.

1) Supercapacitor

Electrochemical Double Layer Capacitors (EDLCs) also called super capacitor (SC).super capacitor is electrochemical capacitors that have high capacitance and high energy density. The electrode materials for SC are three categories such as transition metal oxides, high-surface carbons and conducting polymer. The SC store energy by means of a static charge as opposed to an electrochemical reaction. Applying a voltage differential on the positive and negative plates charges the capacitor. There are many benefits based on CP such as superior capacitive energy density, low material cost, superior electrical conductivity, better pseudo-capacitance [13]. The diagram is as follow

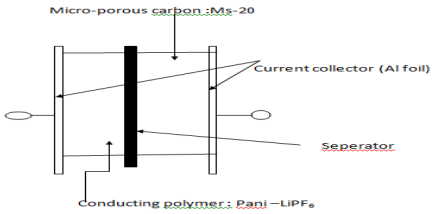

Figure 4: view of super capacitor

2) Transistors and data storage

It is application in electronics as FET and for charge storage. FET device poly (3, 4-ethylene dioxythiophene) working as the source/grain/gate electrode material and poly pyrrole acting as the semiconducting layer. Poly (vinyl pyrrolidine) K60 (PVPK60), an insulating polymer, operates as the dielectric layer. High sensitivity of CPs can be attained by operating them as field effect transistor because of their ability to magnify in-situ and to gate

modulate channel conductance [14]. The figure as follow

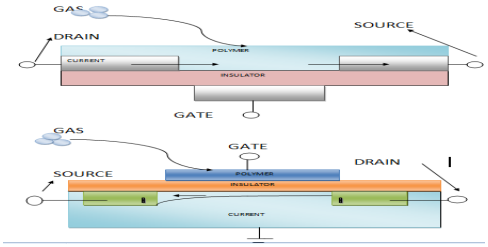

Figure 5: View of Field Effect transistors

3) Sensor:

The application of CPs in sensor technologies include as an electrode modification in order to enhance sensitivity, to impart selectivity, to suppress interference and to give a support matrix for sensing materials. There are as follow.

a) Gas sensor: It is useful to identify and evaluate concentration of gaseous pollutants. PANI, PPY, PTH is used a fabrication of gas sensor apparatus.

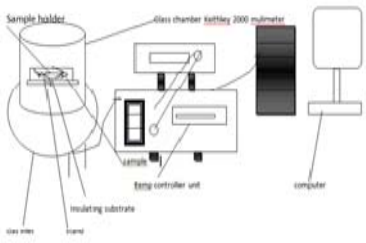

Figure 8: Gas sensing set up reprinted with permission [15]

b) Biosensor:

CP is used in chemical analysis for the detection of ion and molecule in liquid phase at the large scale. it is used as food investigation environmental control, clinical detection medicinal and farming industries etc [16].

c) Humidity sensor:

This sensor is competent for detection of relative humidity in different environments with respect to electrical, optical and other. The calculation and control **of humidity are crycial in several regions such as food and electronic industry, domestic, atmosphere; medical etc.humidity sensor is used as hydrophilic properties of Polymer, polymer composite, modified polymer [17].**

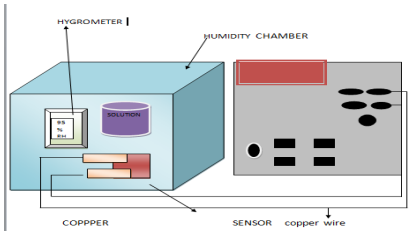

Fig 9: Diagram of humidity sensing set up

3) Radar application

Radio Detection and Ranging is an object detection method that utilizes radio waves to find the range of altitude, path and speed of object. It can be employed to identify aircraft, ships, spacecraft's, motor vehicles, weather formations and topography [18].

4) **Actuators**

Actuators is an device that is dependable for controlling a system and it is operated by a source of energy, electric current, hydraulic fluid pressure and changes that energy into action [19].

IV. CONCLUSION

In the present review, we summarized that the Conducting Polymer polythiophene nanocomposites are mainly synthesized by oxidative polymerization method. It is very simple method with using oxidizing agent at room temperature. The composite show advanced properties for different applications such as solar cell, gas sensor, super capacitor, transistors, Light Emitting Diode, Radar application etc. Therefore in our work we will oxidative polymerization method for polymer material synthesis.

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