International Journal of Recent Research in Physics and Chemical Sciences (IJRRPCS)
Vol. 1, Issue 1, pp: (24-28), Month: April - June 2014, Available at: www.paperpublications.org

SYNTHESIS AND CHARACTERIZATION OF CONDUCTING POLYMERS: A REVIEW PAPER

[1]TASSEW ALEMAYEHU, [2]BIRI HIMARIAM

[1, 2] College of Natural and Computational Sciences, Department Of Chemistry
Adigrat University, Adigrat, Ethiopia, P.O.Box 50

Abstract: **Polymers are long chains of repeating chemical units called monomers. They share several characteristics including macro and micro properties, electrical transport properties, semiconducting properties and optical properties. Polymers can be synthesized by chemical and electrochemical polymerization. Polymers prepared through these methods can also be characterized by their electrical, optical, mechanical and electrochemical means.**

Keywords: **Conducting polymers, Doping, polymerization.**

I. INTRODUCTION

Polymers are special class of organic compounds possessing high molecular weights. A polymer is built up of a large number of small molecules called monomers. A monomer is the low molecular weight substance which when redacted under suitable conditions links together to produce high molecular weight polymer. The some unit of two or three different units are repeated a number of times in a polymers. Conventionally polymers have been related with non-conducting properties and are applied as insulators of metallic conductors until the discovery of polyacetylene (PA) in 1977, which resulted in initiated projects in the field of conducting polymers [1].

Conducting polymers are conjugated polymers possessing an extended π - system and highly delocalized electronic states. This extended electron conjugation is what gives rise to their conductivity. However, unlike inorganic semiconductors (atomic solids), conducting polymers are typically amorphous polymeric materials and therefore charge transport in conducting polymers can be quite different from conventional semiconductors. The polymers themselves are not new; many of them such as polypyrrole are well known in their non conducting form before their conductivity was discovered. Indeed, it may be said that the discovery of conducting polymers is not the discovery of the polymer rather of its unique properties [2, 3].

Conducting polymer share several characteristics; including macro molecular character and electrical transport properties. All the case with poly acetylene is the simplest conducting polymer, in which the electrical transport characteristics are obtaining by placing the alternative carbon double bond structure direction on the back bone of polymer. [4].

Common conducting polymers are; Poly acethlyne, poly pyrrole, polythiophene and Poly3hexythio phone poly (3-hlinr dioxino phne).

II. OBJECTIVE

General objective

The main objective of this review is to study the synthesis and characterizing of conducting polymers.

Specific object

To attain the main aim of the study the specific objectives like; realizing synthesis of conducting polymers, identify the

origin of semi conducting behavior, understanding the application of conducting polymers and the characterization of conducting polymer.

The Origen Of Semi Conducting Polymers

Polymers have semi conducting properties due to their unique structural behavior such as formation alternating single and double bonds between the adjacent back bone carbon atoms. The semi conducting polymers have attracted considerable attention due to wide application. Since carbon atom is the main building blook of most polymers the type of bond that their Vance electrons make with other carbon atom or other element determines the overall electronic properties of the respective polymer. In general they can be categorized as saturated and unsaturated based on the number of the type of the carbon valance electron involved in the chemical bonding between consecutive carbon atoms along the main chain of polymer. Saturated polymers are insulator since all the four valence electron of carbon atom are used up in covalent bonds, whereas most conductive polymers have unsaturated conjugated structure. The fundamental single source of semi conducting property of conjugated polymer originates from the overlap of molecular orbital's formed by the valence electrons chemically bonded carbon atoms [3, 4].

Doping in conducting polymer

Since the discovery off much of new exciting chemistry and physics in the field of conducing polymers, it is possible to control the electrical conductivity of polymer over the range from insulating to highly conducting (metallic) state. This process is often referred to as "doping' the insulating natural polymer is converted in to an ionic complex consisting of polymeric cation, or anion and a counter ion which is the reduced from of oxidization agent. The oxidation or reduction of polymer can be achieved electro chemically by substituting the neutral polymer to the appropriating oxidizing or reducing voltage in an electro chemical cell [5, 6].

The research prioriles at plastics research laboratory postulating new structural properties of polymers made by oxidative coupling copper chloride and aluminum chloride were used to make aligo benzene from benzene. The reaction intended to include other aromatic compounds and hetro cycles. These reactive products were characterized in terms of thermo electric power [7].

Synthesis of Conducting Polymers

There are number of techniques used on conventional small molecules that are relant to the conjugation bond of conducting polymer. The key requirement in the synthesis of conducting polymers is that conjugated nature of monomers is conserved in the synthesis process. Furthermore, the development of novel monomers must be also target the appropriate functionality for polymerization. Polymerization can occur chemically or electrochemically [8].

Chemical Polymerization

The principle of oxidative polymerization does not mandate the use of electro chemical technique. For example poly 3-hexythiophene is well known and often studied conducting polymer that is almost universally synthesized chemically. When designing for chemical polymerization the key requirement is solubility. Successful polymerization to high molecular weight polymer be reactive and soluble to polymerization [8].

Electro chemical polymerization

Electro chemical polymerization offers at once a wide variety of parameters and complexities to the conducting polymer. The monomers solved and electrolyte is placed in to three electrodes cell the working electrode is controlled electrode and from surface for polymerization. The reference electrode offers potential by which measures the voltage at the working electrode. The counter or auxiliary electrode balance the circuit and enables the current to flow the electrolyte. Generally, the basic components of electro chemical polymerization are; [4].

Electrochemical Cell Set Up

Electro chemical process is normally carried out in single compartment electro chemical cell by adopting standard three electrodes configuration, typically electro chemical both consists of monomer and supporting electrolyte dissolved in appropriate solvent. Electro chemical process can be carried out either potentiostatically (constant voltage conditions) recommend obtaining thin films or galvanoststically (constant current condition) which are recommended to obtain thick films. A general set up foe electro chemical cell is given below [9].

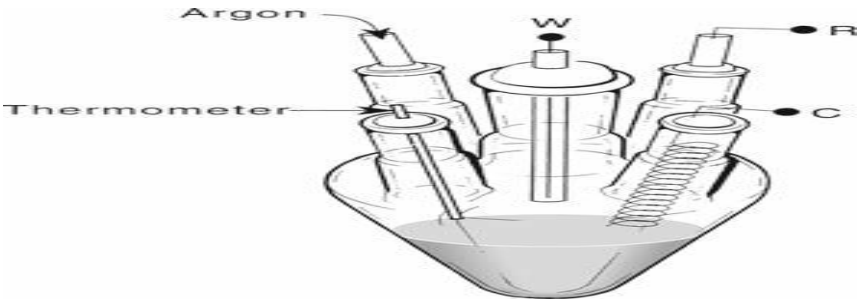

Figure 1 General Set –up for electro chemical cell [10]

Where,
W= working electrode R= reference electrode C= counter electrode

III. ELECTRODE MATERIALS

The three electrodes in electrochemical cell are;

A) Reference Electrode: In most electrochemical measurements, it is necessary to keep one of the electrodes in an electrochemical cell at a constant potential. This so-called reference electrode allows control of the potential of a working electrode (e.g. in voltammetry). A reference electrode must fulfill the following criteria: (i) it should be chemically and electrochemically reversible, (ii) the potential must remain almost constant when a small current passes through the electrode and (iii) the thermal coefficient of potential should be small. The commonly used reference electrode are aqueous Ag/AgCl or calomel half cells, which can be obtained commercially or easily prepared in the laboratory [10].

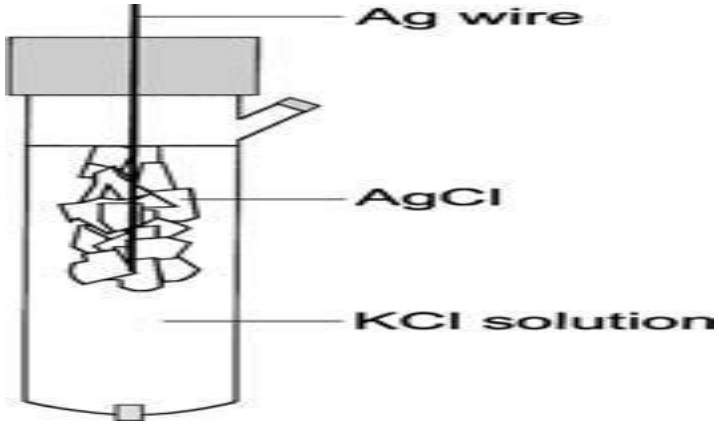

Figure 2 Typical construction of a silver/silver chloride reference electrode [11]

Compared to the calomel electrode, the silver/silver chloride reference system has the great advantage that measurements at elevated temperatures are possible. Special devices have been developed based on the silver/silver chloride reference systems for measurements in high-temperature aqueous solutions and under changing pressure conditions [11].

(B) Counter Electrode: non-reactive high surface area electrode, commonly platinum wire.

(C) Working Electrode: Electronic conductors used as electrodes are metals, rarely metal oxides, various forms of carbon and also rarely some polymers. In aqueous solutions, platinum and gold are used for electrode reactions with positive standard potentials, while mercury is useful for reactions with negative standard potentials. However, in non-aqueous aprotic media, under extremely dry conditions and in the absence of dissolved oxygen, these restrictions do not apply and the working windows are determined by the decomposition of supporting electrolytes or solvents [12].

Choice Of Monomer And Supporting Electrolyte

The compounds which possess relatively lower anodic oxidation potential and susceptible to electrophonic substitution reaction can produce conducting polymers by electrochemical technique. Aromatic in nature undergo electrophilic substitution reaction by maintain the aromatic structure monomers such as phenol which are otherwise difficult to polymerize get converted into polyphenene oxide by electro chemical process. [13].

The choice of supporting electrolyte depends up on the stability, degree of dissociation and nucluophilicty criteria. Limitation of migration is achieved by screening the electrode using a supporting electrolyte meaning a solution in which ions do not discharge themselves at the electrode in the experimental conditions. This electrolyte is added at high concentration to the sample and could be a simple salt, acid, base, or also a buffer solution or a chelating reagent. The supporting electrolyte surrounds the electrode with ions having the same charge with the depolarizing agent. An electrolyte is needed in order to provide electrical conductivity between the two electrodes. In principle, electrolytes can be used in all three physical states: solid, liquid, and gas [11].

Attractive features

The electro chemical polymerization technique has several attractive features mentioned as follows: Supporting electrolyte used in electro chemical polymerization serves two purpose .i.e it make electrolyte both solutions conducting and anions for use as do pant ions becomes available in electro chemical polymerization if we selected the appropriate electrolyte . this is the most important feature of this technique and the most salient feature of electro chemical polymerization, is that polymerization, doping and processing take place simultaneously while in conventional method , first polymer synthesis is carried out which is subsequently followed by doping and process [13].

Characterization of Conducting Polymer

Conducting polymers can be characterized by electrical, mechanical and electrochemical characterization. Electrical conductivity in polymer is the focus of numerous books. Conductivity polymers are more favorable due relatively low densities thus, for a given current caring application conducting polymers of the offer low cost weight solution. The mechanical characterization behavior of conducting polymer does not differ significantly from most polymers. Through the apparent cross linking that complicated traditional characterization methods also confound the observation of mechanical compounds properties. Electro chemical characterization of conductivity of conducting polymers consists of wide battery test applied to conducting polymer. Cyclic voltammeter is often used to assess the basic transport array of time constants to much process including electrochemical behavior [14].

Application

Conducting polymers (CPs) have been used for many applications due to their chemical, mechanical, optical and electrical properties. Their semiconductor properties allow conjugated polymers to be used particularly in large area, such as eletrochromic devices (EDC's), rechargeable batteries, light emitting diodes (LED's), field effective transistors (FET's), photovoltaic cells and chemical Sensors [15].Conjugated polymers are highly susceptible to the chemical or electrochemical oxidation or reduction. These after the electrical and optical properties of the polymer, and by controlling this oxidation and redaction it is possible to precisely control these properties. Since these reactions are often reversible, it is possible to systematically control the electrical and optical properties with a great deal of precision. It is even possible to switch from a conducting state to an insulating state. There are two main groups of Application for these polymers. The first group utilizes their conductivity as its main propriety. The second group utilizes the electro activity they are shown below [16]. The susceptibility of π-electrons of the conjugated polymers to oxidation or reduction alters the electrical, optical and electro optical properties of the polymers, since mostly the redox processes in the conjugated polymers are reversible. Therefore, the electrical and optical properties can be tuned systematically, with appreciable degree of precision by suitably controlling both the chemical or electrochemical oxidation and reduction. It is even possible to switch from a conducting to an insulating state and vice versa. Conducting polymers are thought to replace metals in future because they have superior Properties, such as ease of preparation, light weight and low-cost fabrication, to metals which are also toxic and hazardous to the environment [17].

IV. CONCLUSION AND RECOMMENDATION

Conclusion

From this review it can be concluded that, polymers are applicable in different ways for example solar energy cell sensors and corrosions in heritors and also polymers can be synthesized by differ techniques that is chemical and electro chemical polymerization and can be characterized by different techniques electrical, mechanical and elector chemical characterization and also polymer are doping with other field for example physics, due to this polymers it is more applicable.

Since conjugated polymers are highly susceptible to the chemical or electrochemical oxidation or reduction, it is possible to precisely control electrical and optical properties. It is even possible to switch from a conducting state to an insulating state.

Recommendation

From this point of view it is recommended to deal with these new chemical species through scientific research investigations because of their superior Properties, such as ease of preparation, light weight and low-cost fabrication, to metals which are also toxic and hazardous to the environment. This will signify to have cost effective and green source of electrical energy and to create hazardous free green environment for the future.

REFERENCES

[1] M.Phil. Anwar-ul-Haq Ali Shah, Electrochemical Synthesis and Spectroelectrochemical Characterization of Conducting Copolymers of Aniline and O-Aminophenol, 2007.

[2] R. B.kaner and G.M Alan, Scientific America introduction to polymers, 1988,page 60-65.

[3] S.Subianto, Electrochemical Synthesis of Melanin-like Polyindolequinone, Doctoral thesis in Applied Science, (2002).

[4] M.F Rubber,molecular electronics reaserch studies press,1992

[5] Proceeding of international Confernce on conducting polymers ,J, Phys C_3 ,1983

[6] W.D.Gill,J.C clark,G.B Appl.Phys. Commun,2,1982 21

[7] Luis Alcancer,conducting poliymer,D.Redel publishing campany 1987

[8] Shirkawa H; Louis E.J macdiarmid AG.Jcharge C.k Hegger A.J synthesis of counducting polymer,halogen derivative polyactlyene of ,chem.,soc,chem.,common 1977,16,page [9]. Baily G.C Swager T.M masked machel acceptors phenylence tehnylene for facial, conjugation macro molecule 2006,39 page 2815 -2818.

[9] sScholz, F. Electroanalytical Methods Guide to Experiments and Applications, 2nd Ed.; University of Greifswald, New York, 2009, p 57-330

[10] Michael,T. Standard Additions: Analytical Methodes Committee, 2009 p1-2

[11] Stephen, K. L. Electrochemistry, Chemical Reactions at an Electrode, Galvanic and Electrolytic Cells, Simon Fraser University, 2004

[12] A.K Diaze,J.K .Bargone in : J:A. sko thein (ed) hand book of counducting polymers ,marcel Dekker,New yark 1986 page 81

[13] A.F Diaze ,K.K .Kanazawa in :J.S miller (ed) extended linear chain compounds Vol,3,plenum press New yark 1982 page 417

[14] A.Arslan, Immobilization of Tyrosinase in Polypyrrole Copolymer Matrices Thesis on Masters of Science in Chemistry, (2006).

[15] WR Salanck D.T clark E.J smaull senscience and application of counducting polymers lopub lis 1991.

[16] M.Phil. Anwar-ul-Haq Ali Shah, Electrochemical Synthesis and Spectroelectrochemical Characterization of Conducting Copolymers of Aniline and O-Aminophenol, (2007).