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CONDUCTING POLYMER, DEFINITION, SYNTHESIS AND APPLICATION AN OVERVIEW

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Abstract:
Since their discovery, electrically conductive polymers have advanced tremendously because oxidizing and reducing chemicals cause insulating organic polymers to become significantly more conductive. The manuscript describes various conductive polymer(CPs) kinds, their characteristics, and manufacturing processes. It also briefly describes the primary applications. When large quantities of the polymer are required, chemical synthesis is ideal since it offers the most common commercial route to making electrically conductive polymers. However, the electrochemical structure has advantages. Because the conductive polymeric material is created at the anode when a positive voltage is given, it promotes purity and eliminates the need for oxidizers. The polymer is put on an electrode, however, which makes subsequent electrochemical analysis easier. This article seeks to outline key elements of the electrochemical synthesis of electrically conducting polymers in light of the current state of study in the field. The effectiveness of applying polymers in various industries greatly depends on how well their behavior and characteristics are understood. These polymers could be manufactured using chemical and electrochemical processes.

Keyword: conducting polymer, synthesis method, application

Introduction

Big molecules known as polymers could be connected together in a variety of ways to form a variety of micro-structures, such as linear chain, branched chain, densely interconnected network, etc. Polymers are very large molecules (macromolecules) composed of small molecules known as monomers. There are two distinct definitions for the word "conductive polymer. "The first and most well-known type (class I) consists of polymers packed with conductive elements like carbon fibers, copper foil, or other substances". the second definition refers to polymers whose backbone is in charge of charge carrier production and diffusion[1]. Conductive polymer compounds have a set of excellent properties, such as high specific strength, high temperature, high specific modulus, conductivity corrosion resistance, fatigue resistance and so on. This material can be used not only as a structural material for carrying loads, but also as a functional material[1].

Researchers studying smart substances are fascinated by the complex dynamic architectures of conducting polymers (CPs), like polyanilines, polythiophene, and polypyrrole. The use of electro catalysts has the potential to significantly alter the chemical, electrical, and mechanical characteristics of CPs. We can only aim to regulate these complex traits until we properly know both the nature of the processes that govern them during the production of conductive polymers and the extent to which such properties were influenced by the application of an electrical stimulus [1]. The aim of these article , It is the knowledge of the types of conductive polymers, the method of their manufacture and their multiple applications, because these polymers have many applications, especially in the field of solar cells

Types of conductive polymers

Polyacetylene, Polyaniline, and Polypyrrole were all researched among the various polymers recognized to be conductive. where we will discuss in this section, the structure, synthesis and applications of these polymers[2].

1. Polyacetylene

An organic polymer with a $(C_2H_2)_n$ repeating unit is called polyacetylene (PA). Initially conducting thorough research on acetylene's direct polymerization, Natta found that when acetylene gas bubbles were passed through a Ziegler catalyst solution in a hydrocarbon solvent, polyacetylene powder briefly precipitated. Red semi-crystalline Polyacetylene is fundamentally different from conventional covalent semiconductors since it could be doped at ambient temperature and using a number of doping techniques following synthesis [3].

2 Polypyrrole

Investigators are particularly interested in polypyrrole (PPy) because of its high conductivity, versatility in synthesis, stability, and outstanding mechanical characteristics. Electrolytic capacitor counter electrodes, sensors, electronic and electrochromic devices are some recent technical applications. Pyrrole monomer polymerizes easily to form a black 5 conducting powder. By oxidatively polymerizing the monomer using chemical oxidants in aqueous or nonaqueous solvents or by chemical vapour deposition, polypyrrole (PPy) can be produced in bulk as fine powders [4].

3. Polyaniline

Since its electrical conductivity may be controlled, polyaniline (PANI) is a significant conducting polymer which has received a great deal of attention. The phrase "aniline black," which was used to refer to any substance made from the oxidation of aniline, was first employed to refer to polyaniline in 1835. A few decades previously, Fritzches carried out an initial investigation of the by-products of the chemical oxidation of this aromatic amine. Later, Lethe found that a dark brown precipitate is the end result of aniline anodic oxidation at a platinum electrode in aqueous sulphuric acid solution. Electrochemical and chemical oxidation were used to create conducting polyaniline in aqueous 1.1 M oxalic acid containing 0.1M aniline. On an aluminum surface in H_2SO_4 electrolytes, different modes of polyaniline electrochemical synthesis are possible [4].

Fabrication Methods of (CPS)

You can create conducting polymers (CPs) by employing any of the following techniques:

1 Chemical method

By oxidizing or decreasing monomers and polymerizing matching monomers, CPs were chemically synthesised. Its potential for cost-effective mass production is one of its benefits. Numerous numerical investigations were carried out to boost the output and quality of the manufactured products generated utilizing the oxidative polymerization technique. Electrochemical techniques are not necessary when using the chemical route principles. For instance, the widely used and thoroughly studied CP poly (3-hexylthiophene) is almost always created chemically. PPy and PANI could be produced chemically, however electrochemical preparations typically result in materials with higher conductivity and mechanical characteristics. Following conjugation, the primary requirement for chemical polymerization seems to be stability. For oligomers and low- molecular-weight polymers to polymerize into high-molecular-weight polymers, they should be reactive and soluble sufficiently. Even as concentrations of the monomer and reactive polymer declines, the likelihood that an oligomer would precipitate out of solution and cause polymerization to progress heterogeneously increases. An unsuccessful chemical polymerization should stop before the entanglement molecular weight is attained, leaving the reaction vessel walls with a mechanically unstable covering. Chemical polymerization, though, necessitates a precise choice of oxidant to generate cation in a suitably soluble solution [5].

2 Electrochemical method

Due to its simplicity, low cost, ability to be carried out in a single section glass cell, repeatability, and ability to generate films with the required thickness and homogeneity, the electrochemical synthesis of CPs is one of the established methods of synthesis that is extremely important. Anodic oxidation of appropriate electroactive functional monomers is the electrochemical process that is most commonly used to make ECPs; cathodic reduction is significantly less commonly used. As a consequence of oxidation, a polymer layer is simultaneously synthesized, and counter ions are doped. The likelihood of monomer oxidation leading to polymerization is frequently higher than the likelihood of oligomeric intermediate being charged with polymerization. Using alternate chemical and electrochemical reaction stages, a more straightforward electropolymerization procedure was developed for electroactive monomers like pyrrole or thiophene [6].

3 Photochemical Method

Polymers are typically discovered in industrial and scientific research laboratories through chemical and ECP approaches. Although incompletely understood, photochemical preparation is believed to offer few benefits in the preceding two decapods since it is a quick, easy, and environmentally friendly process. Some CPs could be produced using the procedure. For instance, pyrrole was already properly polymerized to PPy by employing visible light as an appropriate electron acceptor or photosensitizer. Horseradish peroxide is being employed to start oxidative free radical coupling reactions that will polymerize aniline in the existence of hydrogen peroxide. In comparison to the chemical, aniline polymerization can be permitted under environmentally benign conditions [7].

4 Concentrated Emulsion Method

The three components of the emulsion polymerization method are water, latex particle, and monomer droplet. It is a heterophase polymerization process. Radical polymerization is the major mechanism. Both bulk and solution polymerization include a single segment, in which the monomer serves as the initiator and the segment also serves as a solvent. The polymer is still soluble in the monomer or solvent up till it has undergone significant modification. In this approach, a water soluble initiator, a water insoluble monomer, and a micelle-forming surfactant are often utilized. The main sites of polymerization, as opposed to suspension polymerization, are latex particles and monomer-swollen micelles. Because the process begins with a spread of latex particles rather than a monomer emulsion of droplets in water, the phrase "emulsion polymerization" is inaccurate. Usually extremely tiny monomer droplets act as the locus of polymerization in microemulsion polymerization. Inverse emulsion polymerizations are also a possibility in which the continuous segment comprises organic as well as being mixed with a water-soluble monomer in minute water droplets. Only modacrylic masterpieces can be made with it in the acrylic fiber business [9].

5 Inclusion Method

On an atomic or molecular level, inclusion polymerization is utilized to produce composite substances. This kind of polymerization could thus open the door to brand-new, highly promising low-dimensional composite substances An electroconductive polymer, for instance, may cause the emergence of a molecular wire. Depending on inclusion, composites of these polymers with organic hosts were created. Miyata et al. claim that this polymerization may be viewed as a typical space-dependent polymerization and shouldn't only be understood in terms of stereoregular polymerization. The author disregarded more research on traditional solution and bulk polymerizations [10].

7 Plasma Polymerization

Plasma polymerization is a novel method for synthesis of thin films from various organic and organometallic precursors. Insoluble, thermally resistant, chemical inertness, and physically strong films produced by plasma polymerization had no pinholes and a high degree of crosslinking. These films are also very coherent and adhere to a wide variety of substrates, including traditional polymer, glass, and metal surfaces. Because of their advantageous properties, they have recently been widely used for a variety of purposes, including adhesion supports, protective shells, biological substances, electrical, and optical devices{7,11}.

Current Applications and Future Challenges

Every aspect of life on Earth and in space will make utilize the new conducting polymer gadgets. Conducting polymers are less costly to produce, lighter than other present technology, and take up less space.

1 Polymer solar cell

Since they can build inexpensive, flexible, and large-area electronic devices and have a superior solution processing capability, polymer solar cells had garnered a lot of scientific attention. (Williams, 2005; Vignesh and colleagues, 2006; Schiff, 2002). Nevertheless, when compared to organic solar cells, the efficiency of polymer solar cells is still insufficient. By stacking two or more devices with various spectrum responses, one approach to getting around the stringent material criteria is to use solar energy more effectively. Research into the hybrid photovoltaic features of Polyaniline/Si solar cells in the dark and with light revealed that they delivered short circuit. Under AM 1.5 simulated solar light with an intensity of 100mW/cm2, the current density Jsc is 45 A/cm2, the open circuit voltage Voc is 400 mV, and the solar cell efficiency is less than 0.3% [12].

2 Chemical sensors

Although since early days of gas sensor development, conducting polymers like polypyrrole (PPy), polyaniline (Pani), polythiophene (PTh), and their derivatives were used as the active layers (1980). The oxidative polymerization of aniline in N, N, dimethylformamide produced investigated conducting Polyaniline films (Pani) on Corning glass substrates whether using an in-situ doping approach or a co-doping process. Carboxylic trifluoroacetic acid, aromatic toluenesulfonic acid, and bicyclic aliphatic camphorsulfonic acid (CSA). The codoped technique reduces the CSA-doped films' roughness by 50%; nevertheless, the conductivity varies depending on the type of acid utilized in this procedure (TSA or TFA). [13]

Conclution

The many CPs kinds, synthesis methods, conduction mechanisms, characteristics, and applications in diverse fields are discussed in this overview. It has been explored the developments in CPs research during the past 20 years, including:

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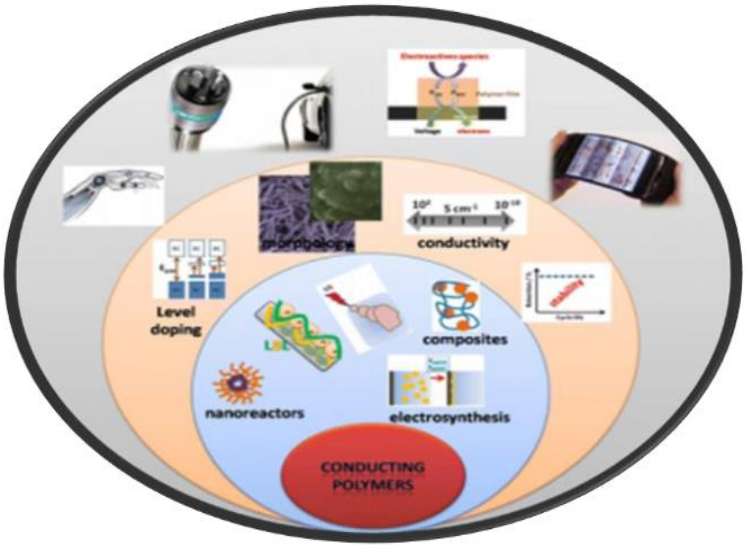
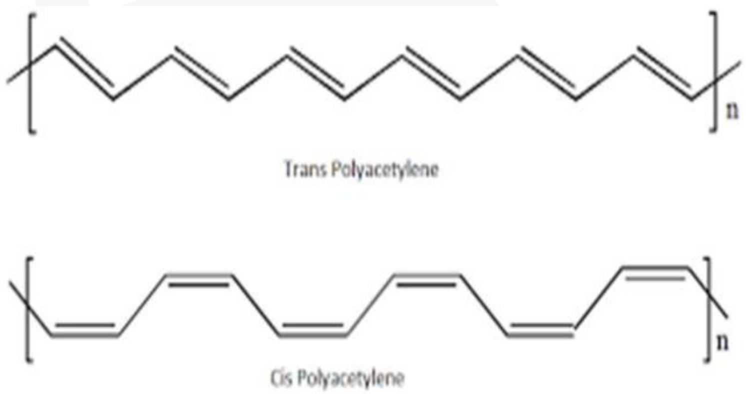
1-An important characteristic of electrically conducting polymers is the presence of a certain molecular structure with a system of conjugated double bonds that results in the delocalization of electronic states.

2- In addition to the type of polymer used, precise doping at the stoichiometric level results in electrical conductivity that spans almost the entire spectrum from the insulator to the conductor regime.



Figuer 1: shows polymers conductivity



Figuer 2: A segment of cis- and trans-polyacetylene [1]

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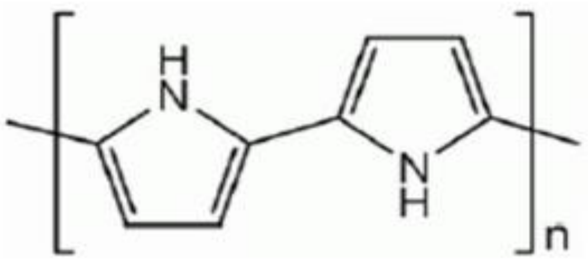

Figuer 3: show polypyrole[1]

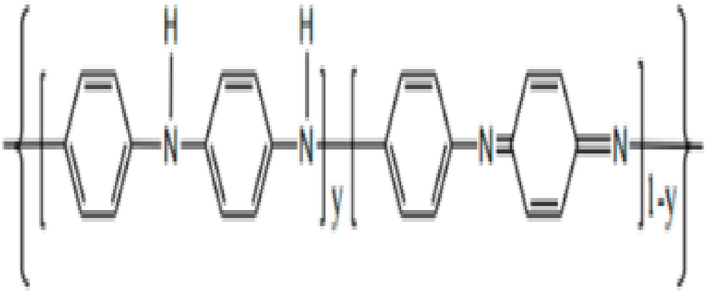

Figure 4: show polyaniline[1]

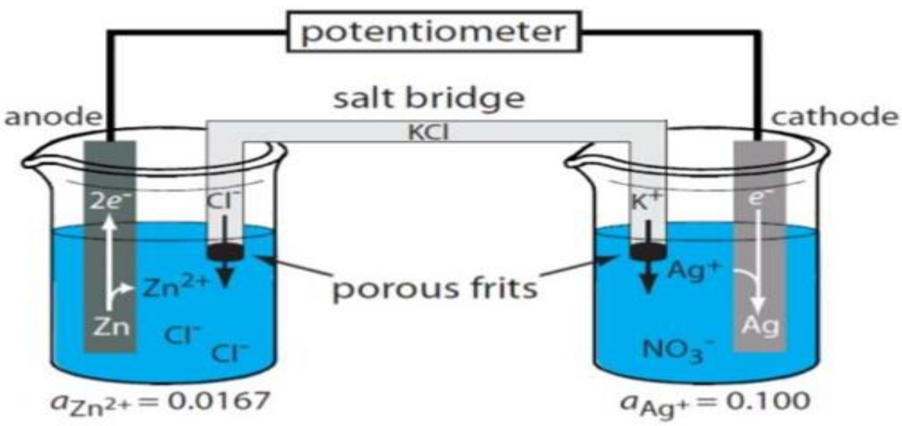

Figure 5 : Electrochemical method

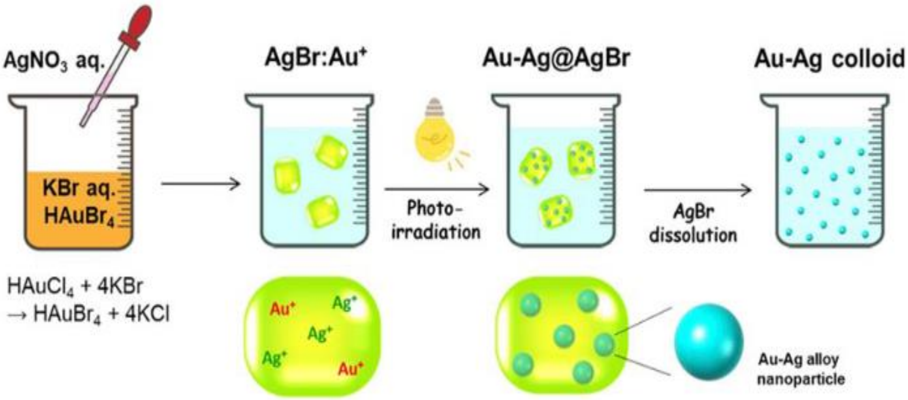

Figure 6 : Photochemical Method[8]

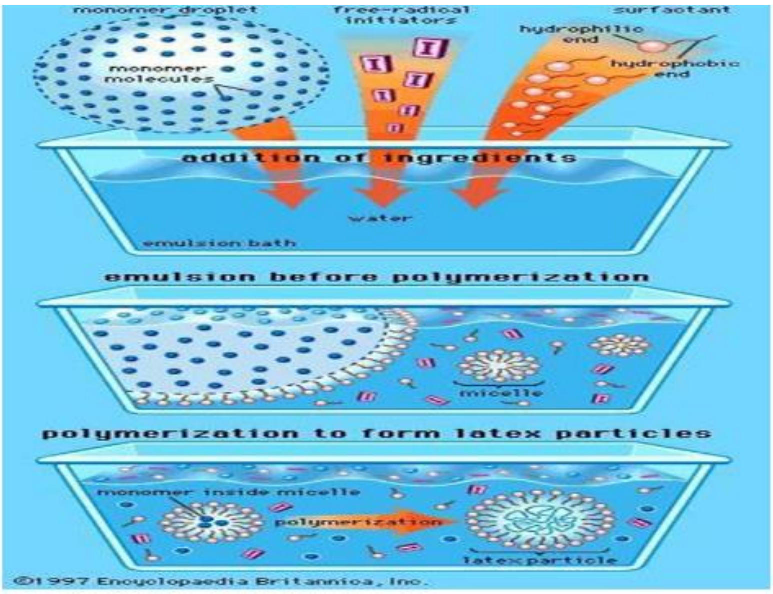

Figure 7 : Concentrated Emulsion Method

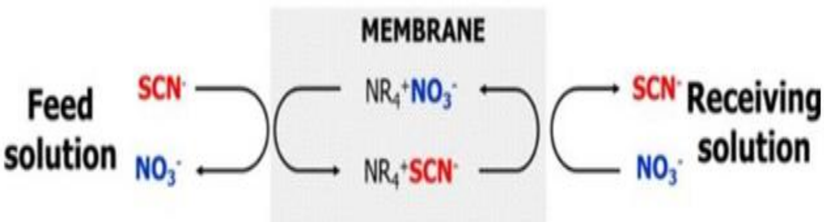

Figure 8: Inclusion Method

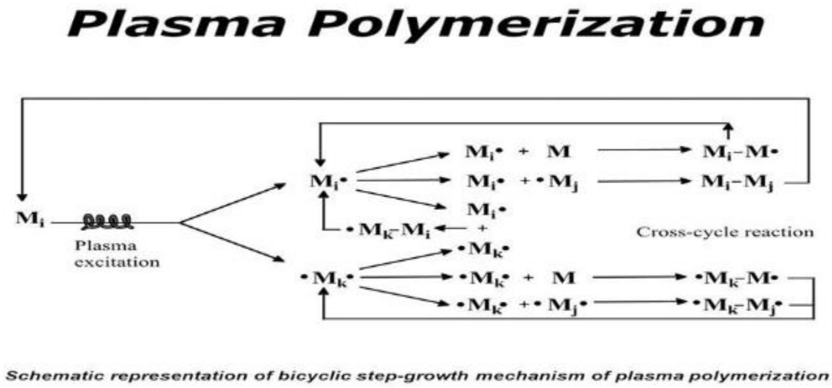

figure 9: Plasma Polymerization

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