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Design, Synthesis and Application of Polyacetylene (PA): An important class of Conjugated π Conductive Polymers

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Abstract: *Conductive polymer (CP) research has exploded in popularity over the years, with applications ranging from nanoelectronics to material science. Conducting polymers have sparked a lot of interest in academic and industrial sectors because they combine the electrical characteristics of semiconductors and metals with the typical benefits of ordinary polymers, such as ease of preparation and low cost production. In this regard, design and synthesis of polyacetylene (PA), an important class of Conjugated π Conductive Polymers, has been well described in this article. Moreover, some important applications of polyacetylene have also been incorporated.*
Keywords: *Conductive polymers (CPs), polyacetylene (PA), electronic and ionic conductivity*

I. Introduction:

Conducting polymers (CPs) are a special class of polymeric materials with electronic and ionic conductivity. Research pertaining to conductive polymers has gained significant traction in recent years, and their applications range from optoelectronics to material science. CPs can be synthesized using simple, versatile, and cost-effective approaches. They can be readily assembled into supramolecular structures with multifunctional capabilities by using simple electropolymerization processes [1]. A diverse array of methodologies have been developed to modify and tune the CPs to integrate and interface them into biomedical applications, including biomaterials and biosensors. Conjugated π polymers are a class of materials with electrons held in their backbones [2]. Delocalized π-electrons move freely within the unsaturated backbone to construct an electrical pathway for mobile charge carriers [3-4]. Polyacetylene (PA), polythiophene (PT), poly[3,4-(ethylenedioxy)thiophene] (PEDOT), polypyrrole (PPy), polyphenylene, and polyaniline (PANi) are some of the most widely used CPs in 3D tissue engineering scaffold construction for the development of human organs, and their chemical structures are depicted in Figure 1.

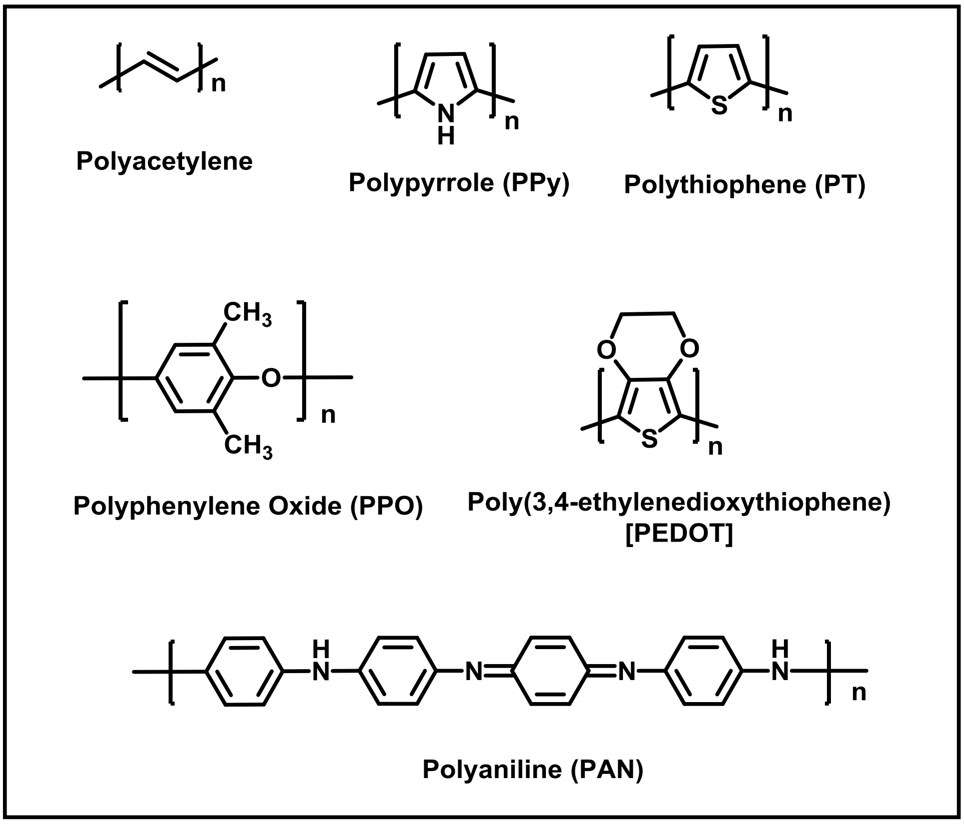

Figure 1: Structures of some important π-conjugated polymers

II. Polyacetylene (PA)

2.1. Properties and Structure: PA is, for all intents and purposes, considered to be a Nobel Prize-winning macromolecule [5]. PA is a conjugated polymer whose functional derivatives demonstrate multifaceted properties that have been extensively reviewed in the literature. Some of its useful features include electrical conductivity, photoconductivity, gas permeability, supramolecular assemblies, chiral recognition, helical graphitic nanofiber formation, and liquid crystal [5-11]. The primitive discovery of electrical conductivity in the doped form has generated much interest in CPs, which engendered an exciting field of research on synthetic metals. The chemical structure of PA is a linear polyene chain $[-(HC{=}CH)_n-]$. Its backbone provides an important opportunity for decoration with pendants due to the presence of repeated units of two hydrogen atoms. Each repeated unit of hydrogen could thus be replaced by one or two substitutes to yield monosubstituted or disubstituted PAs, respectively (Figure 2) [5].

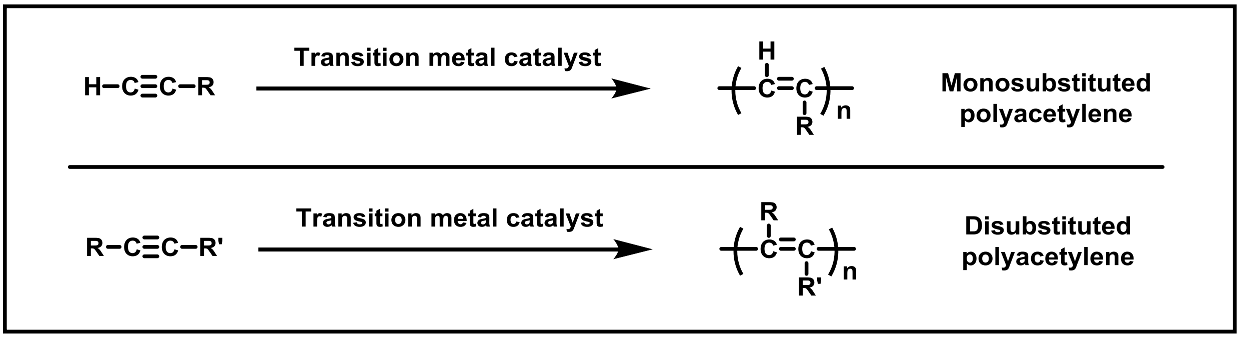

Figure 2: Development of Polyacetylene

2.2 Synthesis of Polyacetylene: Acetylene only or other monomers could be used in a number of methods to develop and synthesize polyacetylene. One of the methods is named Ziegler-Natta catalysis and involves the use of titanium and aluminum in the presence of gaseous acetylene. By changing the temperature and amount of catalyst, this method could be a beneficial way to develop polyacetylene while monitoring the structure and watching for the final polymer products. Note that there is a possibility that metal existing in the monomer's triple bonds could occur. Studies show that the polyacetylene could be synthesized by substituting the catalyst with $CoNO_3/NaBH_4$, and results show stabilities to oxygen and water [12]. Developing and synthesizing polyacetylene could also be obtained by other methods of polymerization radiations such as glow discharge, ultraviolet, and Y-radiation. Use of radiation methods could be beneficial, since they could avoid the use of catalyst and solvents.

2.3. Applications of Polyacetylenes: This section explains the use of different materials for hybridization with polyacetylene to improve the conductivity, such as dihexadecyl hydrogen phosphate [13], quaternized cellulose NPs [14], and Au NPs [15].

Polyacetylenes are also called acetylene black (AB) or polyacetylene black depending on the preparation method. AB is a carbon nanomaterial which is a specific subtype of carbon black and is produced by the controlled combustion of acetylene under pressurized air. ABs are usually used as substitutes for graphitic powder in the preparation of carbon paste electrodes [16-17], and are dispersed in chitosan solution to modify glassy carbon electrodes [18]. An acetylene black− dihexadecyl hydrogen phosphate (AB-DHP) film-coated glassy carbon electrode (GCE) was also constructed to detect 2-chlorophenol [19] and erythromycin [13]. With the physical inclusion of enzymes, quaternized cellulose NPs (QCs)/acetylene black (AB)/enzyme composite electrodes have been constructed in the electrode matrix bulk. This has been used for hydrogen peroxide (H_2O_2) and glucose amperometric detection. The new composite material combines the unique and attractive electrocatalytic behaviors of QCs and acetylene black with excellent biocompatibility, electric conductivity, and a large specific surface area [14].

The analysis of the electrochemical behavior of colchicine, an alkaloid, in AB-DHP composite film-coated GCEs has revealed noteworthy results [20]. Colchicine is used to treat gout, and reduce hepatic fibrous tissue formation in primary biliary cirrhosis and other cirrhotic conditions.

III. Conclusion:

A comprehensive overview of various CPs and their advantages and associated challenges, from synthesis to applications, were fully discussed. Overall application of CPs in biomedicine, especially with surgical implants and tissue engineering, remains challenging, and progress has been slow due to multidisciplinary science lagging behind research and development.

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