



Synthesis of organic conjugated polymers: A review

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Abstract:

Conducting polymers (CPs) have received a great deal of attention due to their excellent properties, including electronic properties, optical properties, high mechanical performance, ease of synthesis, and fabrication compared to other traditional inorganic materials. Conducting polymer (CPs) properties make them useful in a variety of practical industries such as sensors, conductive adhesives, and energy storage devices. These materials are referred to as "organic semiconductors" because they exhibit behaviour that is comparable to that of an inorganic semiconductor. Since their first discovery in 1977, CPs' electrical conductivity has been the topic of study. Because of the wide range of applications and commercial value of conjugated polymers, chemists have worked to improve conventional polymerization techniques and create, modify synthetic routes. This review article describes the various techniques available for the synthesis of Conducting polymers such as polyacetylene (PA), polyaniline (PANI), polypyrrole (PPy), polythiophene (PT), and polyphenylvinylene (PPV) via traditional and some other procedures.

Keywords: Conjugating Polymers, Polyacetylene, Polyaniline, Polythiophene, Polypyrrole, poly(p-phenylenevinylene).

1. Introduction

In the context of our basic needs, the term "polymer" is usually applied. Traditionally, they were recognised as great insulators. And some of them are polyethylene, polyvinyl alcohol and poly-propylene which have had various applications in the past 100 years. Due to their insulating behaviour they were only used in several fields of electronics, such as separator or piezo-electric materials. But since the discovery of conjugated polymers (CP's), their applications have jumped dramatically. Also, due to their distinctive characteristics, including mechanical strength, electrical conductivity, corrosion resistance, stability, and the potential for both oxidative and electrochemical production, conductive polymers have been the focus of a significant number of studies over the past few decades [1]. They are frequently used in applications that rely on conductivity, photo- or electroluminescence, or light-induced charge production, including light-emitting devices, photovoltaics, chemical sensors, etc. with variable complexity in structure and their functioning [2]. Based on their solubility in organic solvents, they extend their conjugation length and proceed through making the roll-to-roll printing, inject printing, and spray-coating. [3] Their solubility depends on the attached side chain and attached dopant ions which give them mechanical, electrical, and optical properties. [4] Some basic conjugated polymers and their structures are shown in figure 1.

Figure1. Representative Structures of some conjugated polymers.

The synthesis of conjugated polymer goes through different routes. PPVs are generally prepared by elimination reaction of non-conjugated precursor polymers. If they have large proportions of cis double bonds they are also prepared by Witting and related condensation reactions. This review of "Synthesis of conjugated polymers" discusses well-known synthesis processes and some other processes that contribute to further discoveries in this field. Table 1 is showing the different processes used in the synthesis of CP's.

Table 1:- Different Synthesis process used in the formation of polymer

Polymers	Applications	Traditional synthesis Process	Other synthesis process	References
Polyacetylenes (PA)	Bioelectrodes, Colchicine Detection, Biosensors	a)Catalytic Polymerization of Acetylene b)Non-catalytic Polymerization process of Acetylene c)Precursor Methods d)Soluble Polyacetylene	Glow discharge, Ultraviolet, Controlled radical polymerization	[5], [6] [7]
Polyanilines (PANI)	Electronic(solar cells, sensors, Electrochromic glasses) Medicine, Anticorrosion materials,	A)Chemical Synthesis B)Electrochemical Synthesis	DHAP, Interfacial Polymerization, Vapour phase polymerization, Microemulsion Polymerization, Solid State Synthesis, Electrospinning and Enzymatic Synthesis.	[8]

Polythiophenes (PT)	Electrochromic devices, field effect transistors, polymer light-emitting diodes, solar cells, chemical sensors	a) Direct Oxidation of Thiophene b) Organometallic Coupling Reactions c) Electrochemical Synthesis	DHAP, Direct C-H coupling method, Chain growth polymerization, Vapour phase polymerization	[9] [10]
Polypyrroles (PPy)	Electroluminescent devices, Synthetic metals, biomedical application, Batteries, Microactuators and anti-electrostatic coatings	a) Chemical Syntheses b) Electrochemical Syntheses	Ultrasonic radiation, Vapour phase polymerization, Electrospinning, Microemulsion polymerization, Mechanochemical Polymerization, Photopolymerization	[9] [11]
Poly(p-phenylenevinylene) (PPV)	Light-emitting diode, photovoltaic	a) Direct synthesis of PPV b) Precursor processes to PPV c) Metathesis reactions	Dithioester precursor route Dehydrochlorination route	[12], [13] [14], [15]

2. Polyacetylenes (PA)

In terms of molecular structure, polyacetylene is the most basic conjugated polymer and thus can be described as the prototype of conducting polymers for the rest of the conjugated polymers [2]. Polyacetylene contains a linear polyene chain as its primary chain which is comprised of repeating $[-(CH=CH-)]_n$ unit [5]. Due to the repetitive units of two hydrogen atoms that make up its backbone, it offers a significant possibility for pendant design. [6] Polyacetylenes are made through a variety of processes that have been employed throughout history. The main categories of the syntheses process are discussed below.

2.1 Catalytic Polymerization of Acetylene [5]-This category of syntheses process contains methods like Ziegler-Natta Catalysts, Luttinger Catalysts, Metathesis Catalysts, Single-Component Catalysts, Rh and Re Catalysts.

2.1.1 Ziegler-Natta Catalysts- The best catalyzed in the formation of the product that is used are $Ti(O-n-C_4H_9)_4$ and $(C_2H_5)_3Al$, because it contains the property to be soluble in organic solvents and is very active to form the crystalline polymerization in the form of mechanically robust freestanding films. Shirakawa's group developed the electronic properties of the synthetic process by using good high concentration of the $Ti(O-n-C_4H_9)_4-(C_2H_5)_3Al$ catalyst [16] and allowing acetylene to polymerize on the catalyst solution's free surface or on the reaction flask's wall on which the catalyst solution is coated. The reaction shown below in fig.2 produced PA.

Figure 2:-Ziegler-Natta Catalysis

2.1.2 Luttinger Catalysts-

Luttinger Catalyst formation is based on a hydride reducing agent, such as sodium borohydride combined with a salt nickel chloride. When these types of reagents are used they produce high molecular weight polyacetylene and show there

is no evidence of cyclic oligomer formation[17]. There is also another excellent catalyst used to form PA, nickel halide-tertiary phosphine and the $\text{Co}(\text{NO}_3)_2$ and binuclear Rh complexes in the presence of NaBH_4 . The type of solvent which is used in the formation is a hydrophilic solvent such as THF, water, acetonitrile, and ethanol. The reaction of this process is

shown in figure 3.

Figure 3 Luttinger Catalysts

Some other methods which are useful for the formation of polyacetylene are *Metathesis catalysts*, *Single-component catalysts*, *Rh and Re catalysts*.

2.2 Non-catalytic polymerization of PA

Electrochemical processes had been done in a variety of situations. Trans-polyacetylene is formed when acetylene polymerizes on metal oxides surface like TiO_2 and Al_2O_3 . By applying acetylene gas to a little amount of AsF_5 or utilising AsF_3 as the solvent, PA had been generated as thin films and when this gas irradiate with UV or ionizing radiation it forms polyacetylene.[18]

2.3 Precursor Methods

Prepolymer that can be thermally transformed into polyacetylene are used in this method. The Feast group[19], [20] was the first to use this strategy. There are three steps to the procedure. The very first step involves a thermal cycloaddition reaction which is performed between hexafluorobut-2-yne and cyclooctatetraene to produce 7,8-bis(trifluoromethyl)tricyclo[4.2.2.0^{2,5}]deca-3,7,9-triene[21] monomer. The second stage involves polymerization using ring-opening metathesis polymerization[22] initiators such as $\text{WCl}_6/\text{SnMe}_4$, and work as only on the 4-membered strained ring to generate a precursor polymer of high molecular weight. And this process confirms that precursor polymer is soluble in a wide range of organic solvents and it can be purified, characterized, and processed using traditional processes. It is thermally transformed to polyacetylene in the final stage. This is a complicated process that combines the exothermic symmetry-allowed elimination process with a new fresh cis double bond and hexafluoro-o-xylene production. To control the end product's appearance the factors in reaction conditions such as temperature, pressure, mechanical stress, time, and the presence of solvent must be controlled. Swager et al. created a new PA precursor process that does not produce volatile byproducts. This approach includes ROMP of benzvalene (an isomer of benzene) which was preceded by catalytic isomerization to low crystallinity PA as shown in fig 4.[5]

Figure 4 Ring opening metathesis polymerization

2.4 Soluble Polyacetylene

PA is a material that is insoluble, infusible, and usually intractable. Substituted acetylenes were polymerized to generate polymers with side groups attached to the conjugated backbone, replacing the hydrogen atoms to obtain soluble PA analogs. Gibson provided an extensive review of substituted PA in 1986.

2.5 Controlled radical polymerization:-

Living anionic polymerization or controlled radical polymerization of 2,3-disubstituted-1,3-butadienes or the subsequent DDQ dehydrogenation process was used to successfully synthesize three types of asymmetrically substituted head-to-head polyacetylenes.[7]

3. Polyanilines (PANI)

PANI was identified for the first time in the nineteenth century by Henry Lethe, who researched the chemical and electrochemical oxidation product of aniline in acidic media.[23] PANI has a lot of advantages but also has some of the disadvantages. It has limited biological application because of inflexibility, and lack of biodegradability. PANI is produced by the method of polymerization of aniline in one of the exact oxidation forms. These are leucoemeraldine, emeraldine (salt/base), and pernigraniline, by their oxidation state.[4], [24] There are two forms in which PANI is present these are completely reduced form and fully oxidised form which contains benzenoid and quinonoid ring and acts as a repeating units.[8] Polyaniline is made by oxidising aniline chemically or electrochemically in an aqueous solution under acidic circumstances. The methods used in the formation of PANI are

3.1 Chemical Synthesis: -It gives high performance than the electrochemical synthesis[8]. It is the most commonly used method to combine HCl or H₂SO₄ with (NH₄)₂S₂O₈ as an oxidant[25]. To avoid degradation due to excessive oxidation, a lower concentration are used rather than an equimolar concentration. Lower temperatures result in higher-quality polymer. Under acidic circumstances, a variety of oxidants have been utilised to carry out the chemical polymerization of the aniline. Synthesis of PANI utilising Schiff base chemistry was described by Gebert in 1989 where condensation of the p-phenylene diamine with the p-benzoquinone is involved in the reaction which are shown below in Fig. 5. And Mattos polymerized aniline in the presence of LiCl and HCl at -40°C to produce a polyaniline with a high molecular weight.

Figure 5 Chemical Synthesis

3.2 Electrochemical Synthesis

Compared to the chemical technique, the electrochemical method has a number of advantages, it is cheap and simple and it is accomplished in a chamber cell containing the electrode–electrolyte and a power supply etc. The polymerization of PANI can be done in three stages. First one is the oxidation step where aniline is oxidized to nitrogen by releasing an electron from the radical cation's pair. The second step is more reactive than first because of the resonating structures. In the third step dimer formed and at last formation of trimer or tetramer polymer. The final step of the process is shown in figure 6[1], [8]

Figure 6:-Electrochemical Synthesis

3.3 Interfacial Polymerization

Polyaniline is synthesized at the interface of two immiscible solutions in this method. In general, organic solvents like toluene dissolve aniline. Slowly, an aqueous solution containing an oxidant and an acid dopant is introduced to the aniline solution. PANI begins to form in the shape of nanofibers at the interface of the two solutions[26]. As the reaction progresses, aniline diffuses into the aqueous phase. PANI nanofibers also float away from the reaction's interphase area, allowing for the creation of new nanofibers[24], [27]

Some other methods that are used to synthesize PANI are *Micro-emulsion* [28], [29], *Solid State Synthesis*, *Electrospinning*[30] and *Enzymatic Synthesis*. [24]

4. Polythiophenes (PT)

In the nineteenth century, thiophene was discovered in tar, gas, and industrial benzene produced from coal. Many thiophene derivatives have been described in the literature, and their physical properties, nucleophilic substitution, and biological activity is still of interest. As a result, polythiophene has been thoroughly investigated using both theoretical and experimental methods[31]. Due to its small band gap and high electrical conductivity, poly(alkylthiophene) has gotten a lot of attention lately[32]. Polythiophene and its derivatives commonly used in device applications. The first polythiophene synthesis was described in 1883, when the purification of thiophene with sulfuric acid yielded a dark, insoluble material. It has been reported that thiophene can be oxidised using orthophosphoric acid or a synthetic silica-alumina catalyst, yielding a series of oligomers. Direct oxidation of thiophene, organometallic coupling, and electrochemical synthesis are used in the synthesis of PT. And polythiophene precursor methods are quite unique.

4.1 Direct Oxidation process of Thiophene

Despite its disadvantages, direct oxidative of thiophene with FeCl_3 is an extensively used approach for studying polythiophene characteristics. This is simply due to the fact that it is approachable to large number of scientists.[5] The reaction is shown in fig 7.

Figure 7 Direct Oxidation process of Thiophene

The FeCl_3 method has number of flaws, one of which is that it shows variable outcomes[33]. Another drawback is that leftover Fe concentrations limit the materials from being used in electrical equipment.

4.2 Organometallic Coupling Reactions:-

Ni-Catalysed Coupling Reactions

4.2.1 Yamamoto Method

In Yamamoto's synthesis, Mg is added to 2,5-dibromothiophene in THF while $\text{Ni}(\text{bipy})\text{Cl}_2$ is present. It is possible for the Mg to react with either type of bromide to produce 2-bromo-5-magnesiobromothiophene or 2-magnesiobromo-5-bromothiophene, which then self-couples with the Ni (II) catalyst to produce a thiophene dimer with an MgBr and a Br at each end. The formation of low molecular weight Polythiophene (PT) eventually results from the condensation reaction. Lin and Dudek reported a related metal-catalyzed polycondensation process.[34] Reactions of these processes are given below in figure 8.

Figure 8 Yamamoto route & Lin and Dudek Route respectively

4.3 Stille Method.

The great adaptability of the Stillepolycondensation approach to a wide range of functional groups is its most significant advantage over other methods.[35]Using the Stille coupling methodology Tour and his fellow scientists proved that functional groups nitro, amine, ketone and quinone are compatible with respect to Stille condensation methods [36] which are shown in figure 9.

Figure 9Stille

Method.

4.4 Methods for poly(3-alkylthiophene)

We can use poly(3-alkylthiophene)[37] to explain the recently used methods for the preparation of polythiophene. It is clear that chemical oxidation or electrochemical polymerization do not provide the defined structure for the poly(3-alkylthiophene) polymer, this is its one of the limitation. The head-to-tail coupling is required for the directed and defined structure. The first synthesis process ofregioregularpoly(3-alkylthiophene)s (P3ATs) was presented by McCullough[38] in year 1992 shown in fig 10. The second method was reported by Riek[12], [39]which is shown in fig 11. McCullough later published another approach Grignard Metathesis for regioregular (P3ATs) which occurs via a living chain growth mechanism. The Grignard metathesis / Kumada-Corriu coupling has become the most extensively utilised approach for synthesizing (P3ATs) with predetermined high molecular weights[12]in fig 12.

Figure 10McCullough Route**Figure 11**Rieke Route**Figure**

12Grignard Metathesis and Kumada-Corriu Coupling

4.5 Direct (hetero) arylation process (DHAP)

DHAP process is recommend for the highly regioregular polymers such as poly(3-substituted thiophene)s. This method was carried out even at a temperature of 60 °C and generally yielded great regioselectivity and hence regioregularity (up to 99 percent). Current advancements in printable electronics have been made possible by the outstanding contribution of regioregularpolythiophenes, and this trend appears set to continue.[40]This technique has been widely employed for polythiophenes with substituted alkyl, alkoxy, and ester groups.[41] The example is shown below in fig 13[10].

Figure 13 Direct (hetero) arylation process (DHAP)

The other method used to synthesize PT is the *electrochemical process* which contains parts Anodic Electrochemical Oxidation and Reductive Electro polymerization.

5. Polypyrroles (PPy)

Polypyrrole is the most often used conducting polymer in commercial applications because of the long-term stability of its conductivity as well as the possibility of the formation of homopolymers or composite materials with improved mechanical properties. In 1916, polypyrrole was created by oxidizing pyrrole with H_2O_2 to produce an amorphous powdery compound called as "pyrrole black." However, there was little interest in this material until it had been electrochemically prepared in the form of continuous films. Dall'Olio obtained pyrrole black by electrochemical oxidation of pyrrole in aqueous H_2SO_4 on a platinum electrode in his early work on the electrochemical synthesis of polypyrrole. Electrochemical techniques for synthesis of polypyrroles became useful in 1979 for obtaining high conductivity freestanding materials. Polypyrroles properties as nontoxic and biocompatibility [42] leads him variety of products, including supercapacitors/electrodes, nanocomposites, gas sensors, biosensors, medication delivery, anticorrosion coatings, actuators, and adsorbents for the removal of heavy metals and dye. The earliest polymerization reaction used to produce π -conjugated polymers is oxidative polymerization. And this polymerization is carry out through chemically, electrochemically [43] and the ultrasonic waves. Chemical and electrochemical polymerizations are the two synthesis techniques for polypyrrole that are most frequently utilise. [44]

5.1 Chemical Oxidation Polymerization:-

Polypyrrole was created using a chemical oxidative polymerization approach with pyrrole monomer and various oxidants. Chemical polymerization was performed in a beaker with 100ml of distilled water by adding various molar ratios of pyrrole monomer, an oxidant, and then a surfactant. Polymerization solution contains different concentrations of pyrrole monomer and oxidants while maintaining a constant amount of surfactant. Since it's an exothermic reaction, distilled water was slowly added (cooled). In order to help the pyrrole disperse, a specific volume of pyrrole monomer was added instantly to the distilled water along with the required quantity of oxidant and surfactant. At a temperature of 25°C, the polymerization process was carried for a total of 4 hours. Fine black particles began to form very instantly. After the required amount of time for polymerization, synthesised polypyrrole was filtered out of the solution using filter paper, completely washed with distilled water, and then properly dried in a vacuum oven at around 40°C overnight [11]. It is an efficient process when a massive portion of polypyrrole is required. But, the main weakness of chemical synthesis seems to be the termination of the increasing polymer chain caused by the addition of functional groups that contain oxygen [45]

5.2 Electrochemical Syntheses

Electrochemical synthesis has various distinct benefits over chemical synthesis. Controlling the conductivity, structure, mass, and thickness of polypyrrole film is possible thanks to electrochemical polymerization. Additionally, using this method of production, a thin polymer film can be applied to cover other materials. [45] The electrochemical polymerization of pyrrole on the Cu electrode is discussed that PPy films were produced using a single cell-three electrode setup and the cyclic voltammetry method. The surface of a passivated copper electrode was coated with PPy in a solution containing 0.1 M oxalic acid and 0.1 M pyrrole monomer at a scan rate of 20 mV/s in 30 cycles on a potential range of: 0.5 V to 1 V. [46]

5.3 Photopolymerization

This approach is divided into main categories i.e. 1) direct photopolymerization via monomer photoexcitation; and 2) photopolymerization via photosensitizer/photoinitiator systems. [47] Polymerization has been discovered to be extremely beneficial in obtaining microfabrication and coatings effectively onto the substrate where temperature and solubility limitations exist. Furthermore, this method was developed to resolve the electrochemical method's over-oxidation problem, and the process can be easily controlled by easily switching the light on or off.

And the some other techniques are *Ultrasonic radiation*[48],*Vapour phase polymerization*[49],*Radiolysis polymerization*[50]*Electrospinning*[51],*Microemulsion polymerization*[52],*Mechanochemical Polymerization*[53]

6. Poly (p-phenylenevinylene) (PPV)

Polymers such as (PPV) have been particularly successful examples of polymer light emitting devices (PLEDs) over the last two decades, with many advantages over conventional inorganic LEDs. PLED thin polymer films, for example, are processable via a variety of low-cost paths and can be employed in flexible materials. This can lead to their use in a variety of applications where flexible materials are required.[54] Furthermore, because of their excellent optical properties, PPV have been good organic materials for chip detectors or related luminescence applications.

The methods used in the formation of these polymers are

6.1 Direct synthesis of PPV- It contains the Wittig Coupling, McMurry coupling, Heck reaction, Suzuki coupling, Knoevenagel Condensation, Siegrist Reaction, Metathesis-Catalysed Reactions, Coupling of Benzylic Halides, Benzothiazole Condensation, and Electrochemical Polymerization.

The direct synthesis of PPV is only possible when the side chain (alkyl, alkoxy) do not take part in the polymerization. So, this polycondensation is based on the coupling reactions.

6.1.1 Heck Reaction-To form the aromatic –vinylic type structure polymers the heck process is used by using the aryl halides with alkenes. To avoid structure defects, the monomers for PPV formation were those that already contained the C-C double bonds. The precursor route is followed for Heck polymerization. The reaction given below in fig.14 is the example of Heck process.[55]

Figure 14: Heck Process

It allows the double bond to be directly incorporated into the polymer chain. PPV and soluble derivatives have been produced by polymerizing aromatic dibromides with ethylene[56]. This reaction can likewise be carried out with other dihalogen derivatives. In addition to the numerous potential side reactions, this approach has the disadvantage that one of the reactants is gaseous and must be introduced precisely. The other disadvantage of the Heck reaction is that it is not strictly regioselective. The conditions in which reaction is performed are mild, and can be tolerated by a wide range of functional groups.

6.1.2 Suzuki Coupling-A Suzuki cross-coupling[57] reaction was used to produce poly(1,4-phenylenevinylene) from trans-1,2-dibromoethylene and aryl diboronic acids.[58] The reaction is given below show that several derivatives have been synthesized in this way, among which poly (trisphenylenevinylene). The reaction is shown below in fig15.

Figure 15 Suzuki Coupling

6.1.3. Knoevenagel Condensation-This technique involves reaction of an aromatic aldehyde with a benzylic nitrile and catalysing with an amine or amine salt in order to add electron-withdrawing groups into the conducting polymers. It is a based catalysed reaction. Like other aldol-like condensations, it proceeds via reversible addition followed by dehydration,

proposing the possibility of developing a dynamic polymerization methodology based on this chemistry.[13]The reaction is shown below in fig 16.

Figure 16 Knoevenagel Condensation

And the some other methods are *Siegrist Reaction, Coupling of benzylic halids, Benzothiazole condensation.*

6.2. Electrochemical polymerization:-

This method has one most advantages than the others is its inherent low- temperature circumstances, which allow the synthesis of polymers that would not survive at the intense thermal conditions of the Wessling route.[59]Electrochemical coupling of $\alpha, \alpha, \alpha, \alpha$ -tetrabromoxylene resulted in the formation of PPV films. Catalyst Cr or Mo carbonyl complexes can be added to speed up the deposition[23], [60].

6.3. Precursor Routes to PPV:-

This method contains Benzoine Condensation, Ring-Opening Metathesis Polymerization, Chemical Vapour Deposition, Sulfonium or Wessling Precursor Route, Alkoxy Precursor Route, GilchRoute, Xanthate Precursor Route, Acetate Precursor Route, Sulfinyl or Louwet-Vanderzande Precursor Route.

6.3.1. Ring Opening Metathesis polymerization-

This method is used to form high-molecular weight precursor polymer which are soluble in organic solvents and is proposed by Conticello. But a silyl-substituted paracyclophane derivative was used in a modification of the Thorn-Csanyi ROMP approach to PPV, which reacted to give a soluble precursor polymer under ROMP conditions[61]. The PPV could be transformed by processing the precursor polymer with acid or by hydrolyzing the silyl group followed by heat treatment. The reaction is shown below in fig17.

Figure 17 Ring Opening Metathesis polymerization

6.3.2. Gilch Route-

Gilch's approach was used to create a series of substituted PPV derivatives. It was discovered that branching long-chain alkoxy, as well as alkyl groups with at least six carbons in length, are particularly effective at increasing solubility. Asymmetric substitution of the aromatic ring tends to promote solubility and film formation. Gilch and Wheelwright used dichloro-p-xylene with potassium tert-butoxide in organic solvents to form PPV[62].A general reaction scheme for the anionic mode and radical path is shown in fig18.[63]

Figure 18 Gilch polymerization route

And some other precursor routes are *Chemical Vapour Deposition*[64], *Sulfonium or Wessling Precursor route*[65], *Alkoxy precursor route*[15], *Xanthate Precursor route*, *Acetate Precursor route*, *Sulfinyl or Louwet-Vanderzande Precursor route*.

6.3.3. Dithioester precursor route

A bifunctional dithioester was used as the monomer in the synthesis of PPV. In this case, high molecular weight PPV was obtained using a simple method with no possibility of physical gelation. Figure 21 shows the reaction process.[66]

Figure 19 Dithioester precursor route**Dehydrochlorination route-**

Dehydrochlorination of p-hydroxyanisole yielded PPV derivatives with a methoxyl group in position 2 and various alkoxy substitutes in position 5. Figure 20[15]

Figure 20 Dehydrochlorination route

Conclusion – The synthetic methods have a significant impact on the purity, molecular weight, and regio-regularity of CPs, all of which are directly related to their performance in electronic devices. They have been used to create a variety of optoelectronics such as PLEDs and others. A chemical tool is required to enhance the performance of conjugated polymers. Indeed, huge advances have been made in the last two decades as a result of the logical and reasonable design of novel CPs by using different synthesis process. In PANI, other than conventional processes Interfacial Polymerization, Vapour phase polymerizations, Microemulsion Polymerization and some also used in the production of PANI. Same in the Polypyrrole other than traditional process some new process is used Ultrasonic radiation, Vapour phase polymerization, Electrospinning, Microemulsion polymerization, Mechanochemical Polymerization, Photopolymerization for the production of PPy.

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Competing Interests

The authors declare no competing interests.

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