

## 1: Engineering Chemistry : Polymers: Conducting polymer

*Conductive polymers or, more precisely, intrinsically conducting polymers (ICPs) are organic polymers that conduct electricity. Such compounds may have metallic conductivity or can be semiconductors.*

**Conducting Polymers** Most organic polymers are insulators by nature. However, a few intrinsically conducting polymers ICPs exist that have alternating single and double bonds along the polymer backbone conjugated bonds or that are composed of aromatic rings such as phenylene, naphthalene, anthracene, pyrrole, and thiophene which are connected to one another through carbon-carbon single bonds. The first polymer with significant conductivity synthesized was polyacetylene polyethyne. They synthesized this polymer for the first time in the year when they prepared polyacetylene as a silvery film from acetylene, using a Ziegler-Natta catalyst. Despite its metallic appearance, the first attempt did not yield a very conductive polymer. However, three years later, they discovered that oxidation with halogen vapor produces a much more conductive polyacetylene film. This discovery started the development of many other conductive organic polymers. The conductivity of non-doped, conjugated polymers such as polyacetylene is due to the existence of a conducting band similar to a metal. The remaining unpaired electron of each carbon atom remains in a pz orbital. However, non-doped polymers have a rather low conductivity. Only when an electron is removed from the valence band by oxidation p-doping or is added to the conducting band by reduction n-doping does the polymer become highly conductive. The four main methods of doping are Redox p-doping: Electrochemical p- and n-doping: Doping is achieved by cathodic reduction p or by anodic oxidation n Photo-Induced Doping: The polymer is exposed to high energy radiation that allows electrons to jump to the conducting band. In this case, the positive and negative charges are localized over a few bonds. Doping increases the conductivity by many orders of magnitude. Another method to increase conductivity is mechanical alignment of the polymer chains. The table below lists typical conductivities of some common conjugated polymers and their repeat units. The actual conductivity not only depends on the structure and morphology of the polymer but also on the type of dopant and its concentration. Electrical Conductivity of some Conductive Polymers Compound.

## 2: Conducting Polymers

*Conductive Polymers Properties. Intrinsically conducting polymers (ICPs) have been the subject of intense research.*

Monday, 28 April Polymers: Applications of conducting polymers. In general many organic polymers are used as electric insulators. The main reason for non-conducting nature of organic polymers is due to the absence of conjugation in the backbone or absence of conducting ingredients. But due to the extensive research work in this area, scientists are able to synthesize conducting polymers. Polyacetylene is the first example of conducting polymer. The electrons in these delocalized orbitals have high mobility. The conducting properties for a polymer can be accomplished by doping with suitable species. These materials can also be doped by reduction, which adds electrons to an otherwise unfilled band. In practice, most organic conductors are doped oxidatively to give p-type materials. Classification of conducting polymers: The conduction of electricity in this type of polymers is due to conjugation in the backbone of the polymer. The conjugation can be due to either pi electrons or due to doped ingredients. In these types of polymers, due to the presence of double bonds and lone pair of electrons conduction of electricity takes place. Electrical conduction can occur only after attainment of required energy of activation either thermally or photo chemically because there will be some gap between the valance and conduction bands. So the electrons need to be excited by some means. Removal of one electron from the pi-back bone of a conjugated polymer forms a radical cation polaron, which on losing another electron forms bipolaron. The delocalization of positive charges causes electrical conduction. When Lewis bases electron rich species are treated with polymers having conjugation, due to reduction of the polymer, negative charge develops. Actually by the addition one electron, polaron and by the addition of second electron, bipolaron are formed. In bipolaron, due to the delocalization of the charge, conduction takes place. Intrinsically conducting polymers are characterized by good electrical conductivity, capability to store charge, capacity to exchange ions, ability to absorb visible radiation thereby yielding the coloured compounds. These are also X-ray transparent. The conductivity of these polymers is due to the addition of external ingredients. When carbon black or some metal oxides or metallic fibers are added, the polymer becomes conductive. The minimum concentration of the element required for the conductivity is called percolation threshold. The filler ingredients that percolate have more surface area, more porosity and filamentous nature due to which they can enhance the conducting properties. It can be synthesized by the oxidative polymerization of aniline in presence of ammonium persulphate dissolved in 1M HCl. Conducting polymers are useful in discharging large quantities of static electricity in computer industries and in chemical industries. Hence conducting polymers are used as antistatics. Conducting polymers can absorb harmful electromagnetic radiation. So these can be used to coat on the cases of computer monitors and cell phones. Printed circuit boards are used in electrical and electronic instruments. These are useful in the preparation of artificial nerves i. These are also called as smart materials. This property can be utilized in detecting the gases. So, these are environmentally safe and non toxic. These are useful as corrosion inhibitors. These are also useful as Flexible Display Devices for mobile phones.

## 3: Properties of Conductive Polymers

*Intrinsically conducting polymers (ICPs) have been the subject of intense research. These polymers have unique electrical and thermophysical properties. Their electrical conductivity is based on the presence of conjugated double bonds along the polymer backbone.*

Synthesis[ edit ] Conductive polymers are prepared by many methods. Most conductive polymers are prepared by oxidative coupling of monocyclic precursors. Such reactions entail dehydrogenation: Some researchers have addressed this through the formation of nanostructures and surfactant-stabilized conducting polymer dispersions in water. These materials have lower molecular weights than that of some materials previously explored in the literature. However, in some cases, the molecular weight need not be high to achieve the desired properties. Molecular basis of electrical conductivity[ edit ] The conductivity of such polymers is the result of several processes. For example, in traditional polymers such as polyethylenes , the valence electrons are bound in  $sp^3$  hybridized covalent bonds. Such "sigma-bonding electrons" have low mobility and do not contribute to the electrical conductivity of the material. However, in conjugated materials, the situation is completely different. Conducting polymers have backbones of contiguous  $sp^2$  hybridized carbon centers. One valence electron on each center resides in a  $p_z$  orbital, which is orthogonal to the other three sigma-bonds. All the  $p_z$  orbitals combine with each other to a molecule wide delocalized set of orbitals. The electrons in these delocalized orbitals have high mobility when the material is "doped" by oxidation, which removes some of these delocalized electrons. Thus, the conjugated  $p$ -orbitals form a one-dimensional electronic band , and the electrons within this band become mobile when it is partially emptied. The band structures of conductive polymers can easily be calculated with a tight binding model. In principle, these same materials can be doped by reduction, which adds electrons to an otherwise unfilled band. In practice, most organic conductors are doped oxidatively to give  $p$ -type materials. The redox doping of organic conductors is analogous to the doping of silicon semiconductors, whereby a small fraction silicon atoms are replaced by electron-rich,  $e$ . Although typically "doping" conductive polymers involves oxidizing or reducing the material, conductive organic polymers associated with a protic solvent may also be "self-doped. Subsequent doping of the conducting polymers will result in a saturation of the conductivity at values around 0. Polyacetylene has alternating single and double bonds which have lengths of 1. Some materials also exhibit negative differential resistance and voltage-controlled "switching" analogous to that seen in inorganic amorphous semiconductors. Despite intensive research, the relationship between morphology, chain structure and conductivity is still poorly understood. Properties and applications[ edit ] Due to their poor processability, conductive polymers have few large-scale applications. They have promise in antistatic materials [2] and they have been incorporated into commercial displays and batteries, but there have been limitations due to the manufacturing costs, material inconsistencies, toxicity, poor solubility in solvents, and inability to directly melt process. Literature suggests they are also promising in organic solar cells , printing electronic circuits , organic light-emitting diodes , actuators , electrochromism , supercapacitors , chemical sensors and biosensors , [25] flexible transparent displays, electromagnetic shielding and possibly replacement for the popular transparent conductor indium tin oxide. Another use is for microwave -absorbent coatings, particularly radar-absorptive coatings on stealth aircraft. Conducting polymers are rapidly gaining attraction in new applications with increasingly processable materials with better electrical and physical properties and lower costs. The new nano-structured forms of conducting polymers particularly, augment this field with their higher surface area and better dispersability. Research reports showed that nanostructured conducting polymers in the form of nanofibers and nanosponges, showed significantly improved capacitance values as compared to their non-nanostructured counterparts. In organic compounds, electroluminescence has been known since the early s, when Bernanose and coworkers first produced electroluminescence in crystalline thin films of acridine orange and quinacrine. In , researchers at Dow Chemical developed AC-driven electroluminescent cells using doping. In some cases, similar light emission is observed when a voltage is applied to a thin layer of a conductive organic polymer film. While electroluminescence was originally mostly of academic interest, the increased conductivity of modern

conductive polymers means enough power can be put through the device at low voltages to generate practical amounts of light. This property has led to the development of flat panel displays using organic LEDs , solar panels , and optical amplifiers. Barriers to applications[ edit ] Since most conductive polymers require oxidative doping, the properties of the resulting state are crucial. Such materials are salt-like polymer salt , which diminishes their solubility in organic solvents and water and hence their processability. Furthermore, the charged organic backbone is often unstable towards atmospheric moisture. The poor processability for many polymers requires the introduction of solubilizing or substituents, which can further complicate the synthesis. Experimental and theoretical thermodynamical evidence suggests that conductive polymers may even be completely and principally insoluble so that they can only be processed by dispersion. Conductive polymer products with embedded and improved electromagnetic interference EMI and electrostatic discharge ESD protection have led to both prototypes and products. For example, Polymer Electronics Research Center at University of Auckland is developing a range of novel DNA sensor technologies based on conducting polymers, photoluminescent polymers and inorganic nanocrystals quantum dots for simple, rapid and sensitive gene detection. Typical conductive polymers must be "doped" to produce high conductivity. As of , there remains to be discovered an organic polymer that is intrinsically electrically conducting.

## 4: Conductive Polymers

*Intrinsically conducting polymers, particularly the soluble derivatives, are attractive alternative charge dissipators for e-beam lithography. These materials combine high conductivity with ease of processability. The first conducting polymer to be evaluated in this type of application is polyaniline.*

The method includes contacting the film with a first acid dopant to form a primary doped intrinsically conductive polymer film; cleaning the primary doped intrinsically conductive polymer film by contacting the primary doped intrinsically conductive polymer film with a vapor; dipping the vapor-cleaned primary doped intrinsically conductive polymer film into a solution including at least a second acid dopant and an organic solvent to form a secondary doped intrinsically conductive polymer film; and annealing the secondary doped intrinsically conductive polymer film to produce a tertiary doped intrinsically conductive polymer film.

Description The present application claims priority to U. Provisional Patent Application Ser. The Government has certain rights in the invention. In another aspect, the present invention is directed to a method of doping an intrinsically conductive polymer film. These and other aspects of the invention will be understood and become apparent upon review of the specification by those having ordinary skill in the art. High IR drop is shown by the arrow. As the voltage increases, the activated carbon had a slow but steady increase in power. At low current, the IR drop is slight. Monomer concentration is 5 mM with 0. The monomer concentration is 1 mM with 0. The applied potential was 0. The polymer color was dark purplish-green. C Plot of current mA at polymer reduction potential vs. Each example is provided by way of explanation of the invention, not limitation of the invention. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. For instance, features illustrated or described as part of one embodiment can be used on another embodiment to yield a still further embodiment. Thus, it is intended that the present invention cover such modifications and variations as come within the scope of the appended claims and their equivalents. Other objects, features and aspects of the present invention are disclosed in or are obvious from the following detailed description. It is to be understood by one of ordinary skill in the art that the present discussion is a description of exemplary embodiments only, and is not intended as limiting the broader aspects of the present invention. It will be understood that whenever an electrically conductive polymer, ICP, or conductive polymer is referred to herein, it is meant that the material is associated with a dopant. A single acid may be used as a dopant, or two or more different acids can act as the dopant for a polymer. Unless otherwise described, the film can have almost any physical shape and is not limited to sheet-like shapes or to any other particular physical shape. Commonly, a film of a conductive polymer can conform to the surface of the dielectric layer of a solid electrolyte capacitor. Although any conductive polymer can be used in the present invention, examples of useful polymers include polyaniline PANI , polypyrrole, polyacetylene, polythiophene, poly phenylene vinylene , and the like. Polymers of substituted or unsubstituted aniline, pyrrole, or thiophene can serve as the conductive polymer of the present invention. In one embodiment, the conductive polymer is polyaniline. Polyaniline occurs in at least four oxidation states: The emeraldine salt is a form of the polymer that exhibits a stable electrically conductive state. In the emeraldine salt form of polyaniline, the presence or absence of a protonic acid dopant counterion can change the state of the polymer, respectively, from emeraldine salt to emeraldine base. Thus, the presence or absence of such a dopant can reversibly render the polymer conductive or non-conductive. The use of protonic acids as dopants for conductive polymers, such as polyaniline, is known and simple protonic acids such as HCl and H<sub>2</sub>SO<sub>4</sub>, functionalized organic protonic acids such as p-toluenesulfonic acid PTSA , or dodecylbenzenesulfonic acid DBSA result in the formation of conductive polyaniline. Although electrical conductivity is often a key property of the final product of a conductive polymer, conductive polymers in their conductive forms are often difficult to process. Doped polyaniline, for example, is typically insoluble in all organic solvents, while the neutral form is soluble only in highly polar solvents, such as N-methylpyrrolidone. It has been found, however, that certain methods of synthesis, and the use of certain functionalized organic acid dopants, rendered electrically conductive polyaniline salt more soluble in organic solvents. PANI is an

ICP considered a suitable candidate for application as electrode material in energy storage devices including supercapacitors. PANI exhibits good stability and film-forming capability. Additionally, PANI exhibits good electrochemical properties such as faradaic capacitance and charge-discharge capability. Doping of PANI is an important step in forming polymer chains with improved electrical conductivity. In one aspect, the present invention is a novel monomer that may be polymerized to form a novel ICP. Scheme 1 illustrates the synthesis of the novel monomer, bisethylene dioxythiophene-bisbenzothiadiazole BEDOT-BBT, compound 7 from the starting material benzothiadiazole BT, compound 1. Reduction of compound 5 with iron powder in acetic acid gives compound 6 greenish-yellow powder. To improve the yield, an alternative route as referenced in J. Vol 38, No 25, , page equation 1 may be utilized. In one aspect, the present invention is directed to novel methods of doping intrinsically conductive polymer films. In some embodiments, the novel methods are methods of secondary doping of ICP films. In other embodiments, the novel methods are methods of tertiary doping of ICP films. In yet other embodiments, the same methods may be used for both secondary and tertiary doping of ICP films. In some embodiments, the methods are particularly useful with respect to PANI films. It may be desirable, in some embodiments, to clean a primary doped ICP film prior to conducting a secondary doping. In some embodiments, the primary doped ICP film may be cleaned by methods known in the art including, but not limited to, solvent washing or rinsing. In another embodiment, the invention is a novel method of cleaning a primary doped ICP film. The novel method includes vapor cleaning a primary doped ICP film. In this embodiment, a primary doped ICP film may be vapor cleaned to enhance the electrical conductivity of primary doped ICP films. Suitable vapors include one or more vapors of Thymol, Carvacrol, isopropyl phenol, diisopropyl phenol, and meta-cresol. Vapor-cleaning may be understood as penetration of non-toxic phenol vapor into the nano-porous film network of the ICP film, resulting in the removal of un-bound dopants and residual solvent. This penetration may result in the creation of nanoporous voids to accommodate incorporation of secondary dopants. In one embodiment, the invention is a film dip-doping method of secondary doping of PANI films. The dip-doping method may be conducted alone or in combination with any of the cleaning methods discussed above, including the presently described vapor-cleaning method. Additionally, the method produces uniform PANI film samples having a thickness of from about 0. In the present embodiment, the film dip-doping may be conducted by dipping primary-doped ICP films into a mixture of an organic solvent and a protonic acid for a suitable period of time. In some embodiments, the film may be dipped for a period of from about 1 second to about seconds. In other embodiments, the time can be from about 5 seconds to about 60 seconds. In still other embodiments, the time can be from about 10 seconds to about 30 seconds. The protonic acid can be any protonic acid that can act as a dopant for the conductive polymer. The protonic acid can be the same as the primary dopant, or it can be a different protonic acid, or it can be a mixture of two or more protonic acids, any one of which can be the same or different than the primary dopant. In an embodiment of the present method, the protonic acid can act as a dopant that when combined with a conductive polymer not only provides electrical conductivity but also improves the thermal stability of the conductive polymer. Further examples of acids that are useful as the protonic acid are described in U. In one embodiment, the protonic acid comprises an organic sulfonic acid. The acid can have one, two, three, or more sulfonate groups. An example of a suitable organic sulfonic acid is a compound having the formula  $R_1HSO_3$ , where  $R_1$  is a substituted or unsubstituted organic radical. Another example of a material that is suitable for use as the protonic acid dopant is a compound having the formula: In the previous structure, it is also suitable when: In one embodiment, the protonic acid dopant comprises p-toluenesulfonic acid. Generally, an organic solvent may be selected so that it will dissolve both the protonic acid and the primary dopant. Examples of suitable organic solvents of the present invention include n-butanol, butylcellosolve, and mixtures thereof. Typically, the mixture of the organic solvent and protonic acid can comprise the protonic acid in an amount of from about 0. Although the mixture of the organic solvent and protonic acid can further comprise almost any other additive that increases the effectiveness of the contacting process, it is typically free of monomer of the conductive polymer and free of the conductive polymer before it contacts the doped conductive polymer film. Optionally, the mixture can consist essentially of the organic solvent and protonic acid. The films may be annealed by one or both of mechanical stretch annealing and chemical annealing.

Without being bound by theory, it is believed that mechanically annealing the films results in improved alignment and orientation of the polymer chains, thereby creating pathways for electron movement. Additionally, and without being bound by theory, it is believed that chemical annealing results in enhanced formation of crystalline domains in the doped ICP films. The combination of mechanical and chemical annealing may result in the formation of uniaxially aligned crystalline domains within the film, allowing increased electron movement in the film. This increased electron movement results in improved conductivity of the films. Mechanical annealing may be conducted on secondary or tertiary doped ICP films by stretching the films. In some embodiments, the films may be annealed at about room temperature. In other embodiments, it may be desirable to heat the film prior to annealing. The film may be heated by methods of heating known in the art including, but not limited to, IR heating, convection heating, thermal oven heating, gas heating, solar heating, and combinations thereof. The film may be subjected to mechanical stress to induce mechanical annealing. In some embodiments, the mechanical stress may be one or more of stretching, twisting, bending, pressing, and other mechanical deformations. When the film is heated prior to stretching, it may be desirable to maintain the film at an increased temperature during stretching. The film may also be allowed to cool to temperatures below the stretching temperature prior to the release of the mechanical stress. In some embodiments, it may be desirable to reduce the temperature to about room temperature prior to release of the mechanical stress. The mechanical stress may be parallel, i. The conductive ICP films may also be subject to chemical annealing. In some embodiments, the chemical annealing may serve as a tertiary doping method. Chemical annealing, where utilized in conjunction with mechanical annealing, may occur prior to, during, or after the mechanical annealing process discussed above. The conductive ICP films of the present invention may be chemically annealed by immersing the films in a solution of protonic acid and organic solvent. Protonic acids and organic solvents contemplated as useful in the present chemical annealing process may be selected from those protonic acids and organic solvents discussed above.

## 5: USA1 - Intrinsically conductive polymers - Google Patents

*PolyDrop provides economic solutions for ESD protection. Our conductive additives can support a wide range of applications.*

These polymers have unique electrical and thermophysical properties. Due to the low hydrogen content and aromatic structure, they show excellent chemical, thermal, and oxidative stability and are practically insoluble in all common solvents. They are also potentially electrical conducting materials, particularly when doped. Due to the fully aromatic ring structure and absence of freely rotating groups, the mobility of the repeat units is highly restricted which results in very high melting and softening points. This makes the synthesis and processing of these resins difficult and expensive. In fact, their melt viscosities are often so high that injection molding and similar processing methods are not feasible or practical. Polyphenylenes Polyphenylenes are an important class of conductive polymers. The phenylene units in these polymers are connected to one another through carbon-carbon single bonds resulting in linear polymers with a backbone that is comprised of aromatic rings only. By far the largest attention received poly para-phenylene PPP. It is quite insoluble in most solvents and has a very high melting point. It exhibits unusual electronic and optical properties and can be processed into a crystalline thin film, for example by vacuum deposition, that is electrically conducting when doped. PPP is photoconducting and has the potential for electroluminescence<sup>1</sup> EL applications such as light-emitting diodes. Polyphenylene vinylene s Poly para-phenylene vinylene PPVs and its derivatives are another important class of conductive polymers that have been widely studied because of many interesting and potentially useful optical and photo-electronic properties. The phenylene units in polyphenylene vinylenes are connected to one another through carbon-carbon double bonds resulting in a rigid, rod-like linear polymer comprised solely of double bonds and aromatic rings. It can be processed into a highly ordered crystalline thin film that is electrically conducting upon doping. Like PPP, PPV is capable of electroluminescent and can be used as the emissive layer in polymer-based organic light emitting diodes, for example, for electroluminescent displays. In fact, PPV was one of the first materials used for this purpose. Polyaniline PAN Another important conductive polymer is doped polyaniline. This polymer is not part of the polyphenylene family because it has amine groups in the backbone. It is a very attractive conductive polymer because it is relatively inexpensive, easy to synthesize, and can be easily chemically modified. Not surprising, it is one of the most studied conductive polymers and finds many applications as a conductor and for electromagnetic shielding of electronic circuits. Polyaniline is also used as a corrosion inhibitor and for the manufacture of conducting nanofibers. It can be easily processed and has many interesting electrical properties. It is chemically and thermally stable. Like many other fully aromatic polymers, PPy is an electrical insulator, however, when oxidized it becomes an electrical conductor. The conductivity of PPy strongly depends on the preparation technique, and on the polymer additives and can be increased by about two orders of magnitude. It can be used as a gas sensor, anti-electrostatic coating, solid electrolytic capacitor and as a component in many other electronic devices. Polythiophenes Poly thiophene and its derivatives are promising conductive materials. Undoped polythiophenes have rather low electrical conductivity. However, when doped at even low levels of less than one percent the electrical conductivity increases many times. In particular, regioregular poly 3-alkylthiophene s PATs are of special interest because of their relative structural order which leads to a high charge<sup>2</sup> carrier mobility. These polymers are soluble and fusible and demonstrate novel characteristics such as solvatochromism<sup>2</sup> and thermochromism<sup>3</sup>. Polyacetylene Polyacetylene or polyethyne repeating unit C<sub>2</sub>H<sub>2</sub> is a rigid, rod-like polymer that consists of long carbon chains with alternating single and double bonds between the carbon atoms. It is a well known conductive polymer as its discovery started the development of doped highly conductive organic polymers. They synthesized this polymer for the first time in the year when they prepared polyacetylene as a silvery film from acetylene, using a Ziegler-Natta catalyst. Despite its metallic appearance, the first attempt did not result in a conductive polymer. However, three years later, they discovered that oxidation with halogen vapor resulted in a conductive polyacetylene film, which had a much higher conductivity than any other previously known conductive polymer. Although its discovery started the

development of conductive organic polymers, polyacetylene has no commercial applications. One of the most exciting potential uses of these novel materials are compact electronic devices such as polymer-based transistors, light-emitting diodes and lasers. Some of these electronic devices might find novel applications in the electronic industry, for example in flat flexible television screens, and as acceptors in polymeric solar cells PSCs. We may soon see many other new electroluminescent plastics. Conductive polymers have the potential advantages of lower manufacturing cost and that they can be processed into thin films. Electroluminescence is caused by recombination of electrons and holes in a semi-conducting material. The excited electrons emit their energy as photons light during recombination with holes. The electrons and holes may be separated either by doping the material to form p-n junctions semiconductor electroluminescent or by excitation when high-energy electrons, accelerated by a strong electric field, pass through the material. Thus, the compound dye will have different colors in different solvents of different polarity. Thus, these materials change its color when the temperature is raised or lowered.

### 6: Corrosion Protection of Metals by Intrinsically Conducting Polymers - CRC Press Book

*Conducting polymers have been synthesized before by mixing polymers with metal or graphite powders. But in the case of a new class of materials, the conductivity was an intrinsic property. Therefore, the name intrinsically conducting polymers (ICPs) was recommended. Conducting properties can be achieved by reduction of the neutral state.*

### 7: Conductive polymer - Wikipedia

*The use of intrinsically conducting polymers (ICPs) like polythiophene (PTh), polypyrrole (PPy) and polyaniline (PANI) in devices and systems for electrochemical energy storage and conversion is briefly reviewed with a focus on an overview distinguishing between already established uses and potential applications.*

### 8: Intrinsically Conducting Polymers (ICPs) | Conductive Polymers | Bellevue | PolyDrop

*Conducting polymer nanocomposites present a class of hybrid materials in which various inorganic particles are combined with the conducting polymers in some chemical and/or electrochemical techniques.*

### 9: PEDOT: Principles and Applications of an Intrinsically Conductive Polymer - CRC Press Book

*This paper summarizes and reviews the research on electromagnetic interference (EMI) shielding with intrinsically conducting polymers (ICPs), mainly polyaniline (PANI) and polypyrrole (PPY), and their composites in various frequency ranges.*

Welcome, little one! Transcending Psychoneurotic Disturbances Boys Over Flowers, Vol. 30 (Boys Over Flowers)  
Macaulays Life of Johnson To sir phillip with love julia quinn History of military uniforms Shining Light on Constipation  
High school earth science International Trade and Global Development Africa, the Wonder the Glory (B.C.P. Pamphlet  
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