Use of conducting polymers in different Fields

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Abstract: Since the discovery of poly-acetylene, the field of conducting polymers is flourishing extensively. With the combination of electrical properties of conductors and advantages of polymers, drastic changes can be expected in day to day life. Conducting polymers and their composites find wide variety of applications ranging from consumer goods in day to day life to highly specialized application in the field of space technologies, electronics, non linear optics and medical science. In this paper, the important applications of conducting polymers are discussed to highlight the potential of such materials for future developments.

Introduction: Generally the organic polymers are insulators with special properties like strength, flexibility, elasticity, mouldability, ease of handling etc. The era of intrinsically conducting polymers (ICP's) started with Noble Prize work in Chemistry for the successful synthesis of polyacetylene as a silvery film with electrical properties and its subsequent doping by Shirakawa& Co-workers from acetylene using Ziegller – Natta catalyst in 1974 [1]. Conducting polymers are formed with the conducting properties of conductors using polymers which make them highly effective material. Their conductivities and permittivities could be tuned easily from insulating state to conducting state through chemical processes [2-10].Intrinsically conducting polymers (ICP) and their blends with thermoplastics are very promising materials for a wide range of applications such as electromagnetic interference shielding, batteries, actuators, chemical sensors, drug delivery, catalysis, anti static coating, corrosion protection, electro optic and electro chromic devices, solar cells and fuel cells.

Applications of Conducting Polymers

The discovery of electrically conducting polymers has attracted a lot of attention mainly because of their great potential for diverse applications. Some of these important applications of conducting polymers are discussed subsequently:

1. **Electro-Magnetic shielding:**The extensive utilization communication devices generate a large amount of EM waves in the living space of human beings. This EM emission leads to the problem of EM Interference (EMI), which not only causes damage to highly sensitive electronic equipment, but also has a remarkable negative effect on physical health. EMI shielding is a process by which a certain level of attenuation is extended using a strategically designed EM shield. ICP's with tunable electrical conductivity and dielectric properties possess unique shielding mechanism of reflection plus absorption rather than dominated reflection for metals and carbons. The intrinsic conductivity of conjugated polymers in the field of microwaves and the

dependence of their conductivity on frequency, permittivity, permeability, non-corrosiveness makes them viable shielding materials [11].

2. **Light weight and rechargeable batteries**

One of the most promising applications of conducting polymers is their use as rechargeable batteries. In polymers, where both *p*- and *n*-doping processes are feasible the possibility exists of their use as both positive and negative electrodes in the same battery system. The polymer battery, such as polypyrrole-lithium cell operates by the oxidation and reduction of the polymer backbone. During charging the polymer oxidizes anions in the electrolyte that enter the porous polymer to balance the charge created. Simultaneously, lithium ions in electrolyte are electrodeposited at the lithium surface. During discharging, electrons are removed from the lithium, causing lithium ions to re-enter the electrolyte. The positive sites on the polymer are reduced, releasing the charge-balancing anions back to the electrolyte. This process can be repeated about as often as in a typical secondary cell. Using thin films of conducting polymers, these solid state batteries may provide plasticity – a feature which would be welcome in various applications. Study of polypyrrole (PPy) / polyimides (PI) composite has also shown its promising properties and potential for use in polymer lithium ion batteries and in supercapacitors.

Advantages

a. Have longer shelf life than conventional batteries.
b. High durability and reliability.
c. Greater flexibility.
d. Do not contain any toxic material, hence easy to dispose.[12]

3. **Electromechanical Actuators:** Actuator is a part of a machine or system that controls the mechanism. It receives a control signal generally a low energy voltage or current signaland converts it into mechanical motion. Polymer based actuators operate by changing dimension or total volume of conducting polymer electrode by doping and de-doping(anodic strip and cathodic strip) during charging and discharging in accordance with the input signal.Due to the precision and quick response ICP's are very useful for the following actuators like**:**

    a) Micro-tweezers, micro-valves, micro-positioners for microscopic optical elements and actuators for micromechanical sorting are very useful for existing as well as future applications in the area of process and manufacturing automation.
    b) Electrically controlled drug delivery devices in the field of medicine [4].

4. **Chemical, Bio-Chemical and Thermal sensors**

The electrical properties of conducting polymers change due to reaction with various redox agents or due to their instability to moisture and heat. Conducting polymers are suitable as chemical sensors due to their high sensitivity, selectivity, high operating speed, reversibility and stability under operating conditions.

a) Conducting polymer like polypyrrole is used for the development of **gas sensors** as it's resistance in the presence of reducing gas such as ammonia and decreases in the presence of oxidizing gas such as NO_2.

b) Conducting polymers such as polyfulvenes (PFV) and polythiophene (PTP) can be used in humidity sensors and radiation detectors.

c) Conducting polymers used as biosensors utilizes the ability of triiodideto oxidize poly-acetylene(PA) as a means to measure glucose concentration. Glucose is oxidized with oxygen with the help of glucose oxidase, which produces hydrogen peroxide to oxidize iodide ions to form tri-iodide ions. Hence,conductivity depends upon peroxide concentration which in turn depends upon the glucose concentration[12-14].

5. Polymer Light Emitting Diodes(P-OLED/PLED)

Electro-luminescent conductive polymer that emits light when connected to an external voltage are used as a thin film between two electrodes, at least one of which is transparent. Polymers generally used for LED's are derivatives of poly(p-phenylenevinylene) and polyflourene. The colour of the emitted light, stability, performance and ease of processing depends upon the substitution of side chains onto the polymer backbone. OLED's are used to create digital displays in devices such as television screens, computer monitors, smart phones etc.PLEDs require small amount of power for the amount of light produced.

6. Aircrafts: Modern planes and spacecraft are often made with lightweight composites. This makes them vulnerable to damage from lightning bolts. By coating aircraft with a conducting polymer the electricity can be directed away from the vulnerable internals of the aircraft. [16]

7. Electrochromic devices: The intrinsic optical properties of polymers are determined by the energy gap between the conduction band and the valence band. The band gap of ICP can be varied under the action of applied electric field. Hence such materials change colour due to change of electric field. Such materials are used to control the sun energy crossing a window [7, 8]

8. Anti-static and Anti-corrosion: Conducting polymers can be used for corrosion protection of metals by different techniques like formulation of polymers with paints, by electro-deposition of conducting polymers onto metal surface and by direct addition of polymers in the corrosive solution as corrosion inhibitors. Coatings on the surface of metals by polymeric materials have been widely used in industries for the protection of these materials against corrosion.

Another important application of conducting polymer and their composites with conventional polymer is their use as an electrostatic charge dissipative material. Polyaniline is one of the most promising intrinsically conducting polymer (ICPs) because of its good environmental stability and high electrical conductivity, which can be reversibly controlled by a change in the oxidation state and protonation of the imine nitrogen groups. Blending of polyanilinewith conventional polymers like polypropylene, ABS, LDPE etc. can also be

used to improve the proccessability of polyaniline creating new materials with specific properties for the desired application at low cost by mixing it with a polymer that has good mechanical strength. [5,6]

Conclusion

We have discussed some of the significant properties of ICP's. Many of the application are currently in use, but much research is still needed to make these application more practical and commercially viable. Thus ICP's to be a challenging research problem in the years to come out with better future technologies.

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