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CONDUCTING POLYMERS AND IT'S APPLICATIONS: A REVIEW

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ABSTRACT

Because of their economic significance, stability, and electrical conductivity, as well as their valuable mechanical, optical, and electronic characteristics, conjugated polymers (CPs) have gotten a lot of attention. Conducting polymers are utilized in electrostatic materials, conductive adhesives, electromagnetic shielding against electronic radiation (EMI), artificial nerves, airplane constructions, diodes, and transistors, to name a few applications. This review discusses some of the potential uses of nanofibers and nanotubes in sensors, nanodiodes, field effect transistors, field emission and electro - optic displays, coupled capacitors and power storage, actuators, therapeutic agents, neural interfaces, and protein purification, as well as their future prospects.

KEYWORDS: *Biomedical, Conducting Polymers, EMI Shielding, Nano Devices, Sensors.*

1. INTRODUCTION

Nanotechnology has grown in popularity over the last decade as a result of its enormous potential for a wide range of applications. Nanostructures are divided into four categories: zero-dimensional, one-dimensional, two-dimensional, and three-dimensional structures. Because of its unique physical, chemical, and electrical characteristics, even in nanoscale systems, one-dimensional (1D-) nanostructures were a focus among them **[1].**The device function of a 1D-nanostructure is its second feature, which may be used as device components in a variety of nano devices. Carbon nanotubes, inorganic inductive in nature and metallic nano - tubes, conjugated polymer nanofibers/tubes, and other 1-dimensional with nanoscale and molecular-scale characteristics that may fulfill the needs of society in the twenty-first century have made considerable progress. Nanotechnology or molecule electronics, nanodevices and systems, nanocomposite materials, bio-nanotechnology, and medicine are all possible uses for these nanostructures.

A variety of conducting polymers, such as polyacetylene (PA), polyaniline (PANI), polypyrrole (PPY), poly(p-phenylenevinylene) (PPV), and poly (3,4-ethylene dioxythiophene) (PED), have special and unique characteristics including being a conducting mechanism, electrical properties, reproducible doping/dedoping process, controllable chemical and electrochemical properties, and easy processability. For the preparation of conducting polymer (CP) nanotubes and nanowires, a variety of synthetic strategies (both physical and chemical) have been used, including electrospinning, hard physical template-guided synthesis, chemical precipitation template synthesis (e.g., interfacial polymerization, template-free method, dilute polymerization, reverse emulsion polymerization, etc.), and lithography techniques. All of the properties of conducting polymers are briefly discussed in this review Figure 1 to understand their specific behavior and working, as well as their wide range of applications in chemical and biosensors, ground transistors, field emmisions and electrooptic display devices, supercapacitors, actuators, and separation membranes, among others **[2].**

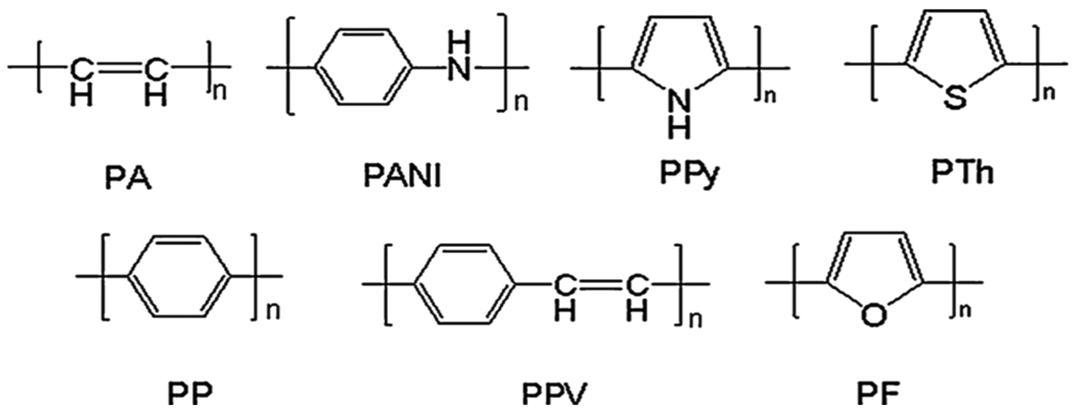

Figure 1 Structure of some conducting polymers[1]

2. DISCUSSION

1. Properties of conducting polymers:

Conducting polymers have a variety of unique characteristics, including electrical, magnetic, wetting, optical, mechanical, and microwave-absorbing capabilities, in addition to conduction.

Figure 2 **[1].**

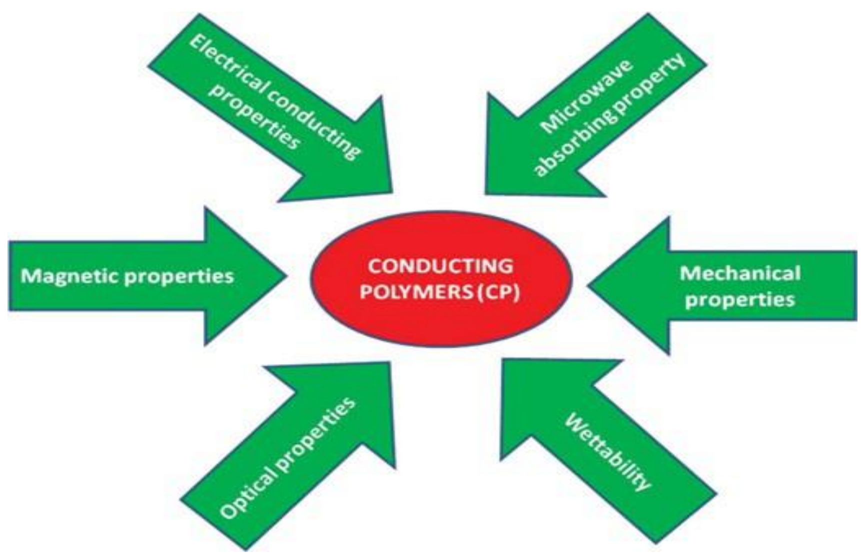

Figure 2: Properties of Conducting polymers.

1.1 Electrical-conducting properties:

Conducting polymers' electrical conductivity may approach the metallic conduction regime after doping. According to Martin, the conductance of a single nanotube is one or two exponentially higher than that of particle nanotubes or nanowires. Chen and colleagues investigated the electrical properties of PANI nanotubes and discovered that a single nanotube's conductivity was increased by two orders of magnitude. Because the insulating component partially blocks the conductive route, combining an insulating element with 1D-conducting polymer nanoparticles reduces electrical conductivity. Long et al. demonstrated that the resistivity of NSA-doped PANI=Fe3O4 hybrid nanowire pellets decreased with decreasing temperature, which is a normal semiconducting characteristic. The higher charge carrier dispersion among NSA-doped PANI\Fe3O4 nanoparticles is responsible for the lower composite conductivity. Various types of 1D-conducting nanocomposite materials systems showed a comparable reduction in electrical conductivity **[3].**

1.2 Magneticproperties:

Conducting polymers' magnetic characteristics have been widely researched because they offer crucial information about charge-carrying species or unpaired spins. The magnetic characteristics of PANI/Fe3O4 hybrid nanotubes produced by ultrasonic irradiation were investigated by Lu et al. investigated the magnetic characteristics of PANI\Fe3O4 composite nanorods made by self-assembly. The samples produced using the ultrasonic irradiation approach enhance the dispersion of Fe3O4 particles as comparing to the self-assembly method. The super-paramagnetic behavior of composite nanotubes produced using the ultrasonic irradiation method was observed. Magnetic characteristics of 1D-conducting polymers, such as Fe, Co, and Ni nanocomposites, have also been investigated **[4].**

1.3 Optical properties:

Because conducting polymers may be used in nanophotonic devices, their unique optical characteristics have been studied extensively. Photodetectors, photochemical sensors, and photonic wire lasers may all be made using 1D-nanostructured semiconductors. Xi et al. investigated the optical characteristics of CdS/PANI composite usually named and discovered that the photoluminescence spectrum resembled that of CdS nanowires, although signal intensities were increased. Photo-generated carriers transferred from the PANI layer into CdS nanowires, resulting in this improvement. Turac et al. evaluated the optical contrast, switching time, kmax, and band gap of a novel polythiophene derivative produced by electrochemical free radical polymerization of 2,5-di(thiophen-2-yl)-1-(4-(thiophen-3-yl)phenyl)-1-H-pyrrole(TTPP) **[5].**

1.4 Wettability:

Wettability is one of the most significant characteristics of a solid surface, and it has applications in self-cleaning surfaces, microfluidics, controlled drug administration, and bio-separation. Conducting polymers are often hydrophilic. Doping hydrophobic acids in conducting polymers results in a coating with super hydrophobic properties. Controlling the chemical composition of concluding polymers results in a reversibly swappable superhydrophobic and superhydrophilic surface. Chemical dual-responsive properties have also been shown in the hydrophilicity of films of PAN/PANI coaxial noanfibers. When formed on surfaces with decreasing hydrophilicity, a leading strand photopolymerized nanocomposite film comprising polystyrene and TiO_2 nanorods changes its wetting characteristic from hydrophobic to hydrophilic **[6].**

2. Applications of conducting polymers:

Conducting polymer nanocomposites have multifunctional and unique characteristics due to the synergistic impact of several components. As a result, conducting polymer nanocomposites are anticipated to find use in a variety of areas, including nanoelectronics, chemical and biological weapons sensors, catalysts or electrocatalysis, electricity, microwave absorbance and EMI shielding, ER fluids, and biomedicine (Figure 3) **[1].**

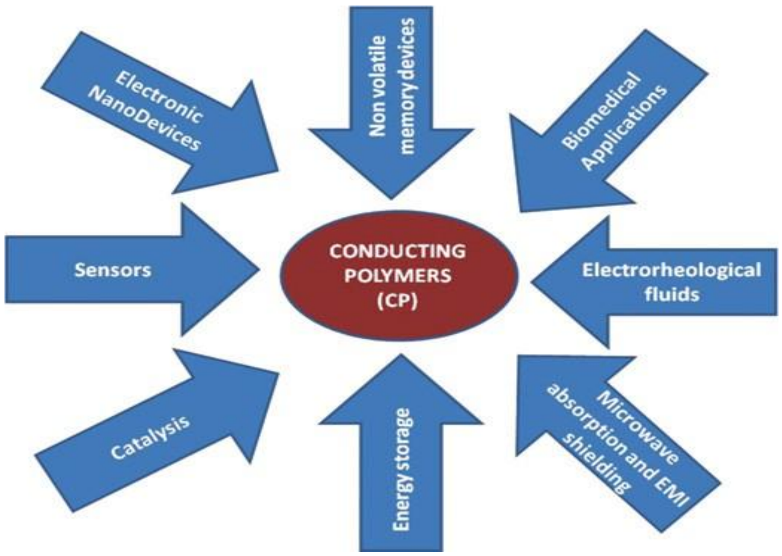

Figure 3: Applications of Conducting polymers.

2.1 Electronic Nanodevices:

Because of the high conductivity, mechanical flexibility, and cheap cost, most conducting polymers are well suited for the fabrication of electronic devices. Metals, semiconductors, carbon nanotubes, and insulating polymers may alter electrical conductivity of conducting polymers, which may be useful in light emitting diodes, transistors, memory, and photovoltaic systems **[7].**

2.2 Sensors:

Because their electrical and optical characteristics may be reversibly altered by doping/depoing procedures, conducting polymers have been extensively investigated as chemical sensors, optical sensors, and biosensors **[8].**

• *Chemical and Gas Sensors:*

Gas sensors are used in a wide variety of applications, including industrial manufacturing, food manufacturing, environmental monitoring, and health care. The sensitivity of PANI nanofibers produced by interfacial polymerization for the detection of NH_3 is considerably greater than that of ordinary PANI films. The inclusion of a second component to 1D-nanostructured conducting polymers, on the other hand, may improve their applicability as gas sensors **[9].**

In addition to NH_3, metal oxide nanoparticles incorporated into 1D-nanostructured conducting polymers may be used to detect various gases. For example, at ambient temperature, PANI/In_2O_3 composite nanofibers produced by carbondioxide polymerization were utilized as sensors to detect H_2, CO, and NO_2. PANI/WO_3 composite nanofibers were also used in H_2 gas sensors, but the sensitivity was lower than that of PANI/In_2O_3 composite nanofiber-based sensors. Metal salts may also be used as gas sensors in the 1D-nanostructured conducting polymer matrix. PANI/$CuCl_2$ composite nanofibers, for example, have a strong sensitivity to H_2S gas. The PANI-PVP mix has better sensitivity to $CHCl_3$ and has the least susceptibility to CH_2Cl_2. Surface plasmon resonance has been utilized to detect Zn_2 and Ni ions in aqueous solution using the polypyrrole chitosan layer.

2.3 Photocatalysis and Chemical Catalysis:

PANI/Pd composite nanofibers' catalytic capabilities have been investigated for application in Suzuki couplings reactions. Chemical catalysts were PANI/Pd nanotubes produced using the templating method. TiO_2 is a powerful photocatalyst with low toxicity and high oxidizing activity. The production of superoxidant (OH. and O_2) from water degrading in the vicinity of TiO_2 under radiation is ascribed to TiO_2 catalysis for degrading hazardous inorganic or organic compounds. The enhanced catalytic ability of TiO_2/PANI bilayer microtubes to breakdown methyl orange was attributed to the red shift of TiO_2's absorption area due to photosensitization by PANI **[6].**

2.4 Microwave Shielding and Absorption:

The fast development of electronics, wireless systems, navigation, space technology, and other technologies has resulted in a severe problem known as radio frequency interference (RFI). EMI has an impact on the functioning of electric devices as well as different living organisms, including humans. To avoid electromagnetic noise, shielding materials such as metals, carbon compounds, and conducting polymers have been used. Because of their excellent electrical conductivity and processibility, conducting polymers have gotten a lot of interest as shielding materials. When conducting polymers are coupled with other Nano components such as carbon nanotubes, PANI improves EMI shielding performance. Microwave absorbers and electromagnetic interference shielding materials may be made from polyaniline microtubes/nanofibers and polyaniline-multiwalled carbon nanotube Nano composites **[10].**

3. CONCLUSION

Significant progress has been achieved in the synthesis, structural and morphological characterizations, as well as the physical and chemical characteristics of electrically conducting nanofibers and nanotubes during the past 20 years. For greater control of 1492, future research should concentrate on enhancing synthetic techniques and developing new assembly procedures. However, there is still a need for simple, fast, and huge synthesis of conducting polymer nanostructures with uniform, non-disperse, and very well shape and size, including directed nanostructure arrays. From harvesting energy and biochemical sensing to electrical devices and medication administration, conducting polymer nanotubes and nanofibers have shown a wide range of applications.

However, due to complex microstructures of conducting polymers, there are still issues with realizing their full potential in nanoscale devices, such as reproducibility and/or controllability of individual polymer nanotubes=wires, doping level stability, and improving process ability of conducting polymer nanomaterials. Super capacitors made of conducting polymers are attracting growing interest in the energy sector because to their high specific capacitance. Their stability, on the other hand, is not particularly excellent. The addition of additional nanocomponent as a scafford of conducting polymers is anticipated to improve the super capacitor device's stability. However, further research is needed into novel techniques for fabricating such materials, as well as discovering new and improved characteristics and extending their uses. Trying to conduct polymer-based hybrid nanostructures offers a very broad and promising field of research, not only in terms of improving their properties and addressing challenges in their applications, but also in terms of achieving multifunctional nanosystems, which opens up new perspectives in the field of biomedical applications.

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