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Study of the optical properties of conductive polymers prepared from plant waste

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Abstract

Conductive polymers have a variety of optical and electrical applications, therefore they have gotten a lot of attention. In this study prepared conductive polymers from plant waste using thin-films method by spin coating. The formation of the (conductive polymers –okra plant) composite and (conductive polymers -okra plant- silver) nanocomposites using different added of Ag% (0.5%, 1%, 1.5%, 2%) was characterized by UV-vis spectroscopy. Transmutation, absorbency, absorption coefficient, and refractive index were the optical parameters studied. The results revealed that the lowest energy gap was obtained at (conductive polymers–okra plant) composite (3.82) eV and then began increased until it reached (4.1) eV in the (conductive polymers –okra plant -Ag) nanocomposites at (2% Ag) . According to the results, the okra plant improved the optical and conductive properties of the polymer, which resulted in the production of a pure copolymer, reinforced the polymer matrix, and was an effective reducing agent.

Key words: Polyaniline, Okra plant, Chloroform, Optical properties.

Introduction

Polymers with loosely held electrons in their backbones and that have conventional polymeric characteristics as well as electrical properties similar to metals and semiconductors they are known as conductive polymers (CPs), it is have gotten a lot of interest in the recent two decades conductive polymers [1,2]. One of the most important conductive polymers is polyaniline (PANI) [3,4]. The polymer's electrical conductivity ranges from (10^{-10}-10^{2} s/cm) [5]. PANI is a polymer with reduced benzoid units and oxidized quinoid units in a mixed oxidation state. This intriguing property of polyaniline was found by Green and Woodhead (1912). Furthermore, it was discovered that under certain experimental conditions, PANI could transition between being a conductor and an insulator [6]. That has sparked a lot of interest in recent years because of its lower costs, ease of preparation, and stability, as well as its high electrical resistance and lightweight design instead of metals conductive polymers were employed as electrical connectors, because polymers have a density of about one tenth that of minerals [7,23-35].When considering the use of fibers produced from plant bark as a composite strengthening procedure, they appear to be particularly suitable for polymer strengthening [8]. Polymer materials reinforced with natural (vegetable) fibers are composite materials consisting of high-strength fibers embedded in polymeric matrices. Pure polymers usually do not have the strength required for application in various fields [9]. A composite materials during the last few were widely used, it is made up of two elements (phases): a matrix material (which is a continuous phase) that is armored with a reinforcement material secondary phase (which is generally the discontinuous phase) [10,11]. Composite materials are classed based on matrix or reinforcement materials type, with polymer, metal, ceramic, and carbon matrix composites as matrix materials, and fibers, fills, whiskers, flake, particles, and directionally solidified eutectics as reinforcing materials [12,13]. Therefore, reinforcement with high-strength fibers provides significantly enhanced physical properties of the polymer, It makes fiber-reinforced polymer composites suitable for a large number of applications in various industrial, medical and other fields. The fibers in these materials are the elements that carry loads, while polymer matrices preserve fiber alignment (position and direction) and shield them from the environment and potential harm they also give strength and stiffness [9]. Okra is one of the natural fibers that improve the optical and conductive properties of polymers [14]. Okra, an annual herb Malvaceae thrives in tropical, subtropical and temperate regions all over the world due to its ease of cultivation and its robust and resistant plant, It is beneficial for human health because it contains biologically active substances such as pectin, sugars and other nutrients [15]. Polymeric compounds reinforced with plant fibers are characterized by their sustainability and light weight, as they are cost-effective, simple and less toxic compared to other polymeric compounds used for multi-nanoparticles attributed to metals [16,17]. The novelty of this work the synthesis of conductive polymer from Okra mucilage and study of its optical properties.

Techniques for sample preparation and experimentation

Materials and methods

In this study, conductive polymer, okra plant, and silver (Ag) nanoparticles were employed, as well as chloroform as a solvent.

Synthesis

To prepared conductive polymer, okra plant and silver (Ag) nanoparticles, there are four methods:

1- we have prepared conductive polymer by dissolving (1gm) of polyaniline in (100 ml) chloroform, then stirring the solution with a magnetic stirrer to make it homogenous.

2- To prepared okra plant , wash it thoroughly with water, chop it into pieces, and soak it overnight in distilled water. After that, the mucilage was extracted by filtering it through muslin cloth, and the extracted mucilage was dried in a 40° C oven. Then (1gm) of dried okra (powder) is dissolved in (50 ml) of chloroform, and the mixture is stirred with a magnetic stirrer. It will be agitated for two hours to create a homogenous solution, then filtered and utilized as an extract. To prepared a (conductive polymer - okra plant) composite, mix the two solutions Polyaniline and Okra plant for 60 minutes with a magnetic stirrer.

3- Silver nanoparticles are prepared by dissolving (0.03 gm) in chloroform (10 ml) and stirring the liquid for 60 minutes in a magnetic stirrer.

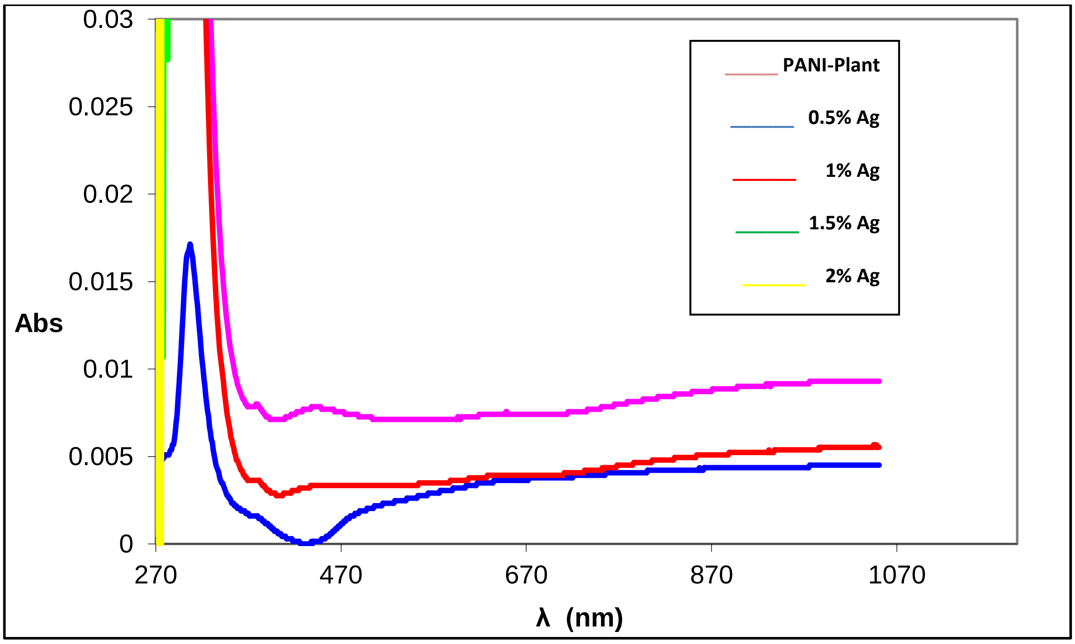
4- Spin coating is used to prepared thin-film (polyaniline – conductive polymer from okra plant) composite and (polyaniline – conductive polymer from okra plant - silver) nanocomposites by adding silver nanoparticles in various amounts (0.5 %, 1 %, 1.5 %, 2 %) to the (polyaniline - okra) composite.

Results and discussion

Optical characterization

Absorption spectrum

Figures (1) and (2). show the UV–vis absorption spectra and absorption coefficient of (polyaniline – conductive polymer from okra plant) composite and (polyaniline– conductive polymer from okra plant - silver) nanocomposites. The absorbance values and absorption coefficient are high in the (polyaniline – conductive polymer from okra plant) composite, while they are lower in the (polyaniline– conductive polymer from okra plant - silver) nanocomposites. In the (polyaniline - conductive polymer from okra plant) composite, there are two primary absorption bands at (325 nm) and (430) respectively. The transition in the benzinoid chains from PANI causes the first domain, whereas the transition in the kinoid loops from PANI causes the second domain [8,18]. The findings show that the okra plant extract functions as a filler for polymer matrices and contains a variety of organic reducing agents in various combinations and concentrations [19,20]. where the chemical groups lignocellulose fiber components (cellulose, hemicellulose, and lignin) of the okra plant appear Absorption bands [8,18].In this system, initiates polymerization to produce a new polymeric (graft copolymer) material [21]. This finding suggests that the okra plant may interact with polyaniline units, resulting in electrical band alterations.



Fig(1). Absorbance spectrum as a function of the wavelength of (polyaniline – conductive polymer from okra plant) composite and (polyaniline– conductive polymer from okra plant - silver) nanocomposites.

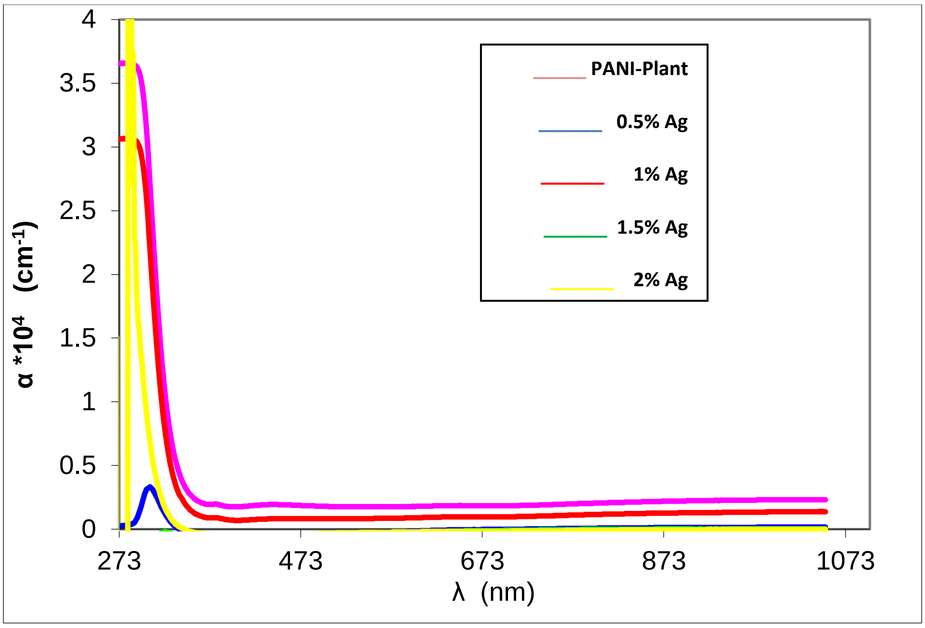


Fig (2). Absorption coefficient spectrum as a function of the wavelength of (polyaniline – conductive polymer from okra plant) composite and (polyaniline– conductive polymer from okra plant - silver) nanocomposites**.**

Optical energy gap

The energy gap is the amount of energy necessary to transfer electron from the top of the valence beam to the bottom of the conduction beam, by showing the graphical relationship between (hv) $^{1/2}$ as a function of photon number, the energy gap value for allowed direct transmission was calculated energy (hv) as in Figure (3).The magnitude of the direct energy gap is represented by junction of the curve's outer tangent with the photon energy axis (hv) $^{1/2}$ = 0) [22].

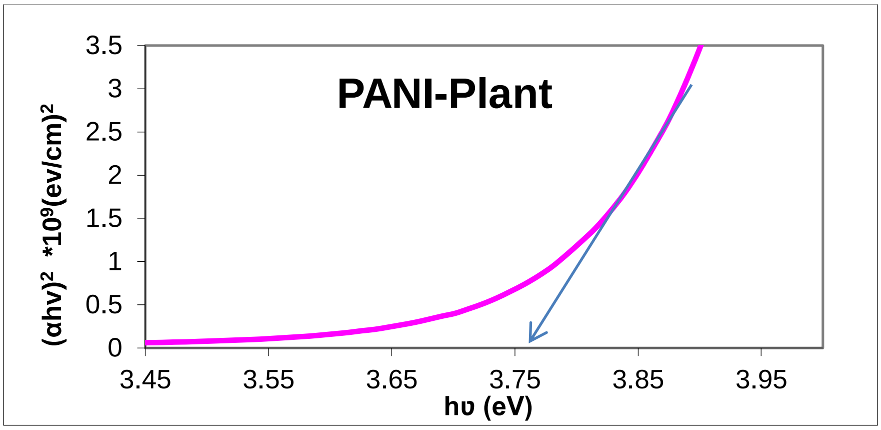


Fig (3A). Energy gap of (polyaniline – conductive polymer from okra plant) composite.

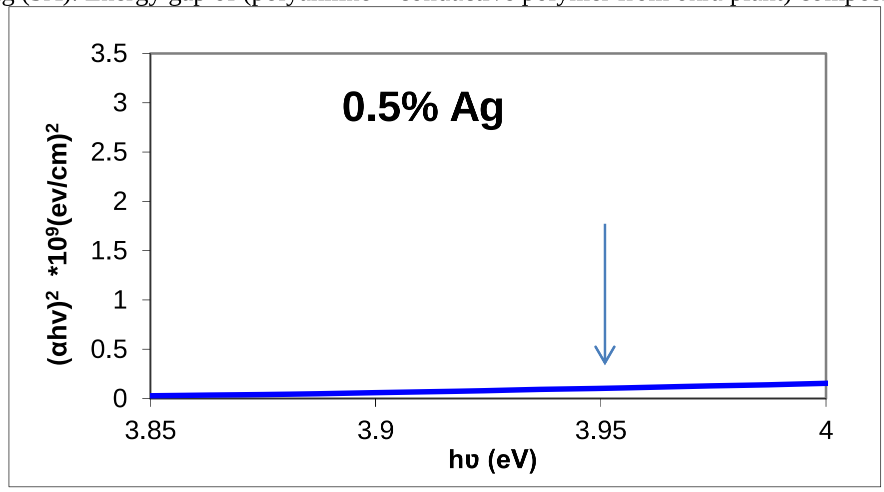


Fig (3B). Energy gap of (polyaniline– conductive polymer from okra plant - silver) nanocomposites / 0.5% Ag .

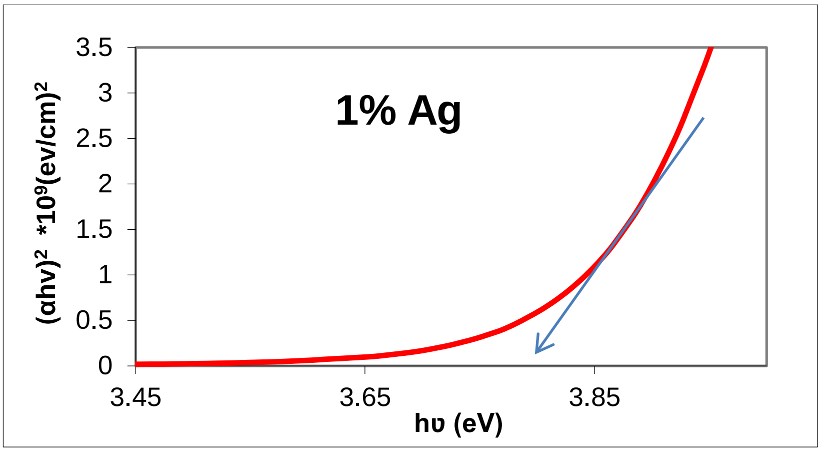


Fig (3C). Energy gap of (polyaniline– conductive polymer from okra plant - silver) nanocomposites / 1% Ag .

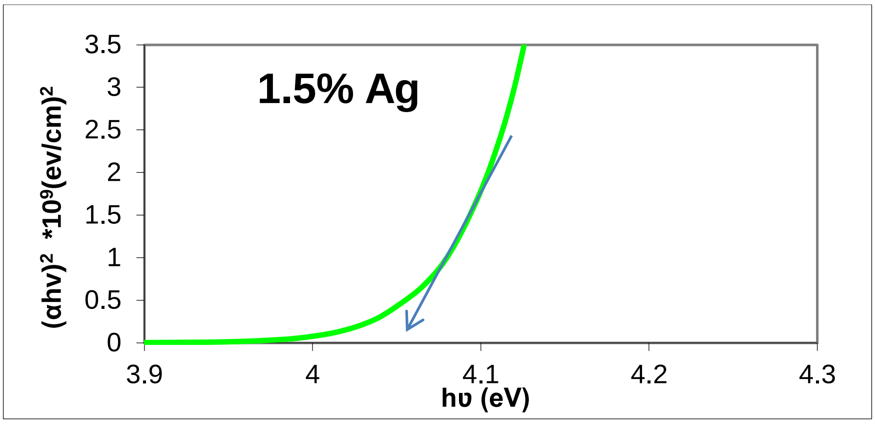


Fig (3D). Energy gap of (polyaniline– conductive polymer from okra plant - silver) nanocomposites / 1.5% Ag .

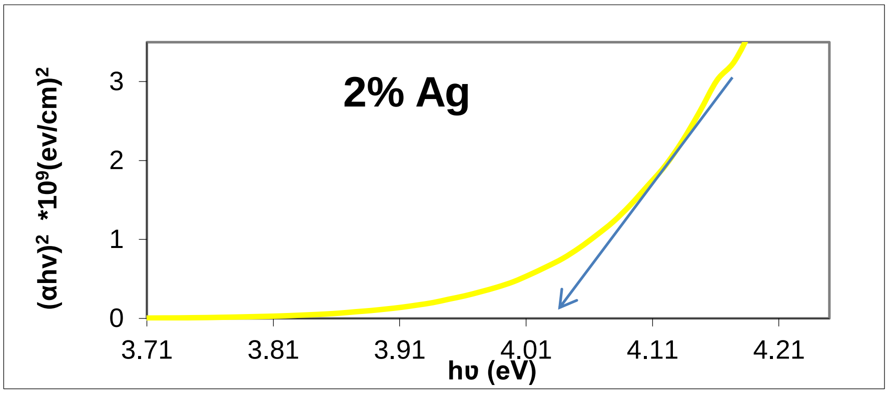


Fig (3E). Energy gap of (polyaniline– conductive polymer from okra plant - silver) nanocomposites / 2% Ag .

The energy gap values of (polyaniline– conductive polymer from okra plant) composite and its nanocomposites ranged from (3.82-4.1) ev, with (polyaniline– conductive polymer from okra plant) composite having the lowest value. The optical energy gap of (polyaniline– conductive polymer from okra plant) composite and its nanocomposites is shown in Table (1). where Figure (4) shows the contrast of Eg with (Ag%) content. We conclude from our research that okra plant enhances the conductivity of the polymer.

Table (1): Showing value energy gap of (polyaniline–conductive polymer from okra plant) composites and (polyaniline–conductive polymer from okra plant -silver) nanocomposites.

(polyaniline–conductive polymer from okra plant) composites	0.5% Ag	1% Ag	1.5% Ag	2% Ag	Specimen
3.82	3.95	3.85	4.07	4.1	Eg (ev)

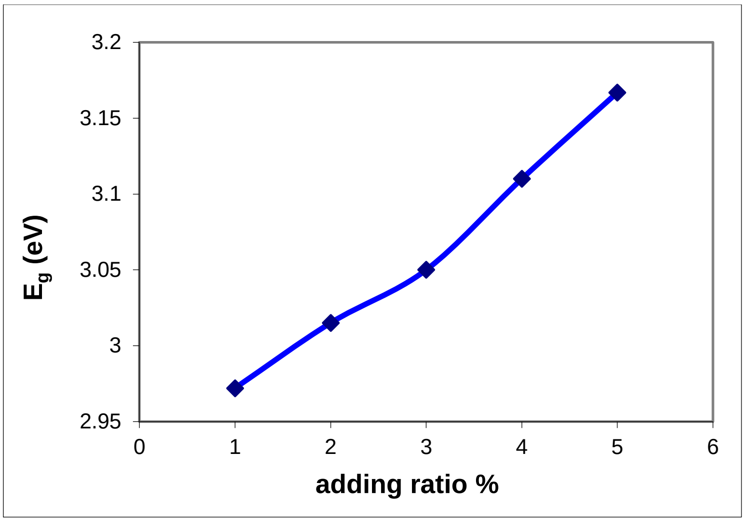
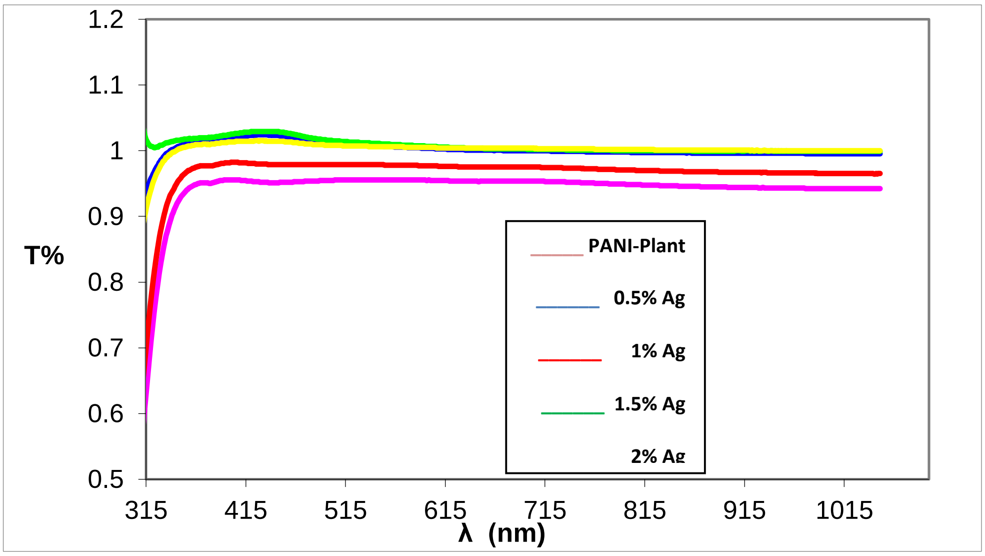


Fig (4). The variation of Eg with the Ag% contents.

Transmittance spectrum

Figure (5). shows the transmittance spectra of (polyaniline–conductive polymer from okra plant) composites and (polyaniline– conductive polymer from okra plant- silver) nanocomposites as a function of wavelength. As a result of electronic transitions, it is observed that transmittance decreases with higher wavelengths [7].



Fig(5). Shows the transmittance spectra

Refractive index

The Figure (6) shows the values of refractive index (n) as a function of wavelength for (polyaniline–conductive polymer from okra plant) composites and (polyaniline– conductive polymer from okra plant- silver) nanocomposites.

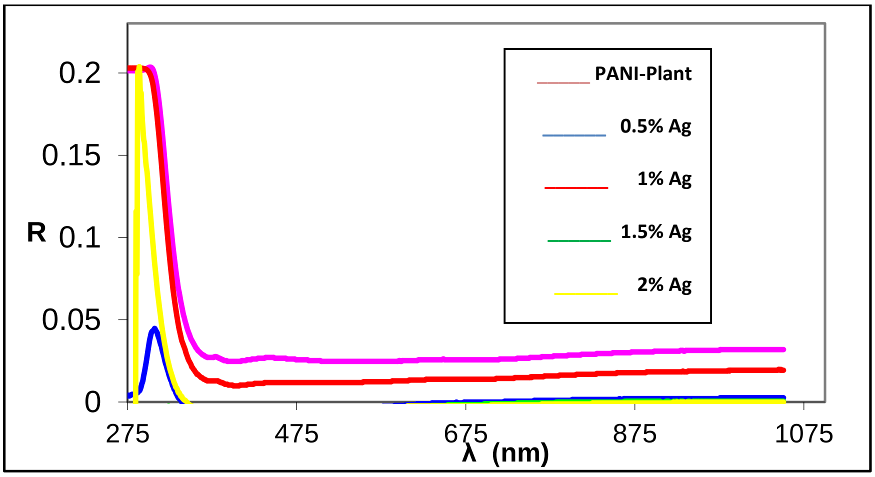


Fig (6). Illustrates refractive index .

It has been found that the values of (n) increases in (polyaniline–conductive polymer from okra plant) composites, this increase can be attributed on the basis of okra plant which in turn increase the degree of cross-linking between chains polymer. This results in an increase in the deflection of the optical path of the light wave through the material, i.e. a decrease in the speed of light [20,7].

Conclusion

1-A method of thin films by spin coating was used to prepared the (polyaniline–conductive polymer from okra plant) composites and (polyaniline– conductive polymer from okra plant -silver) nanocomposites in this study. The optical absorbance, absorption coefficient and refractive index of the (polyaniline–conductive polymer from okra plant) composites all increased, whereas the transmittance spectrum decreased.

2- The energy gap in the (polyaniline–conductive polymer from okra plant) composites is 3.82 ev, it has a direct permissible energy gap and it began to increased when the adding silver nanoparticles. So, employing the okra plant improve the optical properties of conducting polymers while also increasing the polymer's conductivity.

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