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Editorial corner – a personal view

Electrically conductive polymer composites: Today's most versatile materials?

Roland Petrény[1], *Ádám Bezerédi*[1], *László Mészáros*[1,2*]

[1]Department of Polymer Engineering, Faculty of Mechanical Engineering, Budapest University of Technology and Economics, Műegyetem rkp. 3. H-1111, Budapest, Hungary
[2]HUN-REN–BME Research Group for Composite Science and Technology, H-1111 Budapest, Műegyetem rkp. 3., Hungary

Electrically conductive polymer composites represent a class of materials that have garnered significant attention due to their unique combination of electrical conductivity and properties attributed to plastics, such as light weight, corrosion resistance and low-cost manufacturability. Electrically conductive polymer composites are typically created by incorporating conductive micro- or nanoparticles into the polymer matrix, including carbon-based materials like carbon fibers, nanotubes (CNTs) or graphene, (https://doi.org/10.1016/B978-0-12-814615-6.00006-0). These materials contribute to the overall electrical conductivity of the polymer composite. The conductivity of these composites can range from insulating to metal-like conductivity, depending on factors such as the type, concentration and distribution in the matrix of the conductive particles used.

In addition to electrical conductivity, the incorporation of conductive particles can modify other properties of the polymer as well. For example, mechanical properties like strength and ductility may deteriorate, magnetic properties may be enhanced, and thermal properties such as thermal conductivity may be improved. These modifications make conductive polymers versatile materials suitable for various applications. However, they often make it difficult to use the composite as a structural material. Also, two of the main advantages of polymers, their ease of production and low cost, may be lost (https://doi.org/10.1016/j.heliyon.2022.e10287).

Conductive polymer composites find applications across a wide range of fields. Due to their ability to conduct electricity as a function of changes in the environment, conductive polymers are used in sensors for detecting various parameters such as temperature, pressure, humidity, and chemical composition (https://doi.org/10.3144/expresspolymlett.2023.63). By immobilizing specific biomolecules on a conductive polymer surface, these sensors can selectively capture and quantify target analytes, enabling applications in medical diagnostics, environmental monitoring, and food safety (https://doi.org/10.1016/j.ceja.2023.100516). These materials are also utilized in prosthetic devices to create interfaces with biological tissues, enabling communication between electronic devices and the nervous system (https://doi.org/10.1002/adma.201501810). Conductive polymers can be incorporated into textiles to create smart fabrics, which can monitor physiological parameters, detect environmental changes, and provide feedback or stimulation to the wearer, enabling applications in healthcare, sports performance monitoring, and interactive clothing (https://doi.org/10.1177/1528083717699368, https://doi.org/10.1021/acsami.1c15014). Without conductive polymer composites and energy storage systems using them, the exploitation of renewable energy sources would be difficult (https://doi.org/10.1155/2022/2266899). Their electrochemical stability also makes them suitable for electrode materials, improving the performance and efficiency of

*Corresponding author, e-mail: meszaros@pt.bme.hu

energy storage systems such as lithium-ion batteries and fuel cells (https://doi.org/10.3390/polym12122993, https://doi.org/10.1039/C4RA17254J). The large interface area between the matrix and the conductive fillers and the high electrical conductivity of these polymer composites make them suitable for use in supercapacitors, which can be used as energy storage devices with relatively high power density and fast charge/discharge rates (https://doi.org/10.3390/jcs8020053).

Future research in the field of electrically conductive polymers may focus on developing novel synthesis methods and improving the dispersion of conductive particles within the polymer matrix for higher levels of conductivity. Another much-researched area can be to tailor the properties of conductive polymers to meet specific application requirements, such as designing materials with simultaneous electrical, mechanical, and thermal functionalities. For applications in bioelectronics, drug delivery, and tissue engineering, the biocompatibility and biofunctionalization of conductive polymers needs to be further investigated.

Electrically conductive polymer composites represent a promising class of materials with many uses and unique properties. Researchers are constantly working to expand the potential applications of these materials and improve their performance. As a result, conductive polymer-based technologies are becoming more prevalent in various industries.