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Polymer Matrix Composites

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The light weight and high performance of polymer matrix composites (PMCs) are attractive in many applications that can benefit from weight saving. Many advanced applications such as aircraft structures are now using fiber-reinforced composites. Future innovations are needed to further improve the mechanical properties, develop multifunctionality, and develop processing methods that are fast and inexpensive. Consequently, there is significant focus on finding reinforcements and processing conditions that can fulfill such requirements.

The articles presented on this topic are focused on polymer matrix composites. The topic is a continuation of a set of articles published in the June issue on metal matrix composites. Together, these two topics cover a wide range of composite materials relevant to modern industrial and structural applications that require lightweight high-performance composite materials. The topic stems from the symposium Metal and Polymer Matrix Composites III, which was organized as a part of the Materials Science and Technology 2017 conference, but the article submission was not limited to symposium participants. Rapidly growing applications of composite materials in a variety of fields such as aerospace structures, marine structures, consumer goods, and sports equipment resulted in strong participation in the symposium, and the articles capture some of important advancements in the area of micro- and nano-composites.

Conventional composite materials that are now used in aerospace and automotive applications are reinforced with continuous or discontinuous carbon or glass fibers. Production models of many luxury and performance cars have numerous components made of composite materials for weight-saving purposes because of close control over the properties of composites as a result of academic and industrial research in the past decades. In addition, Kevlar and polyethylene fiber-reinforced composites have found applications in ballistic protection. With all these applications already in place, the innovations in the field of composites have moved to areas such as nano- and multiscale composites, functional composites with self-healing or electromagnetic interference (EMI) shielding capabilities, and smart composites with sensing and actuation capabilities. Innovations also include surface modification of fillers for improved compatibility with the matrix for effective load transfer at the interface. The articles presented in this collection are focused on some of these issues for developing next-generation composites.

Use of industrial waste and natural materials offer the possibility of developing low-cost composites. The influence of marble dust (0–30 wt.%) on the mechanical and thermal properties of needle-punched nonwoven jute fiber/epoxy composites is studied by Sharma and Patnaik. The composites were synthesized using vacuum-assisted resin transfer molding. The study found that the filler addition increases the flexural strength, interlaminar shear strength, and thermal conductivity, but decreases the tensile strength.

The drilling mechanism of lightweight syntactic foam, presented by Ashrith et al., is different from that of conventional materials because the drill bit experiences different resistance levels offered by the abrasive hollow filler shell, matrix, and air pockets. Based on the experimental results, Grey relation analysis is conducted to identify processing parameters that can provide the best hole quality. A combination of lower filler content, cutting speed, and drill diameter produces good quality holes. Drill diameter is found to be a dominant factor in determining the drilling hole quality. The results can help industrial practitioners to set appropriate parameters during drilling of syntactic foams.

Nikhil Gupta, *JOM* Advisor, and Mrityunjay Doddamani, Guest Editor for the Composite Materials Committee of the TMS Structural Materials Division coordinated the topic Metal and Polymer Matrix Composites in this issue.

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A novel approach to microwave-assisted curing of silicon carbide-reinforced epoxy composites is presented by Pal et al. Dielectric properties, particularly the loss factor, and thermal and mechanical properties are found to increase with SiC loading. Thermal and mechanical property enhancement is observed for microwave-cured composites compared with the composites pre-cured at room temperature at the same SiC content.

Mishra et al. discuss the synthesis and characterization of a nanographite-filled polyurethane composite with a high dielectric constant. Nanographite dispersed uniformly in the polyurethane matrix, and the composite was studied for its dielectric constant (ε) as a function of frequency. The composite exhibited a logarithmic decrease in ε from $\sim$ 3000 at 100 Hz to $\sim$ 225 at 60 kHz AC field with a significant improvement compared with the polyurethane dielectric constant. The material also exhibited a stable dissipation factor (tan δ) across the applied frequencies implying ability to withstand the current leak. The percolation threshold was observed to be 3 wt.% of nanographite in the composite. The composite also exhibited relatively low dielectric loss with increasing frequency. These properties show that such composites can be suitable for EMI shielding applications.

The study by Buruga and Kalathi modified halloysite nanotubes (HNTs) with γ-methacryloxypropyltrimethoxysilane (γ-MPS) to improve their interaction with the polymethyl methacrylate (PMMA) matrix. The nanocomposites were fabricated using modified HNTs by miniemulsion polymerization assisted by ultrasound. Differential scanning calorimetry (DSC) analysis showed enhancement of the thermal stability of the composite due to the HNT modification. The improvement in dispersion of HNTs in the matrix resulting in enhanced properties is attributed to the combination of HNT surface treatment using γ-MPS and the ultrasound-assisted miniemulsion process.

Khalifa et al. discussed that addition of nanoalumina trihydrate (ATH) and electrospinning synergistically facilitate the enhancement of the β phase of polyvinylidene fluoride (PVDF) up to 10 wt.% filler loading. Piezoelectric voltage output was the maximum at the same ATH loading under both static and tapping modes. The low cost of fabrication, ecofriendliness of ATH, and improved piezoelectric performance of the electrospun nanocomposite fibers played a prominent role in energy harvesting and self-powering of nanodevices.

Shishkin et al. discussed the process of coating a metal layer around hollow glass particles. Such lightweight particles can be used to synthesize syntactic foams. Films as thick as the particle shell could be deposited using a variety of metals. The coated particles were sintered and tested for compressive properties, and the properties were found to depend on the sintering temperature. Infiltration of polymer or metal matrix material in the bed of coated particles can provide syntactic foams with high mechanical properties.

The following papers are published under the topic "Metal and Polymer Matrix Composites" in the July 2018 issue (vol. 70, no. 7) of *JOM* and can be accessed via the *JOM* page at http://link.springer.com/journal/11837/70/7/page/1.

- "Experimental Investigation on Mechanical and Thermal Properties of Marble Dust Particulate-Filled Needle-Punched Nonwoven Jute Fiber/Epoxy Composite" by Ankush Sharma and Amar Patnaik.
- "Hole Quality Assessment in Drilling of Glass Microballoon/Epoxy Syntactic Foams" by H.S. Ashrith, Mrityunjay Doddamani, Vinayak Gaitonde, and Nikhil Gupta.
- "Microwave-Assisted Curing of Silicon Carbide-Reinforced Epoxy Composites: Role of Dielectric Properties" by Ranu Pal, M.J. Akhtara, and Kamal K. Kar.
- "Synthesis and Characterization of High Dielectric Constant Nanographite and Polyurethane Composite" by Praveen Mishra, Badekai Ramachandra Bhat, B. Bhattacharya, and R.M. Mehra.
- "Fabrication of γ-MPS-Modified HNT-PMMA Nanocomposites by Ultrasound-Assisted Miniemulsion Polymerization" by Kezia Buruga and Jagannathan T. Kalathi.
- "Synergism of Electrospinning and Nano-alumina Trihydrate on Polymorphism, Crystallinity and Piezoelectric Performance of PVDF Nanofibers" by Mohammed Khalifa, B. Deeksha, Arunjunairaj Mahendran, and S. Anandhan.
- "Metal-Coated Cenospheres Obtained via Magnetron Sputter Coating: A New Precursor for Syntactic Foams" by A. Shishkin, I. Hussainova, V. Kozlov, M. Lisnanskis, P. Leroy, and D. Lehmhus.