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Editorial

Manufacturing, Characterisation and Properties of Advanced Nanocomposites

Yu Dong [1,*], Alokesh Pramanik [1], Dongyan Liu [2] and Rehan Umer [3,4]

[1] School of Civil and Mechanical Engineering, Curtin University, GPO Box U1987, Perth, WA 6845, Australia; alokesh.pramanik@curtin.edu.au
[2] Titanium Alloys Division, Institute of Metal Research (IMR), Chinese Academy of Sciences (CAS), Shenyang 110016, China; dyliu@imr.ac.cn
[3] Centre for Future Materials, University of Southern Queensland, Toowoomba, QLD 4350, Australia; rehan.umer@usq.edu.au
[4] Department of Aerospace Engineering, Khalifa University of Science and Technology, Abu Dhabi 127788, UAE
* Correspondence: Y.Dong@curtin.edu.au; Tel.: +61-8-9266-9055

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Advanced nanocomposites have demonstrated great potential over conventional composites owing to the incorporation of well-dispersed nanofillers with extremely small sizes of a few hundred nanometers in platelet-like, fibre-like, tubular, and spherical shapes. The enormous commercial success of nanocomposites, such as the use of polypropylene/clay nanocomposites to manufacture General Motors' step-assist, sail panels, centre bridges, and box-rail protectors, reveals the material innovation and development in this field. The breakthroughs in advanced nanocomposites, from the research and development viewpoint, rely primarily on how to achieve homogeneous nanofiller dispersion within matrices by means of mechanical processing with high shear stress or chemical modification or treatment. As such, a good understanding of the processing–structure–property relationship is critical to design robust and well-tailored nanocomposites for their wide range of applications.

This special issue consists of 10 research papers covering advanced nanocomposites reinforced with nanoclays, cellulose nanowhiskers, graphene oxides (GOs), metal nanoparticles, electrospun nanofibres, etc., in relation to their manufacturing, characterisation, and properties. Wang et al. [1] investigated the effect of polyhedral oligomeric silsesquioxane (POSS) and hydroxyapatite (HA) nanoparticles on reinforcing chitosan (CS) in biocomposite fibres. Their results revealed that only fracture-related properties became sensitive to the effects resulting from the interaction between nanoparticle type and concentration. Rahman and Wu [2] carried out a holistic computational study to evaluate the effects of processing parameters, such as the extent of clay exfoliation and clay volume fraction, on the nonlinear elastoplastic behaviour of polymer/nanoclay composites, which was based on the implementation of representative volume element (RVE) in finite element analysis (FEA). It was found that large aspect ratios of clay platelets with full clay exfoliation was crucial for achieving preferable mechanical properties of nanocomposites reinforced with nanoclays. This work also offered guidelines for the computer-aided design of processing-property-tailored nanocomposites. Liu et al. [3] electrospun polylactic acid (PLA)/cellulose nanowhisker (CNW) composite nanofibres and confirmed uniform CNW distribution within PLA nanofibres along the direction of the fibre axis. Besides, the water absorption of PLA nanofibres were effectively improved with embedded CNWs. It is anticipated that both CNWs and their composite nanofibres can lead to widespread applications for biomedical engineering, sensors, and nanofiltration. Pramanik et al. [4] utilised a single insert milling tool to assess the face milling of nanoparticles reinforced Al-based metal matrix composites (nano-MMCs). The impacts of feed and speed on machined surfaces of nano-MMCs in relation to surface roughness, profile and appearance, chip surface and ratio, machining forces, and force signals were analysed in a systematic manner. Umer [5] studied the processing characteristics and mechanical properties of glass fabric reinforcements coated with graphene nanoparticles in epoxy composites via vacuum-assisted resin transfer moulding (VARTM). The relevant results indicated that flexural strengths of composites decreased with increasing the weight fraction of graphene nanoparticles despite no change in flexural modulus. On the other hand, the ply-delamination phenomenon occurred arising from the coating of graphene nanoparticles on glass reinforcements, which also generated localised damage resistance under low-velocity impact as opposed to pure glass samples. Chen et al. [6] implemented a sol–gel method to prepare epoxy/multilayer GO composites. It was evidently shown that both the thermal stability and flame retardancy of composites could be improved with the addition of GOs with modified silicon. Rao et al. [7] worked on the effect of electrical conductivity reduction of GOs as effective nanofillers in thin films by using a partial factorial design of experiments based on the Taguchi method. The experimental findings suggested that the electrical resistivity of GOs highly depended on the type of acid treatment, and that samples treated with hydroiodic acid had the lowest resistivity of ~0.003 Ω·cm. Basak et al. [8] examined the property improvement of Sn–Ag–Cu (SAC) alloys by incorporating two different types of Fe and Al_2O_3 nanoparticles. The addition of Fe nanoparticles led to the formation of $FeSn_2$ intermetallic compounds (IMCs) along with Ag_3Sn and Cu_6Sn_5 from monolithic SAC alloys, while Al_2O_3 nanoparticles acted as a grain refiner with good dispersion along primary β-Sn grain boundaries without the contribution to phase formation. Notwithstanding that insignificant effect arose from the inclusion of Fe and Al_2O_3 on the thermal behaviour of nanocomposites, their nanoreinforcement potentially gave rise to better mechanical performance when compared with that of conventional monolithic SAC solder alloys. Nakagaito et al. [9] explored reinforcing PLA by the combination of cellulose and chitin nanofibres rather than a single reinforcement phase. Such nanocomposites demonstrated higher tensile properties than those reinforced with cellulose or chitin nanofibres alone. It appeared that chitin acted as a compatibiliser between hydrophobic PLA and hydrophilic cellulose, which played a complementary role along with cellulose in view of the formation of a rigid cellulose nanofibre percolated network. Finally, Garcia et al. [10] focused on understanding the effect of polycaprolactone nanofibres on the dynamics and impact behaviour of polymer/glass fibre composites, in which a finite element model was employed to simulate their impact effect. The numerical results coincided with previous experimental data to prove that composites reinforced with polycaprolactone nanofibres possessed more damage resistance when subjected to the same impact as pristine composites. More importantly, interleaving with polycaprolactone nanofibres was revealed to control the vibrations and improve the resistance of impact damage to structures made of composite mats, which could be used for aircrafts or wind turbines.

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