Polymer-Matrix Composites: New Fibers Offer New Possibilities

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If one class of material could represent the transition to the new millennium, it would be the polymer-matrix composite (PMC). From missile components to golf clubs, an ever increasing number of products or specific devices are made of PMCs. Some are new developments, such as the carbon fiber composites in modern commercial aircraft. Others are beneficial to both our health and the environment. Typical examples are the aramid fiber composites replacing asbestos in automotive brakes and clutch linings, as well as recyclable coconut fiber composites substituting synthetic fibers in automobile seat cushions.

Polymer-matrix composites are normally composed of a matrix reinforced with a synthetic or natural fiber. The matrix acts as the intermediate by which an externally applied load is distributed to the stronger and stiffer fibers that structurally support the composite. It protects the fibers from outside chemical (or even atmospheric) attack and abrasion. The plasticity of the matrix serves as a barrier to crack nucleation/propagation, and as such prevents catastrophic rupture.

The real advantages in terms of flexibility and expanding potential for the PMC are the different fibers available. Glass fiber is the most popular owing to its low price, easy processing, high specific strength, and chemical inertness. Carbon fiber is the current preference for advanced structural composites. It is the stiffest and strongest of all fibers. Carbon fiber manufacturing and its composite processing are currently reaching a cost-effective level that permits even common leisure and sporting goods to be relatively inexpensive. Aramid, a kind of polymeric fiber, was a fantastic development only three decades ago. This fiber is the lightest, toughest, and the most impact-resistant among the synthetic fibers. Kevlar, a well-known brand name for aramid fiber, revolutionized the market of bullet-proof vests. Other synthetic fibers, such as silicon carbide, aluminum oxide, and boron, traditionally used in metal-matrix composites, have found commercial niches as PMCs in helicopter rotor blades, circuit boards, tennis rackets, and many other items. Natural fibers are promising options for PMCs. Their environmental advantages (biodegradable, renewable, recyclable) and the large number available as native, cultivated, or industry residuals stand over other fibers. Already used in many automobile components, natural fiber composites may in the future be appraised by their environmentally friendly qualities and seen as an ally in the fight against global warming.

The PMC articles in this issue will deepen scientific and technological understanding related to this important class of material. The article by S.N. Monteiro, F. Lopes, A. Ferreira, and D. Nascimento provides an overview on natural fiber composites. The growing interest and existing applications of these composites by the automobile industry were the main motivation for the article. The economical, technical, and environmental advantages are emphasized.

The paper by S. Sen, E. Schofield, J. Scott O'Dell, L. Deka, and S. Pillay describes the development of advanced PMCs for future space exploration. This new materials will provide shielding from cosmic radiation and micrometeoroid impact during long interplanetary missions such as NASA's planned round trip to Mars.

The article by Y. Ganesan and J. Lou provides an overview on the mechanical behavior of polymer-matrix nanocomposites. The outstanding properties of nanostructured materials are exemplified using the case of carbon-nanotube reinforced composites. The authors emphasize the role played by the interface between nanoparticulate fillers and the polymer-matrix interface.

Characterization of fundamental properties related to the behavior of thermoplastic composites under impact condition is the focus of the article by K. Brown, R. Brooks, and N. Warrior. The strain-rate sensitivity of a glass-woven-fabric-reinforced composite, considered for vehicle impact resistant components, is providing basic information on the material mechanical response in case of a crash event.

The work by T. Rodrigues, M. Tavares, I. Soares, and A. Moreira presents a review on a modern and advanced development, hybrid nanocomposites. These are new materials with improved properties such as gas barrier, thermal stability, and flame resistance for several applications, from food packaging to fuel cells.

It is hoped these articles will update the readers and motivate them to share in the belief that PMC is the millennium material. Finally, a special token of gratitude is due to Ann Hagni, whose experience and effort enabled this issue to move forward.

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