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S. K. Malhotra, Koichi Goda, M. S. Sreekala

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Polymer Composites

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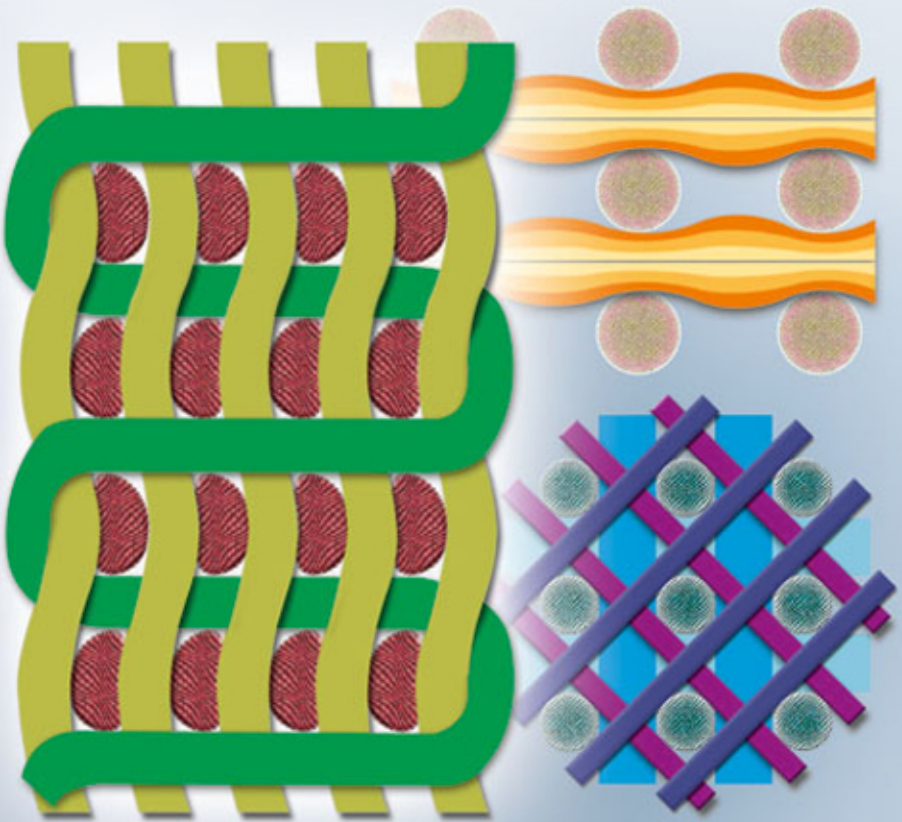

Edited by
Sabu Thomas, Kuruvilla Joseph,
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1
Advances in Polymer Composites: Biocomposites – State of the Art, New Challenges, and Opportunities

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1.1
Introduction

Environmental compatibility of polymer composites has become an important characteristic as the need to reduce environmental hazards is increasing worldwide. Many incidents taking place around the world are enough to bring us around to this point of view. A catastrophic earthquake and *tsunami* devastated the Pacific coast of north-eastern Japan on 11 March 2011. The earthquake, which was the most powerful earthquake ever measured in Japan, was of magnitude 9.0 on the Richter scale. About 19 000 were dead and missing. Three prefectures in the Tohoku (north-eastern) region of Japan, Miyagi, Iwate, and Fukushima, were most severely damaged. Reconstruction is yet to take place in many of the affected cities and towns. The area around the Fukushima Daiichi Nuclear Power Plant was evacuated owing to radioactive contamination. It is said that complete restoration will take more than 30 years, because the influence of the Chernobyl nuclear power plant disaster, which happened more than 25 years ago, continues to be felt. In Fukushima prefecture, many residents are still forced to lead lives as long-term refugees, and the residents in certain areas outside the refuge zone continue to live under threat of radiation that is much higher than is normal. The damage caused by radioactivity has also been considerable: it has already affected the soil of schoolyards, tapwater, grass, agricultural products, marine products, and so on, in large areas within the Fukushima prefecture. It is not clear how much of this damage is due to sea pollution and how long its effects will last in the future.

Against such a background, a planned conversion to renewable natural power sources as recommended by the energy policy, depending on nuclear power generation, attracts attention. For instance, it has been decided to abolish nuclear power generation systems in Germany; they propose to convert from 16% of total energy generation from the natural power sources at present to 35% by 2020 and to 80% by 2050 [1]. In the report ''The Green New Deal'' published in 2009 [2], promotion of use and development of alternative and renewable energy, improvement in energy efficiency, greenhouse gas reduction, and so on, have also been proposed. Today,

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technologies for various natural power sources, such as solar power, hydraulic power, woody biomass, and wind force power generation, are already in practical use. The authors believe that many people in the world desire realization of a sustainable society that uses such renewable energy power generation technologies.

To realize a sustainable society, various supplies around our life also need to be made from renewable materials. Biomass-derived materials are one of the most sustainable materials, which can also be used as industrial materials. On the other hand, most engineering plastic products are petroleum-derived products. As is well-known, the use of fossil resources causes difficulties in recycling and induces the problem of waste plastic and petroleum products, of which the incineration also causes an increase in carbon dioxide linking to global warming. In addition, fossil resources are an exhaustible resource. To maintain a sustainable society, we are of the opinion that biomass resources may be suitably exploited socially/ecologically as much as possible, by their replacing fossil resources. Since the arrival of such a society will result in a carbon-neutral system, this would also greatly contribute to global environmental protection. It is said that biodegradable plastics, for example, polylactic acid (*PLA*) and polyhydroxyalkanoic acid (*PHA*), are among the leading biomass-derived materials, which are finally decomposed by microorganisms into water and carbon dioxide. Therefore, there are only a few impacts on natural environment compared with those of conventional petroleum-derived plastics. Such biomass-derived materials are expected to be more widely applicable for the commodities used by us on a daily basis, for industrial products, and so on.

The main drawbacks of biodegradable resins are low strength and stiffness, and therefore, it is not appropriate to apply resins directly for structural components. Plastics are often reinforced with inorganic fibers such as glass or carbon, as described in Volume I of this series. Carbon fiber-reinforced plastic matrix composites (*CFRP*), in particular, have been recently used for primary structural components in airplanes and automobiles as well as sport goods and construction materials, because of their excellent mechanical properties. Biodegradable resin may also be reinforced with such fibers, similarly to the conventional petroleum-derived plastics. However, let us recall here how we should construct a sustainable society. If the final products do not really require high strength and durability, do we need to use strong artificial fiber-reinforced composites? Cellulosic materials, namely, plant-based natural fibers such as flax, hemp, bamboo, and wood, have low densities, are biodegradable, and inexpensive, and they have relatively high stiffness and less wear/abrasion to material partners. If such cellulosic materials are used as reinforcements of biomass-derived plastics, this material would be a quite suitable for building a sustainable society. We call such a biomass-based composite material a *biocomposite*. This idea of using natural fibers had already been adopted in the experimentally developed automotive body in 1940s by Henry Ford [3]. Fifty years later, Mercedes-Benz applied composites produced from natural fibers and polypropylene to their car interior parts in the 1990s. Although the matrix used in the cars was petroleum-derived thermoplastic resin, this business should be evaluated as an advanced measure in terms of practical and large-scale production. The use of natural fiber-reinforced composites using biomass-based biodegradable