

Advanced Rubber Composites

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Preface

It is known that at least 3,000 years before the first Europeans saw natural rubber, and the Mesoamerican communities had developed ways of collecting it and forming it into a variety of objects such as toys, domestic products, and items related to ritual sacrifice to tribute payments [1]. However, rubber became an indispensable factor of industry and of daily life after one of the effective discoveries and developments of mankind, namely the vulcanization technology in years 1839–1844 by Charles Goodyear and Thomas Hancock, i.e., the transformation of a material, which is sticky when warm and brittle when cold, to a high-deformable chemically cross-linked elastic solid. Since that time the rubber industry was established and has shown a markedly progressive development over the last period of more than 100 years. Developments in the field of synthetic elastomers have progressed so rapidly that the whole concept of rubber technology has changed several times and became adapted to changing demands from society. Currently, a larger number of activities are directed to ways to improve fuel economy, having in mind that world population is growing and the demand for transportation vehicles is increasing rapidly, especially in developing countries. One example to improve fuel economy – with respect to rubber materials – is by reducing the rolling resistance of tires. For every rotation of a tire, it consumes energy as it deforms going through the footprint area in contact with the road surface. Under the condition that other tire properties such as wear, abrasion, and wet skid properties will not fail, this goal can be reached to a large extent by the development of new tire tread rubbers.

In order to produce high-performance elastomeric materials, the incorporations of different types of nanoparticles such as layered silicates, layered double hydroxides, carbon nanotubes, and nanosilica into the elastomer matrix are now growing areas of rubber research. However, the reflection of the “nano effect” on the properties and performance can be realized only through a uniform and homogeneous good dispersion of filler particles in the rubber matrix.

Furthermore, another advantage of nanofillers is not only to reinforce the rubber matrix but also to impart a number of other properties such as barrier properties, flammability resistance, electrical/electronic and membrane properties, and polymer blend compatibility. In spite of tremendous research activities in the field of polymer nanocomposites during the last two decades, elastomeric nanocomposites

are still in a stage of infancy as far as their application is concerned. The major challenge in this regard is the replacement of carbon black and silica which are mostly used in bulk amount in rubber compositions by a small amount of nanofillers to achieve desirable combination of properties. Corresponding recent research activities are described in the contributions of Bhowmick et al. and Das et al. within the prevailing volume about Advanced Rubber Composites. In both contributions, the reader finds also useful information about how the emergence of advanced characterizing techniques has facilitated the present surge in the field of rubber nanotechnology. Insightful research has combined the advances in diverse disciplines to elucidate the structure–property bonhomie in polymer nanocomposites. Developments in synthesis and processing have enabled formation and monitoring of engineered nanoassemblies, while giant steps in analytical techniques such as microscopy and diffraction studies have enabled the precise determination of structural evolution across various length scales in the rubber material.

The contribution of Noordermeer et al. reports about progress how plasma polymerization of acetylene, thiophene, and pyrrole is used to modify the polar nature of silica and carbon black powders as reinforcing fillers for rubber. Silica turns out to be very easy to modify with plasma polymerization because of its reactive surface containing a large amount of siloxane and silanol species. These research activities are straightforward directed to “green tires” because the potential advantages of silane-coupled silicas for reducing rolling resistance in high-performance passenger car tire treads were demonstrated in tire results since approximately 15 years.

The contribution of Babu and Naskar gives a comprehensive overview on the recent developments of the thermoplastic vulcanizates (TPVs) with special reference to the technological advancement. TPVs combine high volume molding capability of thermoplastic with elastomeric properties of thermoset rubber. Therefore, they land themselves to broad area of applications in various fields.

The last contribution in the prevailing volume deals with the application of a relatively new class of materials based on the addition of (electron-beam) activated polytetrafluoroethylene (PTFE) powder in rubber matrixes for preparing PTFE-based elastomeric composites. Besides other properties, the remarkably lower friction coefficient of PTFE enables its utilization for tribological applications. However, PTFE in rubbers has not been fully explored mainly due to its inherent chemical inertness and incompatibility. The present work signifies the electron modification of PTFE powder to improve its compatibility with rubber matrixes, the state of the art regarding its application in rubbers, and the preparation of PTFE-based elastomeric composites for several tribological applications.

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Reference

1. Loadman J (2005) Tears of the tree. The story of rubber – a modern marvel. Oxford University Press, Oxford