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ORIGINAL RESEARCH

Sepiolite hybridized commercial fillers, and their effects on curing process, mechanical properties, thermal stability, and flammability of ethylene propylene diene monomer rubber composites

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Abstract

Ethylene propylene diene monomer rubber (EPDM)-based composites containing sepiolite (sep) hybridized with calcium carbonate ($CaCO_3$), silica (Sil) or carbon black (CB) were prepared on a two-roll mill. The influence of fillers' contents on the curing, mechanical, thermal and flammability of the composites was investigated. In comparison with EPDM/sep at 30 parts per hundred rubbers (phr) as a control composite, EPDM/sep/CB composites exhibited an outstanding improvement in tensile strength followed by EPDM/sep/Sil and EPDM/sep/$CaCO_3$ composites. EPDM/sep/CB displayed the highest thermal stability and also improved flammability resistance. In addition, a higher amount of carbon black gave higher tensile strength. The results were influenced by the ability of CB to disperse well and form protective layers acting as mass transport barriers in the matrix. The field emission scanning electron microscopy analyses proved better dispersion of CB in the matrix. The presence of protective layers on the surface of samples consequently improved the thermal properties of the EPDM composites. The mechanism of formation of char protective layer in hybrid EPDM composites was also investigated based on morphological observations of char residues. According to this work, Sil and CB were able to hybrid with sep, while sep could be a potential substitution of $CaCO_3$ in the EPDM composites.

Keywords Sepiolite · Hybrid filler · Tensile properties · Thermal stability · Flammability

Introduction

Rubber plays an exceptional role in industry due to its remarkably high elasticity. However, rubber is usually a soft material with weak mechanical properties; therefore, the addition of reinforcing fillers such as carbon black and silica is one of the main important criteria [1, 2]. Meanwhile, calcium carbonate is a non-reinforcing filler which has been used in rubber composites since ages. Carbon black offers great strengthening effects such as tensile and tear strength, modulus, hardness and abrasion resistance to rubber composites. But, its production consumes large amounts of fossil fuels. Its production process pollutes the environment and releases large amounts of heat and waste gases as well as the end product being darker in colour [3, 4], which is limited to only certain applications such as tyres. On the other hand, silica is an inorganic (petroleum-independent) filler that offers an outstanding reinforcement effect and low cost, but has poor dispersion due to the abundant of hydroxyl groups on the polar silica surface, as well as, a lot of energy is consumed in its production [5, 6]. Whereas, calcium carbonate is an inorganic powder which is generally supplied as agglomerates and in the processing the agglomerates are broken and dispersed into primary particles. Large amounts of particle–particle interactions may result in inhomogeneous distribution of filler in the polymer matrix, and consequently, decrease of tensile properties of the rubber composites [7]. The drawbacks of commercial rubber fillers might be overcome with new filler systems, guaranteeing good dispersion and

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