Influence of Nanoclay Particles on Rheological and Mechanical Properties of Polyamide 12/Waste Rubber Composites

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INTRODUCTION

Waste rubber is found in abundance in various dump sites and it represents a serious source of environmental and public health concerns. In fact, the end life of this material requires a long time to degrade naturally. So, recycling of waste rubber by mixing it with thermoplastics provides an interesting environmental solution. However, the incompatibility between polymer (PA12) matrix and waste rubber (EPDM) blend can bring about poor interfacial adhesion thereby affecting its properties. The presence of a third constituent, acting as a rubber dispersion agent, could lead to improve the end-use properties of thermoplastics/waste rubber composites. Organoclay montmorillonite is used as third constituent to serve as a compatibilizer for rubber dispersion as reported in (Benneghmouche and Benachour, 2019). To overcome the demerits arising from only inclusion of elastomer particles, some research works have been done on polymer/elastomer/filler ternary networks, where both rigid fillers and rubber were used to improve the properties of the host polymer matrix (Hajibabazadeh, S, Razavi A. M. K. et al., 2020) (Wang K. Wang C. et al., 2007).

The aim of this study is to recycle waste rubber. The blending of this waste rubber into the polymer matrix can lead to the development of a composite. The effect of incorporation of organically modified clay as a dispersion agent was also investigated.

MATERIALS AND METHODS

A The polymer used as a matrix in this study is a polyamide 12 (PA12), referenced as Rilsan© AECHVO supplied by ARKEMA group (Serquigny, France). The number average molar mass was shown to be 20,000 g/mol and the polydispersity index was found to be 1.9. The melting point of this PA12 grade is 183 ^{0}C. Elastomer of ethylene propylene diene monomer (EPDM) particles, with an average size of 425 µm and sourced from end-life car door seals, were also used. The silicate dispersed into the matrix is an organically modified montmorillonite clay (OMMT), referenced as Cloisite© 30B (C30B), and supplied by Southern clay products (Gonzales, Texas). C30B is methyl tallow bis-2-hydroxyethyl ammonium exchanged montmorillonite clay with a cationic modifier concentration of 90 milliequivalents per 100 g. The density of this organophilic clay is 1.98. The three constituents were simultaneously mixed by using an internal mixer (Haake Rheomix 600) at a blade rotational speed of 100 rpm, during 6 min, at 200 ^{o}C. The effects of EPDM and OMMT mass fractions on the rheological and mechanical properties of the composites were studied.

RESULTS AND DISCUSSION

For binary composites based on EPDM or OMMT, complex viscosity increases with increasing mass fraction. The PA12/EPDM blend can be considered as a structured material for EPDM mass fraction superior to 20%, whereas the PA12/OMMT nanocomposite presents a solid-like behavior from the OMMT mass fraction of ~ 2%. It is appeared that when EPDM mass fraction increases, rigidity and stress at break of binary composites are reduced whereas their ductility strongly increased at 5% of EPDM and they recover the ductility of PA12 matrix beyond this fraction. Linear and non-linear mechanical properties of PA12/OMMT nanocomposites also show the existence of an OMMT mass fraction threshold of 2%. This mass fraction separates a significant improvement of all mechanical properties, at low clay mass fractions, from the stabilization of Young's modulus and a dramatical decrease of properties at the break, at high mass fractions. However, the rheological properties showed that EPDM entities slightly weaken the percolation network of PA12/OMMT nanocomposite.

CONCLUSION

The slight decrease of viscosity of ternary composite, relative to that of binary nanocomposite, at equivalent clay mass fraction, is interesting during the recycling mixing. The ternary material has the advantage to recycle rubber waste, while exhibiting mechanical properties close to those of corresponding PA12/OMMT nanocomposite.

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