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ScienceDirect

Procedia Chemistry 19 (2016) 401 – 405

Procedia Chemistry

5th International Conference on Recent Advances in Materials, Minerals and Environment (RAMM) & 2nd International Postgraduate Conference on Materials, Mineral and Polymer (MAMIP), 4-6 August 2015

The Effect of Acrylic Acid on Tensile and Morphology Properties of Wollastonite Filled High Density Polyethylene/Natural Rubber Composites

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Abstract

Inorganic filler manufactured for incorporation into thermoplastic elastomers usually are surface treated with organic reagents in order to improve the interfacial adhesion between filler and the matrix. In the present paper, the effects of acrylic acid (AA) on tensile and morphology properties of wollastonite (WS) filled high density polyethylene (HDPE)/Natural Rubber (NR) composites were studied. The untreated and treated HDPE/NR/WS composites were melt-blending at 180 °C with rotor speed of 50 rpm for 10 minutes. The composites were tensile-tested according to ASTM D638 and the etched surfaces were observed using scanning electron microscope (SEM). Tensile strength and elongation at break of the compositesdecreased upon the addition of wollastonite, but Young's modulus improves. The results of this study showed that the treated composites are found to have better tensile properties than the untreated composites. The morphology of treated composite showed better interfacial interaction between HDPE/NR and wollastonite.

Peer-review under responsibility of School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia

*Keywords:*Thermoplastic elastomers; Wollastonite; Acrylic acid

1. Introduction

Thermoplastic elastomers (TPEs) are polymeric materials that generally possess the processability of thermoplastics with outstanding mechanical properties and the elasticity of rubber. This unique combination of properties and easy processing allows the preparation of objects with complex shapes and smoothsurfaces using

Peer-review under responsibility of School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia
doi:10.1016/j.proche.2016.03.030

common plastic processing equipment[1]. The TPEs make useful products such as in many automotive parts, footwear, cables, sealants and adhesives, hoses, coated fabrics, tubings and sheetings[2]. Thermoplastic Natural Rubber (TPNR) is a TPE prepared by melt mixing natural rubber with a polyolefin at different proportions and it is an excellent way to add values tonatural rubber (NR). The most well known materials used to prepare TPNRs are polypropylene[3,4], low density polyethylene[5,6] and high density polyethylene[7,8]. NR and HDPE blends combines the excellent processing characteristics of HDPE and elastic properties of NR that can be used in automobile components and other industrial applications[9].

The addition of inorganic fillers is one of the most common methods in modifying thermoplastic elastomers[1]. Inorganic fillers are often added into thermoplastic elastomers formulation to enhance processability, permeability, mechanical and thermal properties as well as lower the cost of the compounds[10]. Wollastonite belongs to an interesting new class of functional materials. It is a form of the naturally occurring mineralwhite calcium silicate ($CaSiO_3$) with high aspect ratio (its aspect ratio usually 5-20). It is relatively a hard material (Mohhardness of 4.5–5.0) with a specific gravity of 2.78–2.91[11]. Because of its acicular nature, wollastonite is a promising reinforcement for thermoplastic such as polypropylene[12,13]. Like most inorganic fillers, wollastonitehas polar, hydrophilic, and high free energy surface and is incompatible with thermoplastics, leading to deteriorated mechanical properties, such as low toughness. Due to these characters, a treatment of the particles are needed to achieve a good dispersion of the filler particles and satisfactory mechanical properties[14].

The purpose of the present work was to study the effect of using acrylic acid treated wollastonite in thermoplastic elastomercomposition based on HDPE/NR blend on tensile strength and morphology.

2. Materials

2.1. Materials

High-density polyethylene (HDPE) was procured by Lotte Chemical Titan Sdn. Bhd., Malaysia. HDPE homopolymer used in this study was blow molding grade Titanzex HB6200 with a density of 0.956 g/cm3 and a melt flow index MFI 0.45 g/10 min. Natural rubber (NR) was purchased from Rubber Research Institute of Malaysia (RRIM). NR is an SMRL grade with a density of 0.93 g/cm^3. Wollastonite powders with an average particle size of 40 μm was obtained from Ipoh Ceramics Sdn. Bhd. The acrylic acid was obtained from Aldrich, Malaysia.

2.2. Preparation of treated wollastonite

Wollastonite filler was chemically treated through a reaction with a solution mixture of acrylic acid in an ethanol. Wollastonite was gradually added to the acrylic acid solution and stirred for 2 h. The solution was left for 24 h, then filtered and dried at 80 °C for 24 h.

2.3. Preparation of HDPE/NR/wollastonite composites

Thermoplastic natural rubber (TPNR) matrix was prepared from high-density polyethylene (HDPE), natural rubber (NR) in a ratio of 70:30 by melt blending. HDPE/NR/wollastonite composites were prepared in a Brabender plasticoder at 180 °C and a rotor speed of 50 rpm. HDPE was loaded first to start the melt mixing for 3 min. Then, NR was added and the mixing continued for another 4 min. After 7 min, the wollastonite was added and the mixing continued for another 3 min until the mixing torque stabilized. The total mixing time was 10 min for the blends. The HDPE/NR/wollastonite composites were taken out and compression-moulded into a 1.0 mm thick mould in an electrically heated hydraulic press. The hot-press procedure involved preheating at 180 °C for 4 min followed by