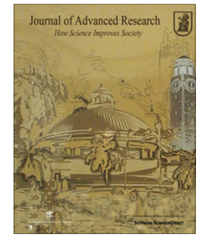
Journal of Advanced Research (2015) **6**, 811–817

Cairo University

Journal of Advanced Research



ORIGINAL ARTICLE

An investigation on chloroprene-compatibilized acrylonitrile butadiene rubber/high density polyethylene blends

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A R T I C L E   I N F O

Article history:
Received 26 March 2014
Received in revised form 19 May 2014
Accepted 11 June 2014
Available online 19 June 2014

Keywords:
Blend
Compatibilization
NBR
HDPE
Mechanical properties

A B S T R A C T

Blends of acrylonitrile butadiene rubber/high density polyethylene (NBR/HDPE) compatibilized by Chloroprene rubber (CR) were prepared. A fixed quantity of industrial waste such as marble waste (MW, 40 phr) was also included. The effect of the blend ratio and CR on cure characteristics, mechanical and swelling properties of MW-filled NBR/HDPE blends was investigated. The results showed that the MW-filled NBR/HDPE blends revealed an increase in tensile strength, tear, modulus, hardness and cross-link density for increasing weight ratio of HDPE. The minimum torque (M_L) and maximum torque (M_H) of blends increased with increasing weight ratio of HDPE while scorch time (ts_2) cure time (tc_{90}), compression set and abrasion loss of blends decreased with increasing weight ratio of HDPE. The blends also showed a continuous reduction in elongation at break as well as swelling coefficient with increasing HDPE amount in blends. MW filled blends based on CR provided the most encouraging balance values of overall properties.

Introduction

Acrylonitrile–butadiene rubber (NBR) is well-known unsaturated copolymers for about five decays [1,2]. It has been used in many industrial required purposes as hoses, O-ring seals, insulation base product and other many packaging materials [3].

The main components of technically related NBR composed of 24–30 wt% of acrylonitrile and include some benefits in contrast to other elastomer like polymers, such as, good processability, resistance to oils as well as hydrocarbons, especially resistance to hydrocarbons and oils, and NBR has wide region of service temperature (from −35 °C up to 100 °C) [4,5]. High density polyethylene (HDPE) is a semi-crystalline with outstanding chemical resistance as well as simple processability. Acrylonitrile butadiene rubber (NBR) is a simply processable, tough, and flexible rubber.

The knowledge of thermoplastic elastomers (TPEs) from blends of NBR and HDPE has occurred as a valuable implement in tailoring polymers to require of end users. A various articles as well as books were published on this issue [6–10], and the theoretical studies performed generally on engineering

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Peer review under responsibility of Cairo University.

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http://dx.doi.org/10.1016/j.jare.2014.06.003

thermoplastics covered the approaches for industrial applications Coran and Patel [11] accounted the technological compatibilization of PP/NBR and PE/NBR blends. They have reported the effect of addition of graft copolymer and dynamic vulcanization on mechanical properties of these blends. Recently, Liu et al. [12] studied the effectiveness of various basic functional groups in polypropylene as compatibilizers in a PP/NBR system using morphological and impact property measurements. Commonly, it is simple to blend of similar polarities and solubility of rubber and plastic to make a valuable thermoplastic elastomer, for example PP/ethylene–propylene–diene copolymer (EPDM), epoxidized natural rubber (ENR) with polyvinyl chloride (PVC), PVC/NBR) and nylon/NBR. However, it is obscured to fabricate a TPE via an elastomer and plastic composing different polarities as well as solubility.

This is due to large interfacial tension between these two polymers. This intricacy could be solved by the use of a compatibilizer to get better interfacial relation between two phases [13–16]. Accordingly, the objective of this research was to study cure characteristics, mechanical as well as swelling properties in the blends of NBR with HDPE which was chosen as blend constituents, because these NBR and HDPE are available in great amounts, possess outstanding properties and are paced among the most frequent polymers applied for the fabrication of commercially existing NBR/HDPE based blends.

The aim of the study expressed in this article was to compatibilize NBR with HDPE by using Chloroprene (CR) as compatibilizer that gets better compatibility of NBR/HDPE blends through interfacial chemical response. Cure time, scorch time as well as torque measurements, mechanical and swelling properties of these blends were also evaluated.

Experimental

Materials

Acrylonitrile–butadiene rubber (NBR 3310, acrylonitrile, 35 wt%) Chloroprene rubber (CR) as compatibilizer and HDPE used in this study is a commercial product from the local market of Karachi. The melt flow index (MFI) of HDPE is 5.64 g/10 (190 °C, 2.16 kg), and density is 0.953 g/cm^3. Marble waste (MW) was arranged from marble industry.

The MW was desiccated in oven for 24 h at 80 °C, then mashed and passed through 37 μm sieve. The other constituents were Zinc oxide delivered by M/S S. Chemicals Industries Ltd. Pakistan. Stearic acid was purchased from Nimir (Pvt.) Ltd., Lahore, Mercaptobenzothiazole (MBT),Tetramethylthiuram disulfide (TMTD) as accelerators, 3-Dimethylbutyl-N-phenyl-p-phenylenediamine and sulfur were obtained from commercial market.

Preparation of NBR/HDPE blends

Locally existing NBR, HDPE and CR, as above, were purposed for compatibilized blends. The concentrations for NBR/HDPE blends are expressed in Table 1. The NBR/HDPE blends were fabricated via two-step mixing process. To prepare the blends, the NBR, HDPE and fillers were fed into a Brabender internal mixer (Brabender Instruments, Germany), along with other ingredients at 160° C and 60 rpm for 10 min. The Brabender mixer, equipped with a pair of Banbury blades, has a total volume of 50 ml and it was filled to 70% of the total volume, as recommended by Brabender, for all sample preparations. After blending, the blended mixture was cooled down and sulfur was added on two-roll mill (16 × 33 cm) according to ASTM D 3182 (2001). Eventually, when mixing finished, the compounds were kept at room temperature for as minimum 24 h before their cure characteristics were measured. Test specimens were obtained by compression molding at 160° C and a pressure of 20 MPa for the respective optimum cure time (t90) obtained from rheographs. After curing, the vulcanized sheet was taken out of the mold and immediately cooled under tap to stop further curing. All samples were cured at this temperature and stored in a cool dark place for 24 h.

Table 1 The main compositions of studied MW filled NBR/HDPE.

Ingredients	Designation NBR:HDPE blends					
	100:00	85:15	70:30	55:45	40:60	25:75
NBR	100	85	70	55	40	25
HDPE	00	15	30	45	60	75
ZnO	5.00	5.00	5.00	5.00	5.00	5.00
Stearic acid	1.5	1.5	1.5	1.5	1.5	1.5
TMTD	0.8	0.68	0.56	0.44	0.32	0.2
MBT	1.2	1.02	0.84	0.66	0.48	0.3
Antioxidant	1.00	1.00	1.00	1.00	1.00	1.00
Sulfur	2.00	1.7	1.4	1.1	0.8	0.5
Processing oil	4.0	4.0	4.0	4.0	4.0	4.0
MW	40	40	40	40	40	40
CR	5.00					

Cure characteristics

The cure characteristics of blends were epitomized (ASTM method D 2084 at 160 °C) as in our prior research works [17,18].

Physical properties

Analysis of all physical mechanical properties (ASTM-412, ASTMD-624 Hardness according to ASTM D 2240) swelling and aging properties was conducted as ASTM D 573) of chloroprene compatibilized NBR/HDPE blend was performed as depicted before employing standard procedures [19–21].

Compression set (as per ASTM D 395-61) is generally empathized as percentage (%) of applied deformation, i.e., but can be stated as % of original thickness. The assessment of set is enormously effective quality control analysis as it is a comparatively easy test as well as the results is susceptible to state of cure.

Abrasion loss was also measured by abrasion check tester (Gibitre Italy), according to DIN 53516/ASTM D 5963, where all tests performed a room temperature.

Equilibrium swelling

The equilibrium swelling of blends was evaluated as in our former research works [22–24].