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ORIGINAL PAPER

Novel thermoplastic natural rubber based on thermoplastic polyurethane blends: influence of modified natural rubbers on properties of the blends

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Abstract Three different forms of natural rubber: maleated natural rubber (MNR), epoxidized natural rubber (ENR) and natural rubber-graft-poly(methyl methacrylate) (NR-*g*-PMMA) were prepared. Degree of functional groups in rubber molecules was quantified using the integrated peak areas of ^{1}H NMR. It was found that the modified rubbers with similar level of functionality had been successfully prepared. Thermoplastic natural rubber (TPNR) based on blending of thermoplastic polyurethane (TPU) and various forms of rubber were then prepared using melt blending method. The properties of the blends were studied and compared together in relation to different types of natural rubbers prepared (i.e., unmodified NR, MNR, ENR and NR-*g*-PMMA). It was found that the blends with modified NR exhibited superior stiffness, entropy effect and damping factor compared to other blends with unmodified NR. This is attributed to the chemical interaction between the functional groups of modified NR molecules and polar functional groups in TPU molecules which facilitated higher interfacial adhesion between both phases. The chemical interaction was verified by ATR-FTIR and TSSR techniques. It was also found that the MNR/TPU blend showed the highest tensile modulus, mechanical and elastic properties with smallest and finer grain dispersion of co-continuous phase compared to ENR/TPU, NR-*g*-PMMA/TPU and unmodified NR/TPU blends, respectively. This might be due to higher chemical interactions between MNR and TPU phases. Furthermore, the incorporation of rubber did reduce hardness (i.e., <60 Shore A) with improvement of elasticity of the blends compared with the original TPU (i.e., ~85 Shore A).

Keywords Maleated natural rubber · Epoxidized natural rubber · Natural rubber-*g*-poly(methyl methacrylate) · Thermoplastic natural rubber

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Introduction

Thermoplastic elastomers (TPEs) are polymeric materials which exhibit functional performance of conventional elastomeric materials at room and service temperature. They are typically processed using thermoplastic processing equipment with a capability of reprocessing and thermal welding. The TPE materials have gained more importance nowadays due to the wide range of applications in fields such as automotive parts, house hold appliances, electrical equipment, industrial supplies, food contact articles and medical applications [6]. However, most commercially available TPEs are manufactured as non-renewable petrochemical polymers. Under an increasing awareness of environmental issue and fuel shortage in the future, natural rubber and other renewable and sustainable resources are undoubtedly the promising materials in the future uses. One of these resources is natural rubber which can be used to prepare thermoplastic elastomer materials. They are typically named as thermoplastic natural rubbers (i.e., TPNRs) which are one of the alternative environmental friendly polymer materials. However, NR contains