Iran Polym J (2015) 24:135–148
DOI 10.1007/s13726-015-0307-6

ORIGINAL PAPER

Polymeric composites based on natural rubber and hemp fibers

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Received: 19 June 2014 / Accepted: 5 January 2015 / Published online: 18 January 2015

Abstract The purpose of this work is to present the results of preparing a polymeric composite with enhanced properties based on natural rubber and hemp. Amounts of 10 and 20 phr hemp were used to obtain the composites. The samples have been processed by sulfur vulcanization and characterized by several methods. The mechanical characteristics, gel fraction, cross-link density, rubber-fiber interactions and water uptake have been investigated depending on the hemp content. Fourier transform infrared spectroscopy (FTIR) and scanning electron microscopy (SEM) techniques were also employed for characterization. The values of hardness, tensile strength and tearing strength have increased with the fiber content increasing due to the interaction between the fibers and natural rubber. Also, good adhesion between hemp fibers and rubber matrix was observed in SEM micrographs. The gel fraction value was over 95 % for all composites and increased with the increasing of hemp content. The cross-link density was determined on the basis of equilibrium solvent-swelling measurements applying the modified Flory–Rehner equation. It was observed that cross-linking density of composites increased slightly with the increase of amount of hemp but still was lower than that of the natural rubber without hemp. The extent of interaction between rubber and fiber was determined using the Kraus equation. Results of water absorption tests showed that water uptake increased with the increase of fiber content and temperature. The physical and chemical investigations have shown the reinforcing effect of hemp on sulfur vulcanized natural rubber, as well.

Keywords Polymeric composites · Natural rubber · Hemp · Physical–mechanical characteristics · Cross-link density · FTIR

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Introduction

The reinforcement of rubber compounds with fibers has become necessary in many products, especially in the tire, hose and belt industries [1]. Currently, the most viable way toward eco-friendly composites is the use of natural fibers as reinforcement. Natural fibers represent a traditional class of renewable materials which, nowadays, are experiencing a great revival [2]. On the other hand, natural fibers exhibit many advantageous properties which promote the replacement of synthetic fibers in polymer composites. They are low-density materials yielding relatively lightweight composites with high-specific properties, therefore, natural fibers offer a high potential for an outstanding reinforcement in lightweight structures.

Natural fibers are derived from renewable resources and do not require a large amount of energy to process them and are biodegradable, as well [3, 4].These fibers also offer significant cost advantages and therefore the utilization