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Mechanical properties of chicken feather fibre reinforced natural rubber composites

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Introduction

Green composites are a specific class of biocomposites, where a bio-based polymer matrix is reinforced by natural fibres (NFC), and they represent an emerging area in polymer science. In an economic situation, such as the present one, where oil price increases, the use of green composites is advantageous not only for the environment but also from an economical viewpoint. Some authors label all NFCs as ''green composites'', irrespective of the nature of the polymeric matrix (both bio- and oil-based). In this work, we use the term ''green composites'' for wholly bio-based composites, that is, both fibres (CF) and matrix (NR) from renewable resources. In the present work chicken feather fibres (CF) were selected as fibres because CFs is waste products of the poultry industry. Billions of kilograms waste feathers are generated each year by poultry processing plants creating a serious solid waste problem. Chicken feather fibres are approximately 91% protein (keratin), 1% lipids and 8% water. These are cheap, abundantly available and renewable source for protein fibres. The objective of the study is to investigate the effect fibre loading and, fibre treatment on the curing characteristics and mechanical properties of CF reinforced NR composites.

Experimental

Biocomposites of NR with 5, 10 15, 20, 25 and 30 phr of raw chicken feather fibre (RCF) were prepared using dicumyl peroxide (DCP) as vulcanizing agent in a laboratory two roll mixing mill. CFs was chemically modified with 2% sodium hydroxide to enhance their compatibility with the hydrophobic rubber polymer matrix and it was characterized by FTIR and the cure characteristics studied by an oscillating disc rheometer (Goettfert elastograph).The samples vulcanized at 150°C in a hydraulic press. Dum bell shaped tensile (ASTM D.412) and tear (ASTM D.624) specimens were punched from vulcanized sheets. Stress strain measurements were carried out at a crosshead speed of 500mm/min on a Shimadzu model UTM. The hardness was measured with a shore A type durometer as per ASTM D-2240. Composites were analyzed by SEM and FTIR.

Results and Discussion

Chicken feathers are important agricultural waste. They have keratin based structure. CF made up of 3 separate units- Rachis, Barbs, Barbules. Barbules have hooks like structure at ends which offer better adherence with polymer matrix. RCF has smooth surface. Alkali treatment leads to fibrilliation by removal of lipids [Fig.1a]. This rendered roughness to the CF and enhanced the mechanical interlocking at fibre-matrix interphase. These features make the CF, a promising material for the use as structural reinforcement in polymeric composite.

The addition of CF into NR matrix offered good reinforcement and resulted in an improvement of mechanical properties. The mechanical properties of RCF-NR composites were enhanced by alkali treatment on the fibre surface and were characterized by FTIR and SEM analysis. A fibre loading of 25phr has been found to be optimum for the best balance of properties. ACF filled composites show better mechanical properties than RCF composites [Fig.2a]. The interfacial interaction between CF and NR was also confirmed from FTIR spectrum by the shift in the absorption peaks of the NR matrix [Fig.2b].SEM studies of tensile fracture fronts showed the fibre dispersion within the NR matrix and a good adhesion of fibres with the matrix [Fig.1b]. SEM micrographs also revealed that the CFs is