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Dielectric Properties of Composites of Natural Rubber and KeratinFibre from Chicken Feather

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Abstract: The dielectric properties of chicken feather fibre-natural rubber (CF-NR) composites have been studied at varying frequencies. The effects of alkali treatment, thermal treatment and a three-component dry bonding agent consisting of hexamethylenetetramine, resorcinol and nano silica (HRS) on these properties were studied. Dicumyl peroxide (DCP) and sulphur were used as curing systems in the preparation of the composites. Fibre filled composite systems have higher values of dielectric constant than the gum (unfilled) sample. This is due to the polarization exerted by the addition of fibres into the matrix. The dielectric constant decreases with frequency due to the dropping out of dipolar and interfacial polarization at higher frequency. The dielectric constant values of composites containing alkali treated chicken feather fibres (ACF) were higher because of the increase in number of polar groups after the treatment. The carbonized chicken feather fibre (CCF) incorporated NR composites have highest dielectric constant values because they consist of conducting material in an insulating matrix which leads to interfacial polarization. The dielectric constants of sulphur cured composite samples are higher than the corresponding DCP cured ones. The addition of fibres and with the incorporation of the bonding agents causes an increase in the dielectric constant and decreases the volume resistivity of the composites.

Keywords: Natural rubber, Chicken feather fibre, Dicumyl peroxide, Dielectric properties, Bonding agent

Introduction

Polymers are generally good electrical insulators and are commonly used in the electronics industry for housings and assemblies. For antistatic applications and shielding against electromagnetic interference, electrical conductivity of rubber and plastic compounds is an important factor [1]. For specific applications, polymers are made conductive by adding metals, carbon black and conductive fibres. Electrical conductivity can be combined with desirable physical properties by incorporation of a conducting polymer into a host polymer substrate to develop a blend, composite or an interpenetrating network. The composition, chemical structure, physical texture as well as the conditions of measurement influence the process of conduction through a polymeric system [2].

Substantial information about the chemical and physical states of polymers can be obtained from dielectric properties such as the dielectric constant and the dielectric loss. These properties vary with the method of preparation, molecular structure and crystal structure. External factors such as frequency of the applied voltage and temperature also influence it [3]. Natural rubber (NR) has high value of permittivity and reasonably good insulating properties. Considerably high dielectric loss values of NR causes to lose its insulating properties. Haseena *et al.* [4] explained the dielectric properties and the conduction mechanism of sisal-coir hybrid fibre reinforced natural rubber composites. Honey John *et al.* [5] prepared different compositions of conducting NR with polyaniline (PANI) semi interpenetrating networks and determined their dielectric properties in microwave frequency. Jayamani *et al.* [6] analysed the dielectric properties of composites poly lactic acid with different lignocellulosic fibres. Pervoskite ($BaTiO_3$) nanoparticles were charged into NR matrix reinforced with conventional stabilizer additives by Gonzalez *et al.* [7]. The dielectric elastomer becomes more insulating with the addition of nanometric oxide ($BaTiO_3$) particles. Ward *et al.* [8] studied the effect of phosphate pigment on dielectric properties of NR and NR-Acrylonitrile budtadiene rubber (NBR) blend and compared it with the effect of carbon black. It was found that there is correlation between the variation of dielectric properties with phosphate pigment and mechanical properties of the composites. Matchawet *et al.* [9] studied the effect of carbon black on electrical conductivity and dielectric constant of the epoxidized NR-50 matrix. Curing characteristics and dielectric properties of NR-Graphite composite was compared with NR-Carbon Black composite by Ravikumar *et al.* [10] and it was found that the latter is more conductive than former.

Keratin fibre from waste chicken feather is quite attractive from an economic and environmental point of view for developing a dielectric material. CF has alpha helix structure at the molecular level and is light and tough to endure mechanical and thermal stress. The nodes and hooks present in the hollow structure helps to improve the structural properties and increase the surface area. Since the fibre has a hollow structure, a given volume of it naturally contains a

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