Reinforcement of synthetic rubber with carbon nanoballs to produce nanocomposite ion exchange membrane

Abstract

The improvement of the mechanical properties of emulsified styrene butadiene rubber ion exchange membrane through blending with 60nm carbon nanoballs is reported in this work. Homogeneous blending was achieved using a 200W Probe Ultrasonicator at 60% amplitude to produce a 160μm thick nanocomposite ion exchange membrane. Weight concentrations varying from 0.25 to 4wt%CNB were added to the sulphonated styrene butadiene rubber in solution and cast by the evaporative technique. Mechanical testing was done using Hysitron Nanotensile5000 Tester to evaluate the effects of blending. Tensile strength, σ_s, increased linearly (2 - 3.88MPa) with carbon nanoball volume fraction (V_f), achieving a maximum improvement of 94% at 14.2% V_f. The Young's modulus, E increased as a power function of V_f, reaching a maximum of 79% (13.71 – 24.58MPa) improvement at 3.3% V_f and decreasing gently afterwards due to agglomeration. The fracture toughness, $U_{f.t}$ increased as a power function of V_f up to a maximum improvement of 215% (0.84 – 2.65MPa) at 14.2% V_f. Strain, e increased by a maximum of 63% (0.68 – 1.11) at 14.2% V_f. Higher ultrasonication amplitudes achieved superior dispersion effectiveness as compared to lower amplitudes. The nanofiller addition also significantly reduced degradation of mechanical properties with time. Below a critical nanofiller volume fraction, V_c, related to the fractional free volume of the polymer matrix, the E profile was consistent with existing models by Guth and Thomas. However, the coefficients of V_f, were significantly higher, which was attributed to the higher mechanical properties of carbon nanoballs as compared to the fillers assumed. Beyond V_c, agglomeration distorted the profile. The tensile strength profile for the well dispersed carbon nanoballs was different from the existing models by Nicolais and Narkis and Nielsen. It was concluded that the addition of [1-14vol% *(1-4wt%)*] carbon nanoballs improved the mechanical properties by a margin between 79% and 369%. With good dispersion, it can also be shown that prediction of mechanical properties for a given V_f was possible. Further work on dispersion improvement was shown to have the potential to increase the mechanical properties by up to 700%.