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Rheological Study of Aging and pH Effects on Polymer-Particle Interactions

Rheological techniques were used to study the viscoelastic properties of aqueous carboxymethyl cellulose sodium salt (NaCMC) solutions containing graphene nanoparticles. NaCMC is a long-chain polymer molecule that ionizes when in aqueous solution. This results in a negative surface charge that forms hydrogen bonding sites. These interchain and intrachain sites are of particular interest as it has been shown that the addition of nanoparticles interact with them. Also, the presence of hydroxyl and hydronium ions in these solutions impacts the bonding sites in a different way; previous exploration has demonstrated that the interactions between the solvent and solute have pH dependence. Solutions with pH of 4.4, 6, 8.4, and 10 were analyzed in order to determine the impact of the pH on the formation of polymer-particle networks through changes in the viscoelastic properties. Rheological experiments were carried out using a TA Instruments AR-GR rheometer. Both flow and oscillatory experiments were performed on the samples, which measure viscosity and the viscoelastic storage and loss moduli respectively. The storage and loss moduli are measures of the amount of energy stored in the fluid and the energy dissipated. Viscosity was measured over a range of shear rates from 0.1-1000 s-1 as a function of time in peak hold tests to determine the transient behavior of the solutions, understand their susceptibility to hysteresis, and construct flowcurves of viscosity versus shear rate. The samples were also subjected to a strain sweep test to determine the linear viscoelastic region for each sample pH. From these results, an oscillatory experiment, or frequency sweep, was performed for frequencies from 0.1-100 Hz. These tests evaluated the strength of the polymer-particle network.

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