Rheological Behavior of Lyotropic Solutions of Cellulose in the NH_3/NH_4SCN Solvent System

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In the past, facile dissolution of cellulose has been hampered by the lack of suitable nondegrading solvents. Recently, this problem has been solved in our laboratory by the discovery of an inexpensive, convenient solvent system, that is the mixture of NH_3 and NH_4SCN, for cellulose. Also, the cellulose/NH_3/NH_4SCN solution system has been found to form the anisotropic, i.e., liquid crystalline phase. It is believed that both the cholesteric and the nematic phase occur. This finding has prompted extensive on-going research on the formation of the liquid crystalline phase from an inexpensive natural source such as cellulose since the nematic phase is envisioned as an excellent precursor sources for products with desirable properties, for example, high modulus and high strength. This interest naturally leads to a desire to understand the rheological properties of the nematic phase so that the transformation of the nematic phase to the solid state with desirable properties can be efficiently accomplished,

From this point of view, the rheological behavior of the cellulose/NH_3/NH_4SCN system has been studied as a function of shear rate and shear stress over a wide range of solvent compositions, cellulose concentration, centrifugation and urea contents. Results indicate that the viscosity decreases with increasing shear rate. A marked shear thinning behavior and a quasi-Newtonian behavior were observed in the low shear rate region and in the high shear rate region, respectively for all solvent compositions. The cellulose /NH_3/NH_4SCN solution system only exhibited the viscosity increase with increasing cellulose concentration and failed to show the viscosity drop generally observed at the point of incipience of liquid crystal formation. This may be due to the gel-like nature of the solution by the association of the rodlike molecules into bundles which may serve as crosslinking points giving the cellulose solution a network structure. Also, simply hydrogen bonding may be so restrictive of molecular mobility that a viscosity drop is blocked. In addition to the above results, yield stress and thixotropy were also observed in the cellulose/NH_3/NH_4SCN solution system which are characteristics of liquid crystal and gel. The results of the effect of centrifugation on viscosity show that viscosity decreases by the application of centrifugation. This may be explained by the change of the piled polydomain structure to the dispersed polydomain structure due to the pressure gradient generated during centrifugation.