Rheological model for short fiber suspension in polymeric liquid

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In the present study, a rheological model for a short fiber suspension in a polymeric liquid is proposed following the approach of irreversible thermodynamics. The model combines Leonov and Dinh-Armstrong models, which respectively accounts for the polymer and fiber contribution to the total stress. Fiber orientation kinematics is described by Folgar-Tucker model using fiber orientation tensor where invariant based optimal fitting closure approximation is employed. In particular, the anisotropic effect due to the fiber orientation is introduced in the kinematic equation of the polymer by using kinetic tensor which is a function of a recoverable Finger strain tensor of the polymer and the fiber orientation tensor. The present rheological model could be also derived from a general Poisson bracket formulation. Comprehensive investigations are carried out with the proposed model using steady and transient shear flows. The model can predict important features of the fiber suspension in polymeric liquid: i) increase of the shear viscosity and the first normal stress difference; ii) shear thinning behavior at a lower shear rate than a neat polymer; iii) stress overshoot in the transient shear flow; iv) negative first normal stress difference in the transient shear flow when the flow direction is reversed. The model has a particular feature, which is different from the other models in the literature, that the slop of the material functions (shear viscosity and first normal stress difference in a steady shear flow) in a high shear rate regime is nearly independent of the fiber volume fraction and the fiber-polymer interaction. The model could fit the experimental data available in the literature very well using only two or three relaxation modes.