점탄성 유체 및 반고형 물질을 대상으로 한 COX-MERZ 법칙의 적용성에 대한 재검증

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It has long been known that the similarities exist between steady shear flow viscometric functions (non-linear behavior) and linear dynamic viscoelastic properties for polymeric liquids. The first paper on this topic was reported by DeWitt[1], who had derived theoretically the equivalence between steady flow viscosity $\eta(\dot{\gamma})$ and dynamic viscosity $\eta'(\omega)$, written as follows.

$$\eta(\dot{\gamma}) = \eta'(\omega) \qquad \text{at} \qquad \omega = \dot{\gamma} \tag{1}$$

Here, $\dot{\gamma}$ is shear rate and ω is angular frequency. The DeWitt's theory was, however, found to be incorrect at high shear rate or frequency ranges[2-4] where $\eta'(\omega)$ decreases more rapidly than $\eta(\dot{\gamma})$ does.

Cox and Merz[5] suggested a useful empirical relationship which can be expressed by the following equation.

$$\eta(\dot{\gamma}) = |\eta^*(\omega)| \qquad \text{at} \qquad \omega = \dot{\gamma} \tag{2}$$

Here, $|\eta^*(\omega)|$ represents the absolute value of complex viscosity. This empiricism came to be known as the Cox-Merz rule, because it had been confirmed for most polymer systems by many authors[6-11].

Recently, this relationship has been extended to establish a new rheological model for concentrated suspensions and other materials with a yield stress[12]. The significance of the rule is that, a relation between linear and non-linear viscoelastic properties exists, therefore, one can obtain steady shear viscosity informations only when linear viscoelastic data are available and the reverse case. However, the validity of the Cox-Merz rule becomes a focus of the rheologists' attention, ever since some studies showing deviations from the rule have been published[13-16].

The purpose of this study is to re-examine the applicability of the Cox-Merz rule for viscoelastic polymeric fluids and viscoplastic semi-solid materials. To accomplish this, using a Rheometrics Fluids Spectrometer (RFSII), steady flow viscosity and dynamic viscoelastic properties have been measured for some polymer solutions and commercial semi-solid foodstuffs over a wide range of shear rates and angular frequencies. In this paper, some interesting results obtained from the study are reported.

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