Rheological Studies on Linear Viscoelasticity of Xanthan Gum Solutions

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Xanthan gum solution (XGs) is known as a viscoelastic solid when its concentration is high enough. Here, we define viscoelastic solid as a viscoelastic material whose zero-shear viscosity is infinitely high or fully relaxed stress is not zero. Since xanthan gum chains are not connected by covalent bonds in solution state, it should behave as viscoelastic fluid if its concentration is too low. Hence, there should be a transition concentration at which xanthan gum solution changes from viscoelastic fluid to solid as concentration increases.

Dynamic measurement for xanthan gum aqueous solution is limited to the range of frequency because time-temperature superposition is not available. To detect long-time behavior, creep test may be recommended. However, high elasticity of xanthan gum solution gives rise to creep ringing which prevents from identification of creep compliance from creep strain data. Recently Cho and coworkers developed an algorithm for the extraction of material functions from creep strain data with ringing[1]. This algorithm will be used to detect the transition.

As shown in Fig.1[a], XGs 2wt% looks different from viscoelastic fluid because long time behavior follows

$$\gamma(t) \approx \gamma_\infty \left(1 - e^{-t/\tau}\right)^b \text{ in long time regime} \quad (1)$$

On the other hand, XGs 0.3wt% shows typical behavior of viscoelastic fluid such as

$$\gamma(t) \approx \frac{\sigma_o}{\eta_o} t + \frac{\sigma_o}{J_e^o} \text{ in long time regime} \quad (2)$$

where σ_o is the stress amplitude, η_o is the

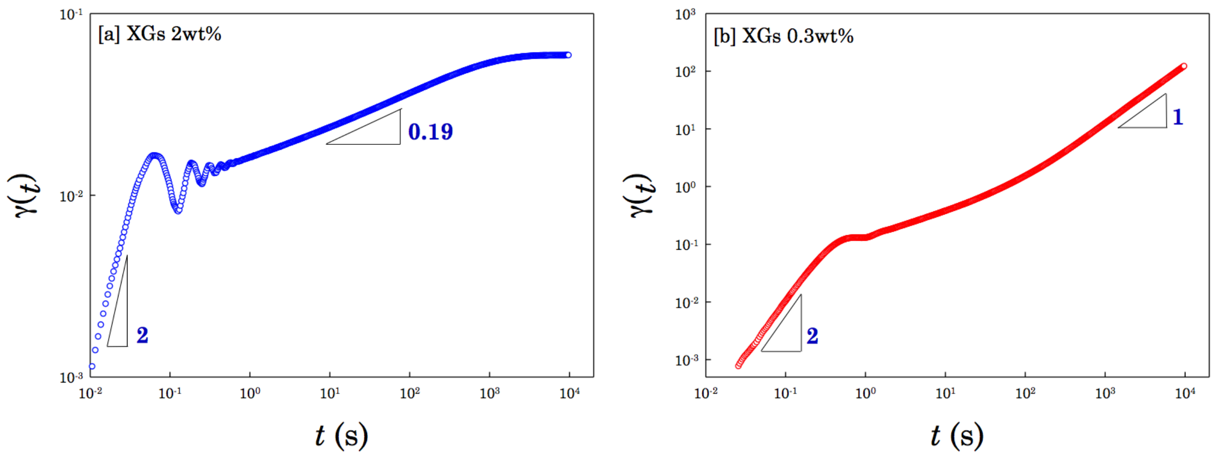

Figure 1. Creep ringing of xanthan gum solution (0.3wt% and 2wt%)

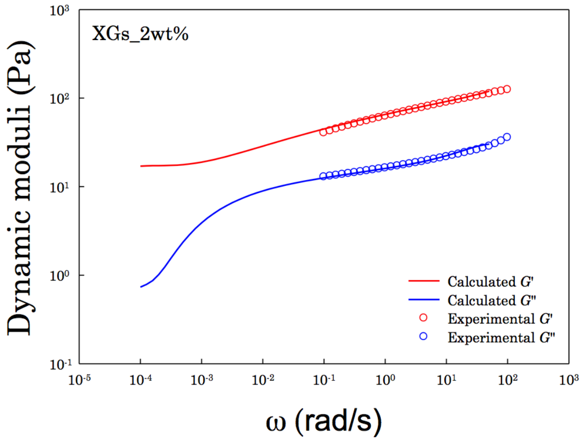

Figure 2. Comparison of measured and calculated dynamic moduli of XGs 2wt%.

zero-shear viscosity and J_e^o is the steady state compliance. XGs 2wt% shows strong creep ringing while XGs 0.3wt% shows weak creep ringing because of comparatively low elasticity.

As for low concentrations, viscoelasticity of XGs can be understood by dynamic measurement. However as concentration increases, dynamic measurement cannot provide the terminal regime which contains the information of molecular structure. This enforces us to use creep test and numerical algorithm for removing inertia effect. We adopted numerical algorithm which is an improvement of Kim et al. (2015) and applied new asymptotic equation (1) to understand the effect of concentration on linear viscoelasticity of XGs.

Figure 2 compares the measured dynamic moduli of XGs 2wt% and those converted from creep data. The improved algorithm was the one to be presented in “Direct Conversion of Creep Data to Dynamic Moduli” by Kwon et al. From this algorithm, we found that the transition from viscoelastic fluid to solid occurs at the concentration of about 1 wt%.

REFERENCES

1. Kim, M., Bae, J.-E., Kang, N., and Choo, K.S. (2015), "Extraction of viscoelastic functions from creep data with ringing", *J. Rheol.*, **59**, 237-252.
interfaces: their structure, rheology and applications", *Soft Matter,* **9**, 10791-10798.