Effect of Surfactants on Shear-Induced Gelation and Gel Morphology of Strawberry-like Particles

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Abstract
We study the effect of surfactants on aggregation and gelation of strawberry-like particles induced by intense shear without adding any electrolytes. The particles were composed of rubbery core (with $T_g \approx -56$ °C), partially covered by plastic shell, and well stabilized by negative charges originating from the polymer chain end groups. In the absence of any surfactant, at the Pelet number and initial particle volume fraction, $Pe=220$ and $\phi=0.15$, the shear-induced gelation does occur after the colloidal system passes through a z-shaped microchannel. Moreover, from both SEM pictures and the light scattering measurements, we have observed partial coalescence among the particles during the shear-induced gelation, and the fractal dimension of the clusters constituting the gel is equal to $D_f=2.76$. Then, three different surfactants, ionic sulfonate surfactant (Emulgator K30/95), and two nonionic surfactants, Triton X-100 and Tween 20, were added to the system, respectively. It is found that for all the three types of surfactants, at the same $Pe$ and $\phi$ values, the conversion of the primary particles to gels decreases as the amount of the added surfactant increases, and when the surfactant concentration increases to a certain value, the shear-induced gelation or even aggregation becomes impossible. Detailed computations of the colloidal interactions demonstrate that such improved stability against shear is not due to the DLVO forces, because at the given $Pe$ value, the aggregation behavior of the system is purely controlled by the shearing force. Thus, the improved stability is related to additional non-DLVO forces (e.g., short range hydration force, steric force, etc.). Another important observation is that for the Triton X-100 and Tween 20 surfactants, the fractal dimension of the clusters constituting the gel decreases as the surfactant concentration increases, till to the value of 2.48 and 2.45, respectively, while for the sulfonate surfactant, the $D_f$ value is independent of the surfactant concentration and equal to 2.76. These results indicate that both Triton X-100 and Tween 20 surfactants can protect the rubbery core from the coalescence, while the sulfonate surfactant cannot.