Research focus is placed on the molecular origin of rheological properties of various materials. Depending on time and temperature, homogeneous polymeric materials exhibit typical features of glass, rubber, and viscous fluid while heterogeneous polymeric systems exhibit plasticity in addition to these features. For basic understanding of these features, the molecular motion and structures at various scales are studied for polymeric systems in deformed state. Rheological measurements are performed with various rheometers. Auto-correlation of the molecular orientation is also investigated with dynamic dielectric spectroscopy. Analysis of rheological and dielectric behavior elucidates a new aspect of softmatter physics.

**KEYWORDS**
Rheology  Dielectric Spectroscopy  Softmatter

**Selected Publications**
Watanabe, H.; Matsumiya, Y.; Kwon, Y., Iscoelastic and Dielectric Relaxation of Reptating Type-A Chains Affected by Reversible Head-to-Head Association and Dissociation, Macromolecules, 51, 6476-6496 (2018).
Nonlinear Elongational Rheology of Non-Entangled Polystyrene and Poly(p-tert-butylstyrene) Melts

Nonlinear rheological behavior under uniaxial elongation was examined for unentangled melts of polystyrene (PS27; \( M = 27k \)) and poly(p-tert-butyl styrene) (PtBS53; \( M = 53k \)) having nearly the same number of Kuhn segments per chain, \( n_K = 30 \) and 35 for PS27 and PtBS53, respectively. For both materials, the steady-state elongational viscosity \( \eta_E \) exhibited strain-rate-hardening and then strain-rate-softening on an increase of the Weissenberg number \( Wi \geq 0.3 \) (\( Wi = \dot{\varepsilon} \tau_1^{eq} \), with \( \dot{\varepsilon} \) being the longest relaxation time in the linear viscoelastic regime and the Hencky strain rate, respectively). For the unentangled melts, the hardening and softening were free from any entanglement nonlinearity, so that the hardening was unequivocally related to the finite extensible nonlinear elasticity (FENE) of the chain, and the softening, to suppression of the FENE effect due to reduction of the segmental friction \( \zeta \) occurring for the highly stretched and oriented chain. Thus, the \( \zeta \)-reduction, speculatively discussed for entangled melts so far, was experimentally confirmed, to the first time, for unentangled melts. Quantitatively, the hardening at intermediate \( Wi \) was stronger and the softening at higher \( Wi \) was weaker for PtBS53 than for PS27 despite the similarity of their \( n_K \) values, which suggested that the magnitude of \( \zeta \)-reduction depends on the chemical structure of the chains. For estimation of this magnitude, the well-established FENE bead-spring model (FENE-PM model) was modified for the \( \zeta \)-reduction in an empirical way with an assumption that \( \zeta \) at a given time is fully determined by the chain stretch/orientation and thus by the elongational stress \( \sigma_E \) at that time. This modified model was able to mimic the steady state \( \eta_E \) data excel-