Supplementary Information (SI) for Soft Matter.

Supplementary Material:

Colloidal Rod Dynamics under Large Amplitude Oscillatory Extensional Flow

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1 Residual Birefringence

Fig. S1 displays the residual birefringence $\langle \Delta n \rangle_{\mathrm{res}}$ as a function of Pe_0 for different pulsation periods ($1 \leq T \leq 50$ s) and various CNC concentrations. As the period decreases, *i.e.*, as the pulsation frequency increases, the onset of detectable residual birefringence $\langle \Delta n \rangle_{\mathrm{res}}$ shifts to lower Pe_0 values.

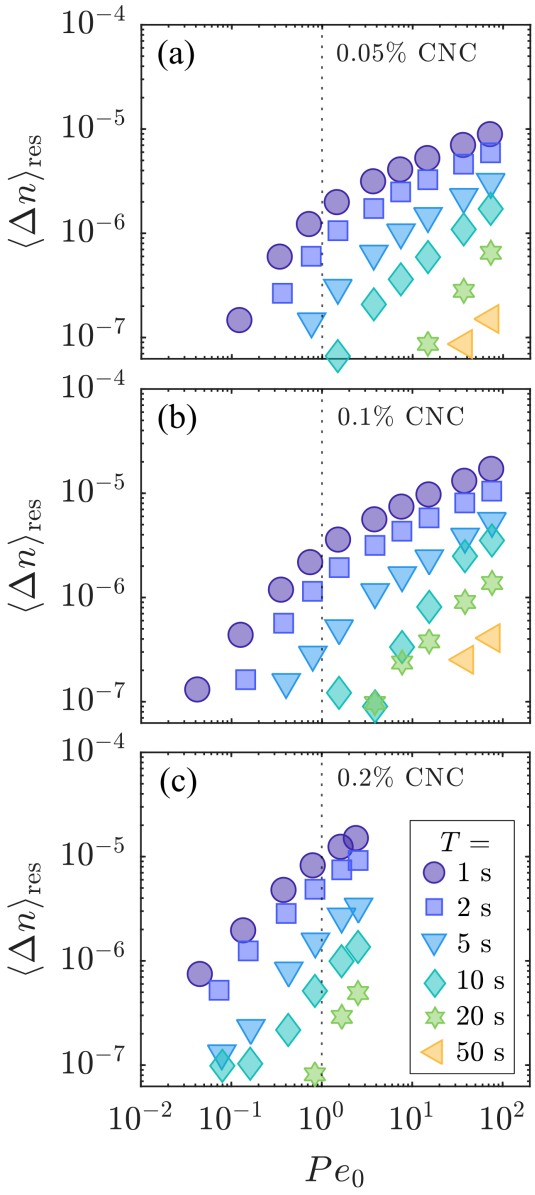

Fig. S 1: Residual birefringence $\langle \Delta n \rangle_{\mathrm{res}}$ during pulsatile LAOE. Data is shown as a function of Pe_0 for the three samples (a-c) and various periods T.

2 Lissajous Plots

Fig. S2 displays the experimental Lissajous plots for a 0.1 % CNC sample over a broad range of T and $\dot{\varepsilon}_{0,\text{set}}$. We can highlight the following general trends.

At relatively high T (*e.g.*, $T = 50$ s), there is a lack of hysteretic behavior as well as residual birefringence, indicating that the CNCs are in a flow-independent regime. However, at $\dot{\varepsilon}_{0,\text{set}} \gtrsim 2\ \text{s}^{-1}$, the birefringence becomes progressively non-linear.

As T decreases and approaches values comparable to $1/\overline{D}_r$, evidence of flow-history dependence in the CNCs emerges, manifested as hysteresis. At even smaller T, residual birefringence also appears *e.g.*, see $\dot{\varepsilon}_{0,\text{set}} = 5\ \text{s}^{-1}$ as T decreases). It appears that hysteresis provides a more sensitive measure for detecting the onset of flow-history dependence than residual birefringence. This is likely because the residual birefringence is limited by the detection threshold of the experimental setup.

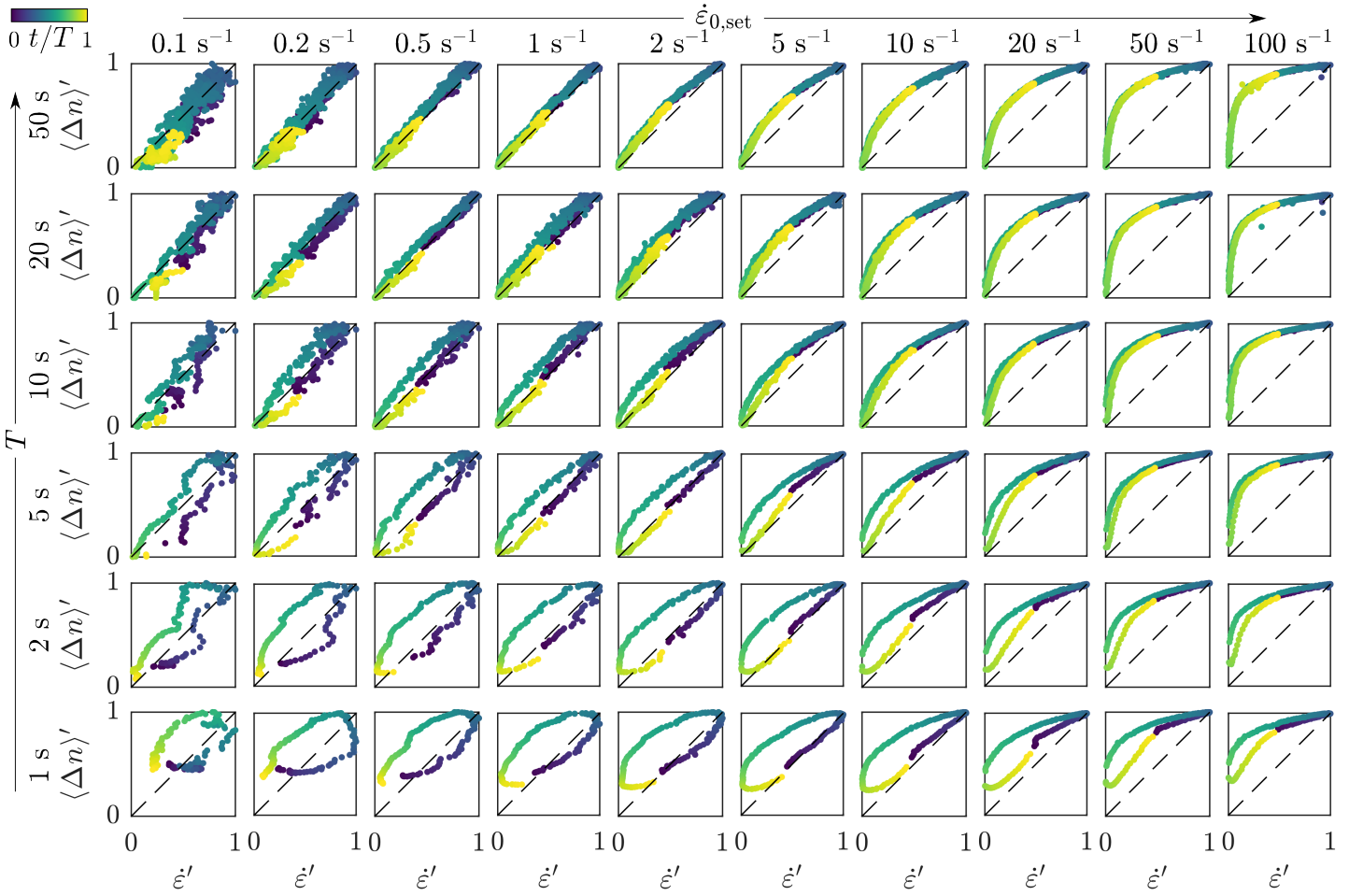

Fig. S 2: Experimental Lissajous curves of the normalized average birefringence $\langle\Delta n\rangle' = \langle\Delta n\rangle(t)/\langle\Delta n\rangle_{\text{max}}$ as a function of the normalized extension rate $\dot{\varepsilon}' = \dot{\varepsilon}(t)/\dot{\varepsilon}_{\text{max}}$ for various T and $\dot{\varepsilon}_{0,\text{set}}$. Data is shown for the 0.1 % CNC sample. Black dashed lines correspond to slopes of 1.