On the (Micro)Rheology of Lactoferrin/β-Lactoglobulin Coacervates

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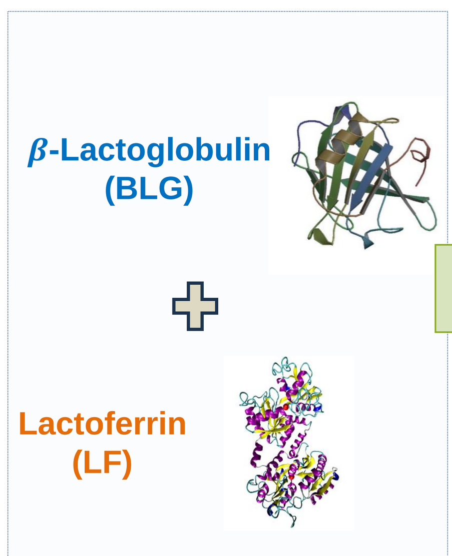
MOTIVATION

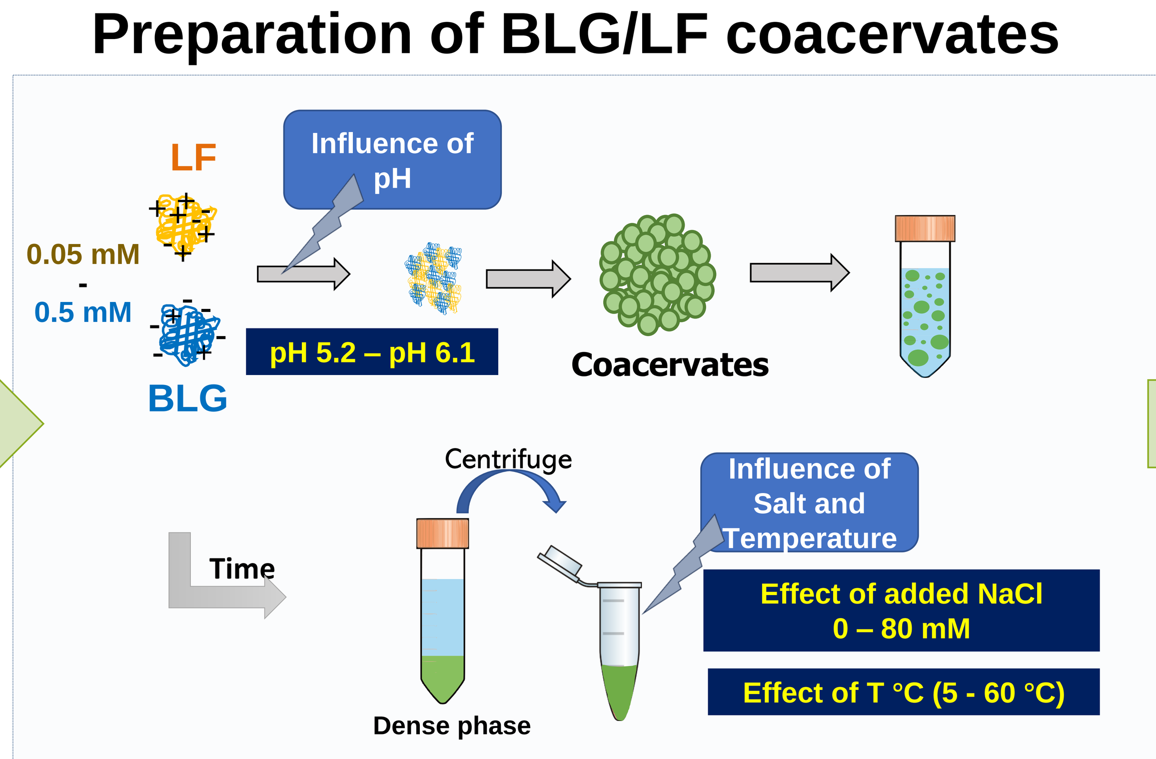
The various applications of heteroprotein complex coacervation have made it of great interest in many fields including food industry. However, the sensitivity of the coacervates to slight changes in the physico-chemical environment deserves to be better understood.
In the present study, heteroprotein complex coacervation between positively charged lactoferrin (LF) and negatively charged β-lactoglobulin (BLG) was investigated. The effect of slight change of pH (pH5.2 – pH5.6), ionic strength (up to 80 mM) and temperature (5 – 60 °C) on the rheological properties of LF/BLG coacervates was conducted, as these parameters were proved to be critical for practical applications.

EXPERIMENTAL APPROACH

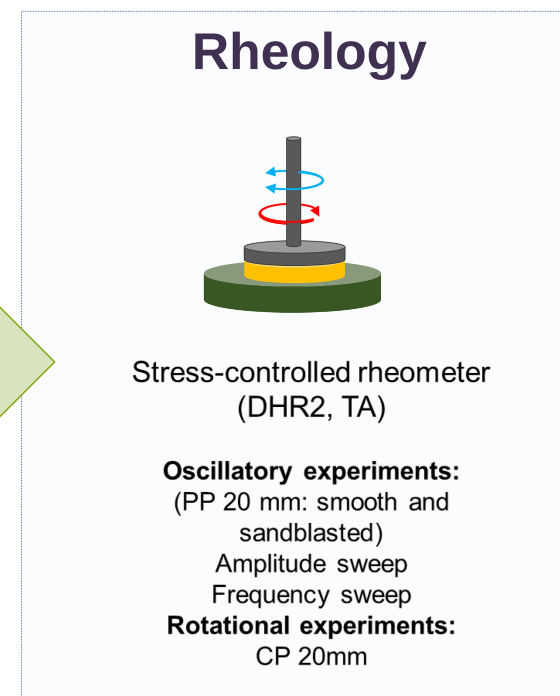
Selected system

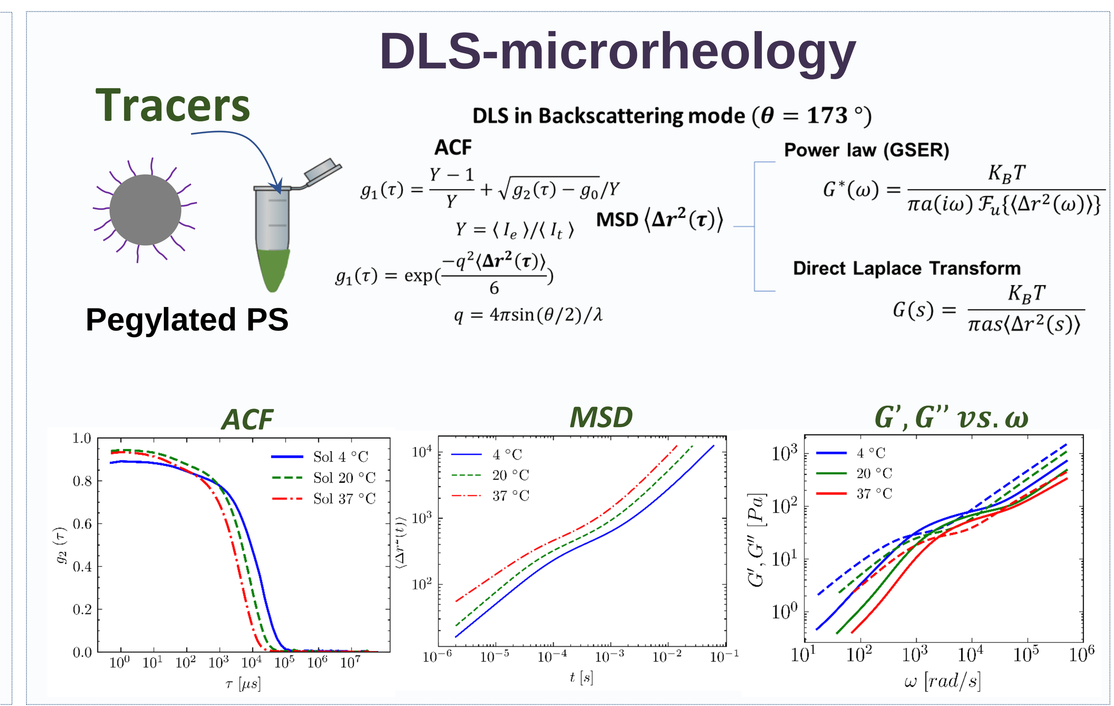


Preparation of BLG/LF coacervates



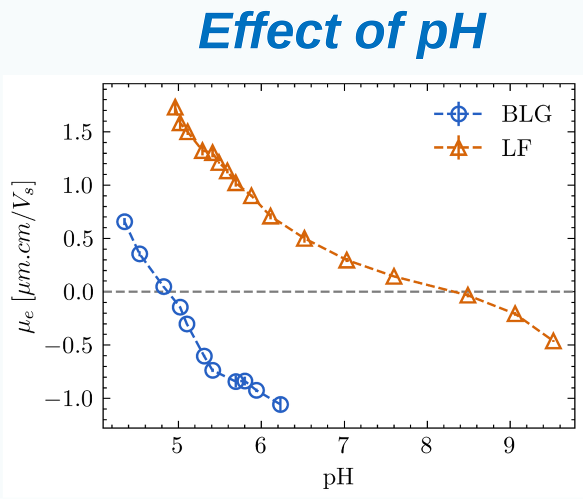
Characterization

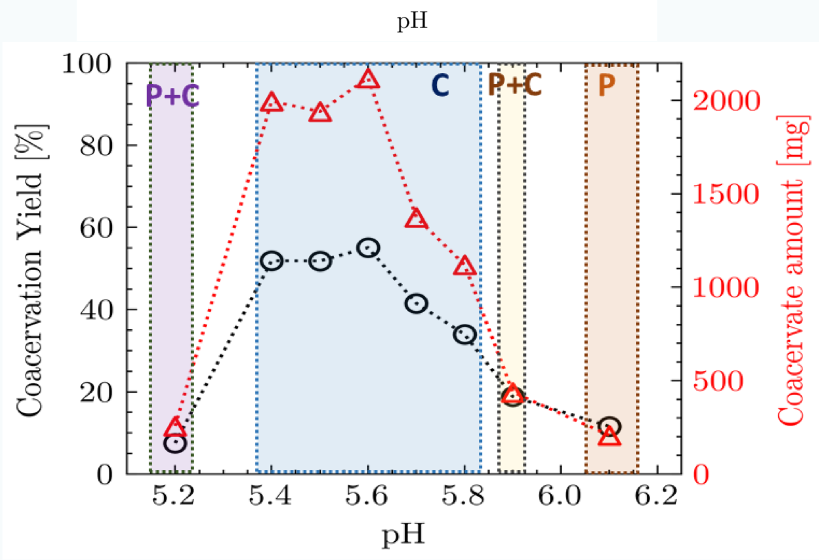


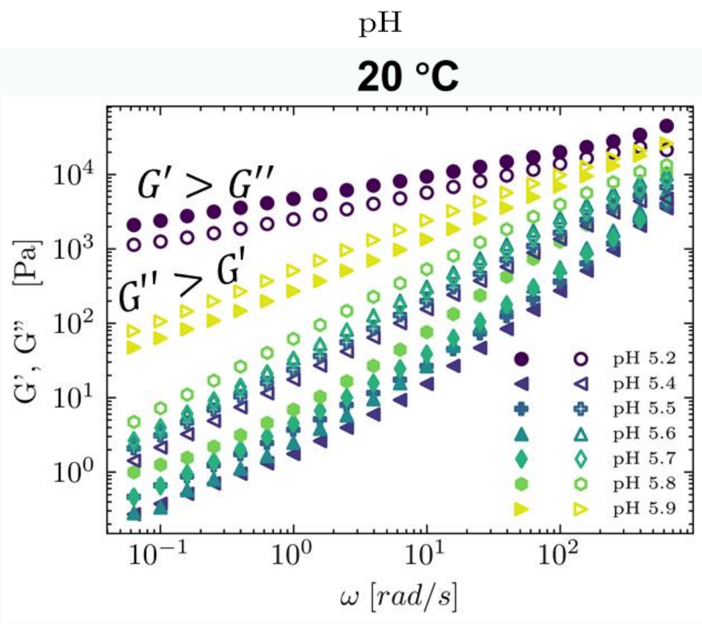


RESULTS & DISCUSSION

Effect of pH

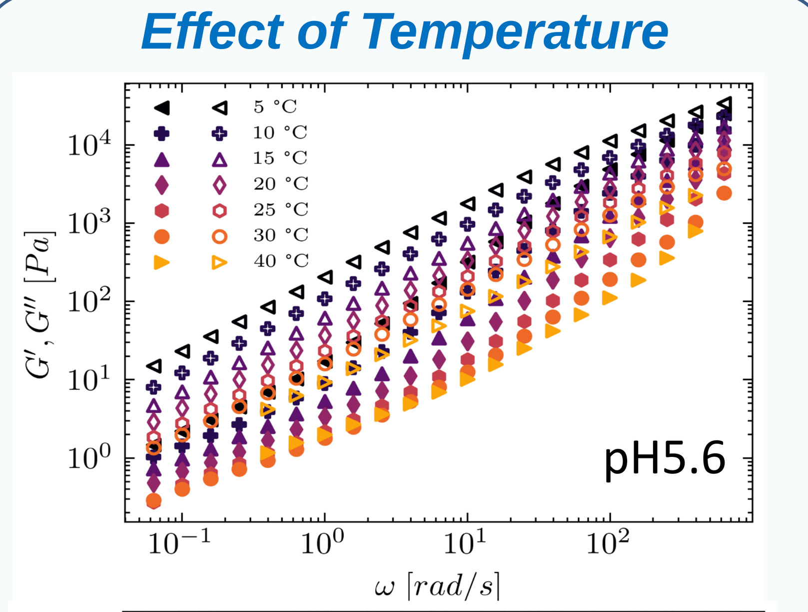


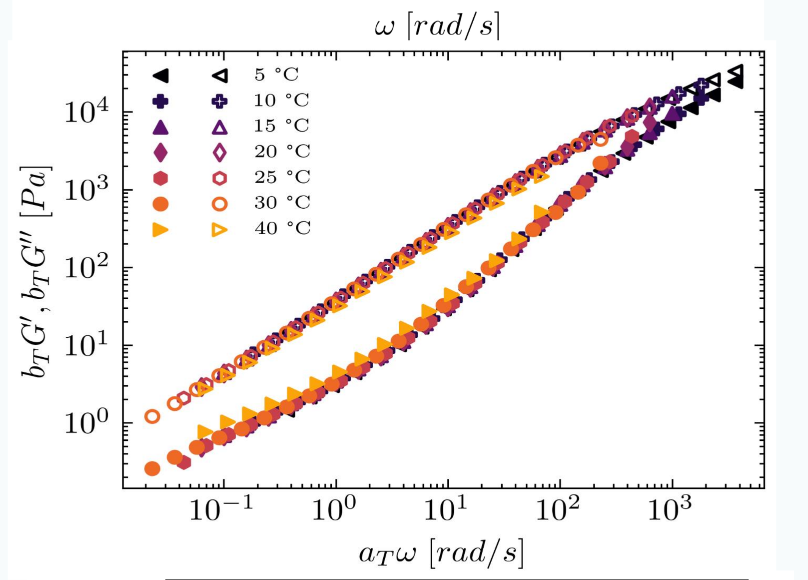


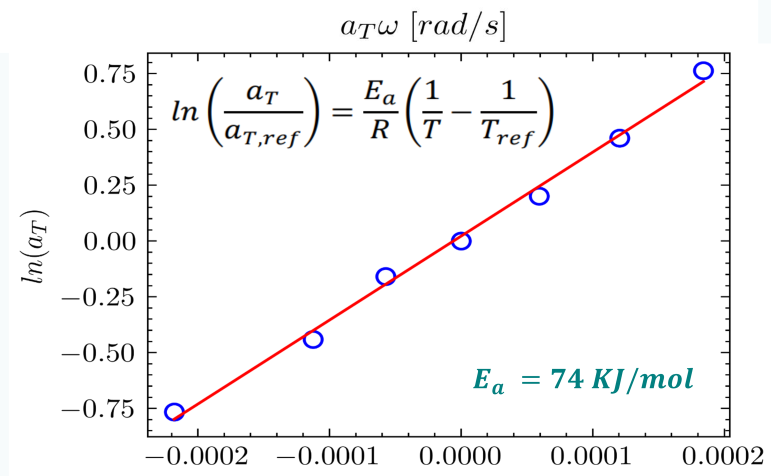


- High sensitivity of the system as a function of pH (0.1 unit).
- pH 5.2: P+C: BLG precipitation close to the Ip ($pH \sim 5$)
- pH5.9 & 6.1: precipitation due to strong electrostatic interaction between BLG and LF

Effect of Temperature

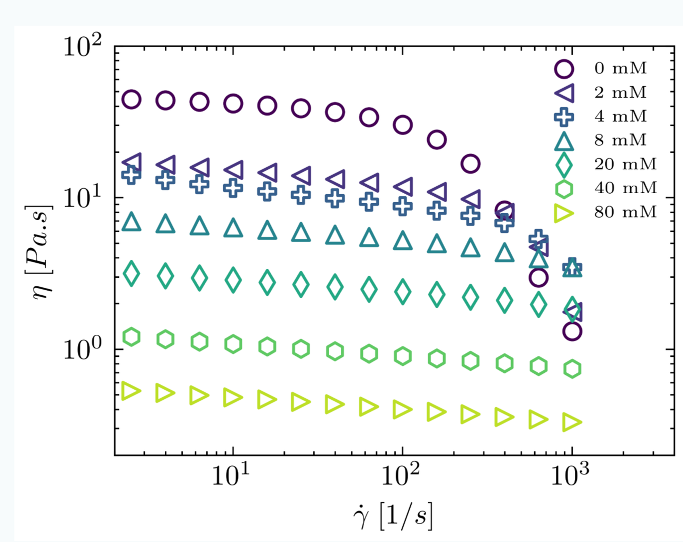


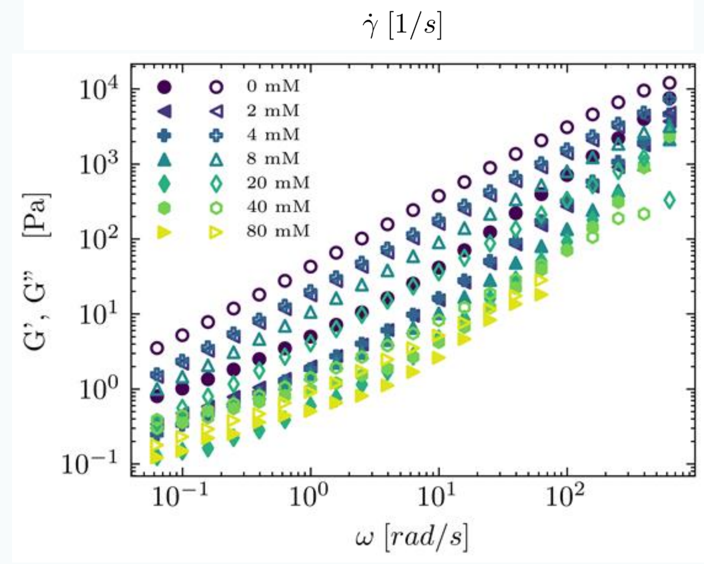


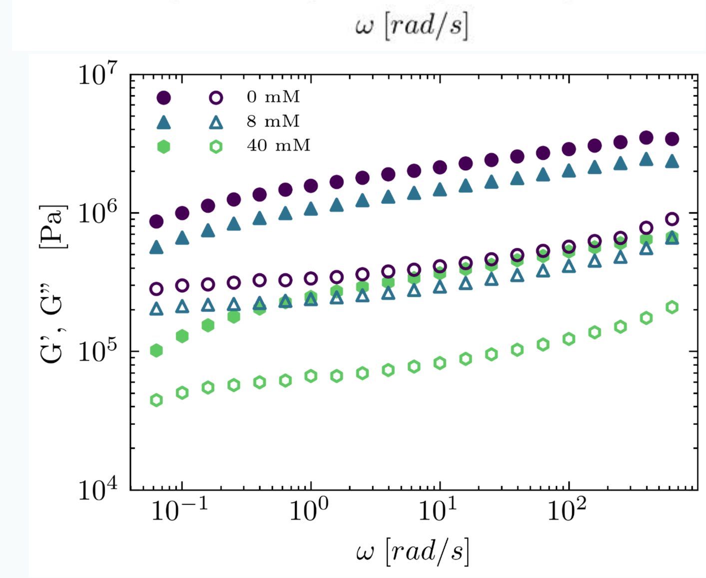


- Heating: accelerate the coacervate's dynamics
- TTS principle applies in the limited range of T°C ($5 \leq T < 50$ °C):
- Both proteins show the same T-dependent monomer friction.
- The dynamics of the coacervate is dominated by BLG/LF interactions.

Effect of added NaCl

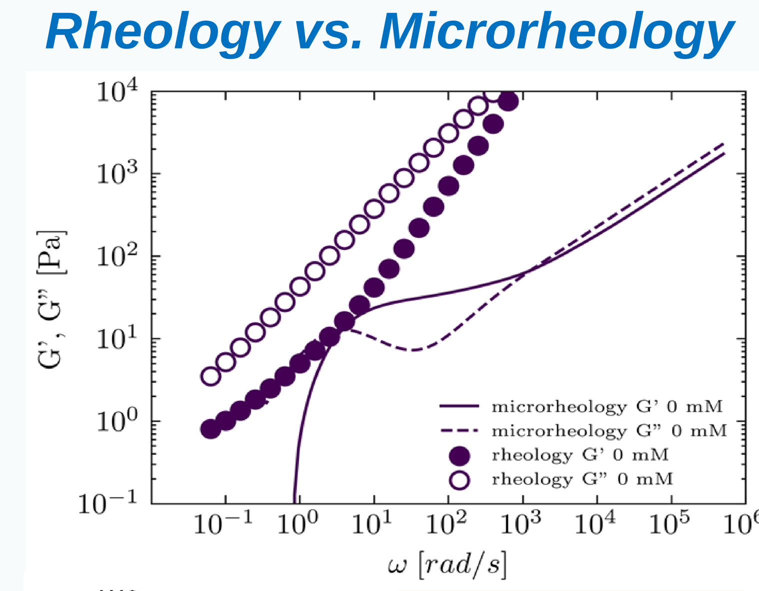


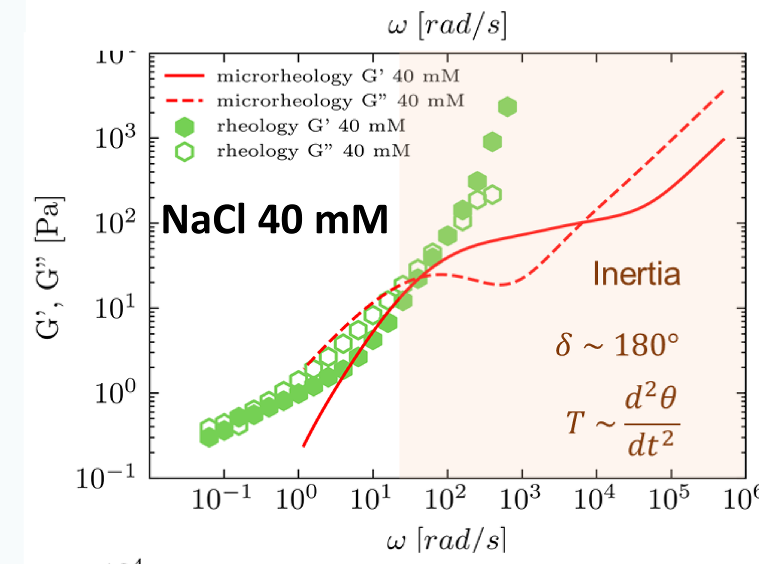


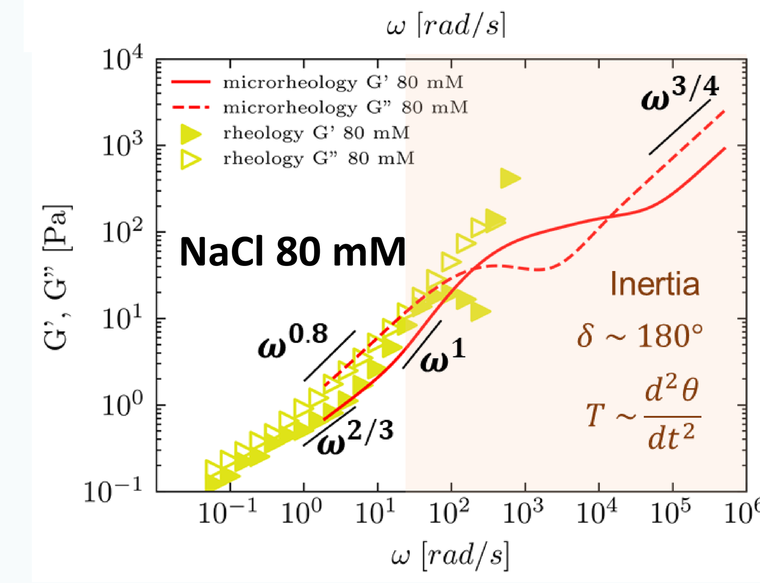


- Increasing [NaCl]: decrease the viscosity of coacervates and accelerates the coacervates dynamics by a decrease of the number of intrinsic ion pairs and reducing local friction.
- Gelation of the coacervate phase lead to stiff materials (1 KPa < G' < 1 MPa).

Rheology vs. Microrheology







- Up to NaCl 20 mM: Discrepancy between rheology and microrheology: Inaccuracy of microrheology for $G' \sim 10^4\ Pa$
- Good agreement between rheology and microrheology for NaCl 40 and 80 mM.

CONCLUSION

Fine-tuning pH (0.1 unit): 1) Affect significantly the rheological response from viscoelastic solid to liquid. **2)** Optimum coacervation pH range (similar rheological signature): $5.4 \leq pH \leq 5.8$.

Increasing T °C: 1) $5\,°C \leq T \leq 50\,°C$: Faster dynamic of coacervates in solution. **2)** $50\,°C \leq T \leq 60\,°C$: Irreversible gelation of the network.

Addition of NaCl: Decrease the viscoelasticity by reducing the net attractive interactions.

Rheology *vs.* microrheology: 1) For relatively high G', G'': Discrepancy at low salt concentration ([NaCl] < 40 mM).
2) Higher salt concentrations: Good agreement between rheology and microrheology.

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