

Resolving Solvent-Polymer Interactions in Eutectogels

DIRECTEUR DE THESE : MEHDI VAHDATI (CPJ) ET JOACHIM WITTMER (DR, HDR)
INSTITUT CHARLES SADRON, 23 RUE DU LOESS, 67034 STRASBOURG
TEL : 03 88 41 40 30 ; E-MAIL : MEHDI.VAHDATI@ICS-CNRS.UNISTRA.FR,
JOACHIM.WITTMER@ICS-CNRS.UNISTRA.FR

Soft polymer networks swollen in a solvent, known as gels, are useful for many applications which require a specific combination of (i) low elastic moduli (<100 kPa) and (ii) large extensibility (> 100%). Gels, although much softer than elastomers, have a drastically lower toughness (by more than 2 orders of magnitude). This is due to the typically large volume fraction of the solvent resulting in the loss of the internal dissipation mechanisms such as molecular friction. This inherent brittleness of soft gels has motivated a large body of research on toughening strategies, where the main focus has been on designing dissipation mechanisms into the polymer network, mostly via multiple networks or dynamic bonds [1].

We have recently worked on polymer networks swollen in Deep Eutectic Solvents (DES). DES are formed due to extensive hydrogen bonding between certain combinations of sugars, salts, and acids featuring a *deep* eutectic point at certain molar ratios [2]. These solvents are generally interesting due to the tunability of their physico-chemical properties (viscosity, polarity, etc.), their low volatility, and natural origin. More importantly, we recently found that the toughness of simple polymer networks prepared in DES, called Eutectogels, is comparable with that of double network gels. Preliminary viscoelastic measurements suggest that these Eutectogels are more dissipative than their hydrogel analogs. **Understanding the mechanisms of DES-induced extra dissipation will allow the design of novel soft materials with tunable mechanical properties with minimal synthetic effort.**

We hypothesize that cononsolvency effects [3] via the formation of specific polymer-solvent interactions make important contributions in toughening Eutectogels (Figure 1). **The goal of this project is to use experiments and simulations [3] to investigate the role of solvent-polymer interactions in toughening polymer Eutectogels.**

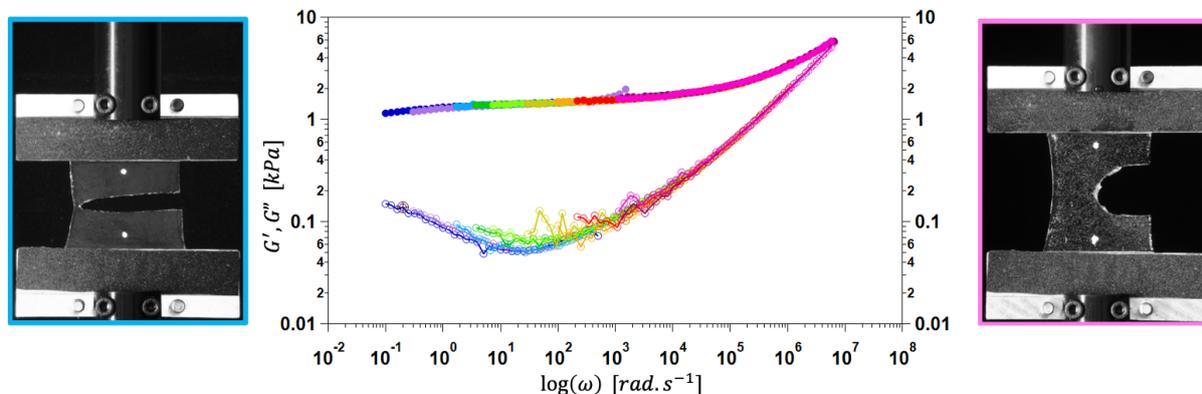


Figure 1. Wide-ranging dynamics (dynamic moduli vs. frequency) and different fracture behaviors (images of a sharp (left) versus a blunt (right) crack) of gels in solvents of different qualities.

By gradually tuning the DES-polymer interactions (i.e. the solvent quality) in coarse-grained simulations, we will attempt to probe the effect of these interactions in the dynamics of Eutectogels. The simulations will complement experiments on polymer Eutectogels prepared from several DES-polymer combinations (Figure 1). The dynamics of these polymer networks will be studied using linear rheology. The solvent quality and chain conformation will be investigated via X-ray scattering and FTIR, while the solvent structure may be elucidated via NMR.

Profile: Curious, driven master's students with a degree in materials science or physics and an interest in polymer physics are invited to apply with a CV and letter of motivation.

References: [1] C. Creton, *Macromolecules*, 2017, 50 (21), 8297. [2] B. Hansen, et. al., *Chem Rev*, 2021, 121 (3), 1232, [3] J.U. Sommer, 2017, 50 (5), 2219.