STRUCTURE, DYNAMICS AND GELATION IN A TRANSIENT-NETWORK FLUID

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Many soft materials can be described as network-forming fluids, i.e., as dispersions of particles connected by transient elastic bridges. Their cooperative dynamic behavior exhibits striking features, characterized by non-linearities (shear thinning and thickening), instabilities (shear banding, rheochaos) and heterogeneities, which lack any microscopic understanding. Here we introduce a simplified model of transient-network fluid, composed by particles and bridging polymers, amenable to detailed theoretical, numerical and experimental analysis. Three different phases - sol, gel and coexistence - conform the model phase diagram (see Figs. below). A percolation critical line separates the sol and gel phases, characterized by novel critical exponents. Within the gel phase, distinguished by a spanning network of connected particles, two different time scales emerge: a microscopic one, τ_1, associated with particle diffusion, and a mesoscopic one, τ_2, controled by the polymer residence time. For times shorter than τ_2 the transient-network fluid behave as a disordered solid. In particular, when stretched at appropriate rates, the system develops fractures whose properties resemble those of brittle solids, but which are reversible. The response to shear stress is nonlinear, with shear-thinning, shear-thickening and rheochaos regimes as observed in many complex fluids. The simplicity of the model allows us to propose simple explanations for these intriguing collective properties.