Thermoreversible Ferrogels

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In paraffinic oil, appropriate blockcopolymers form a microphase-separated system with insoluble glassy domains (network junction points, crosslinking points) and domains, which are compatible or soluble respectively to the paraffinic liquid. In consequence, a gel is formed showing a gel-sol transition, which seems to be connected with the glass transition of the insoluble domains. Using paraffinic ferrofluids, thermoreversible ferrogels have been produced similarly.

The gel-sol transitions T_{G-S} of the pure gels and the ferrogels have been determined by the falling-ball method.

With these transition temperatures, a simple phase diagram has been established of the pure gels. Below a critical gelator concentration, two-phase systems of fluid and gel are formed (cf. figure 1).

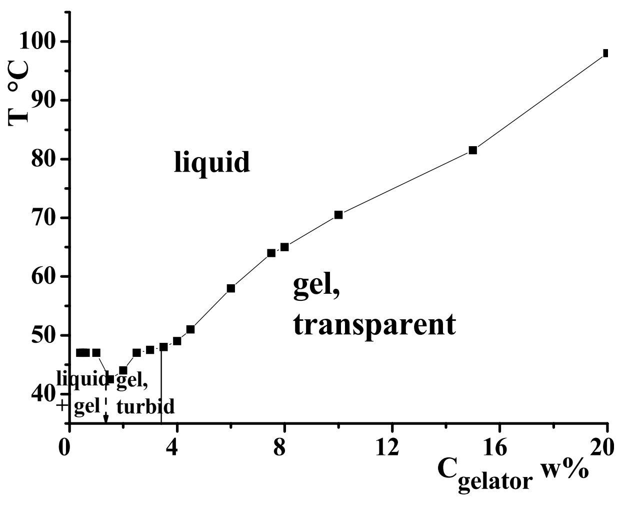

Figure 1: Pure gels: gel-sol transition in dependence of the gelator concentration.

The incorporation of magnetit Fe_3O_4 nanoparticles in the gels results in stable, thermoreversible systems at somewhat lower gelator concentration than for the relevant pure gels. The consistency of the ferrogels in dependence of the temperature and the gelator concentration (with equal ferrofluid concentration, i. e. concentration of the magnetic particles) can be varied between hard gel-like and very soft/viscoelastic.

In Figure 2, the relevant dependencies of T_{G-S} from the gelator concentration are shown for the ferrogels with different content of magnetit. Furthermore, it is shown that at the highest concentration of 8,8 vol% of magnetit in paraffinic oil, a strong increase of the gel-sol transition can be observed.

On the other hand, above certain limit concentration of the gelator (different for different ferrofluid concentrations) inhomogeneous, grainy hard gels are obtained. Either associate formation occurs or the receptivity of the matrix is limited.

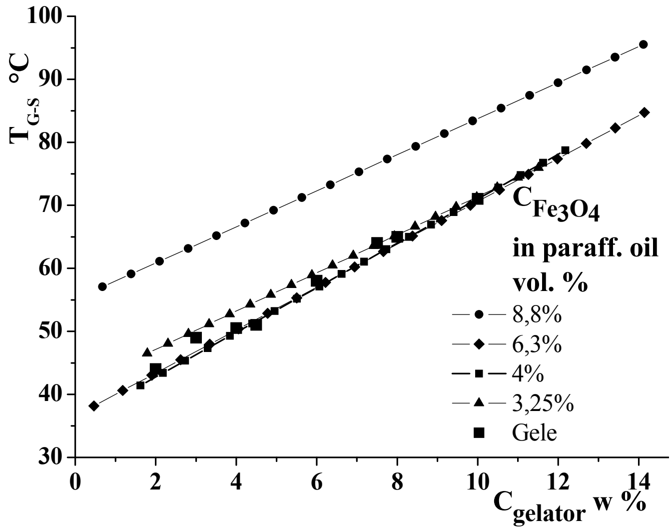

Figure 2: Pure gels; ferrogels with different Fe_3O_4 content (vol.% in paraffinic oil): T_{G-S} in dependence of the gelator concentration.

The dimensions of the polymeric glassy network forming domains and the magnetit nanoparticles have been determined by TEM.

Figure 3 shows a cryo-cut of a pure gel with stained glassy network domains of ca. 20 nm diameter.

Figure 4 shows a cryo-cut of an unstained ferrogel with magnetit particles of ca. 8 nm diameter. They are irregularly distributed in the matrix. We suppose that the "empty" parts are the "unfilled" (and unstained) glassy network domains.

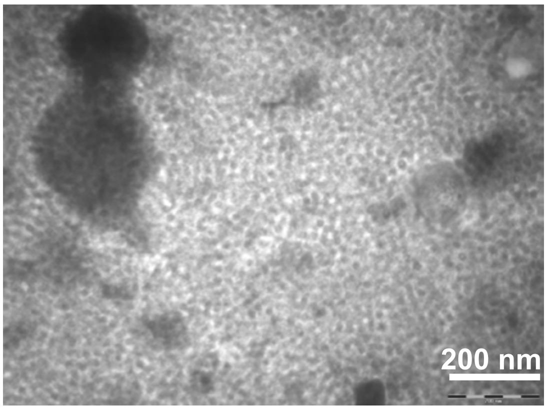

Figure 3: TEM; pure gel, cryo-cut, stained with RuO_4

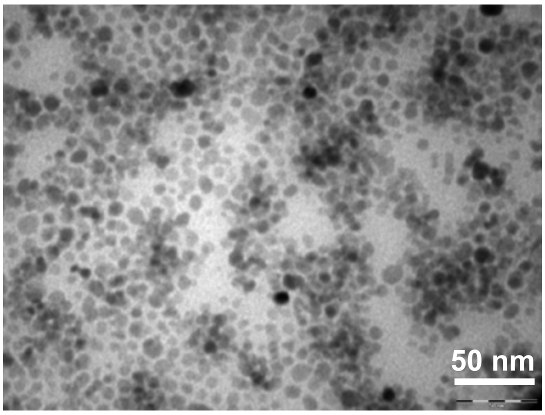

Fig. 4: TEM; ferrogel, cryo-cut, unstained

Acknowledgments

The grant of the Frauenbeauftragte der Universität Bayreuth for M. K. deserves many thanks. Furthermore, we gratefully acknowledge the financial support from the DFG Research group FOR 608.