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Shear flow experiments on particle filled polymers

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Objective : The aim of this work is to investigate the flow-induced changes in the microstructure of dispersions of spherical particles in polymeric media and their effect on the rheological properties. Special attention was given to detecting the flow-induced anisotropy in different particle filled polymer solutions was investigated. As particles colloidal silica's of 28 nm diameter were used, as suspending fluids solutions of hydroxypropylcellulose in water, of polyethyleneoxide in water and of an telechelic associative polymer in water. 2D Small Angle X-ray Scattering patterns were recorded, the shearing conditions were varied from low shear rates ($<1s^{-1}$) up to high shear rates (a few hundred s^{-1}).

Configuration : The experiments were performed on beamline BM26 (Dubble). The configuration used to collect small angle X-ray scattering patterns consisted of a Couette shear cell as sample environment and as detector a 2D multiwire gas-filled SAXS detector placed at 8 metres from the sample.

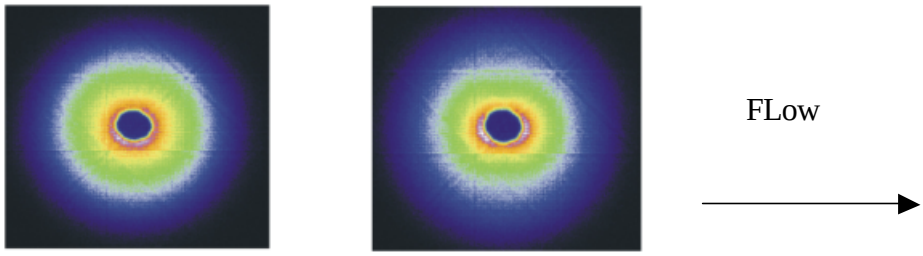

Figure 1. 2D SAXS pattern of a sample of 5 vol% of SiO_2 particles in a 30% HPC in water solution. Left image : isotropic structure – right image : anisotropic, butterfly shaped pattern obtained when shearing at a shear rate of 10 s^{-1}

1) **Particles in HPC/water** : At rest the SAXS patterns are isotropic (see fig.1), the patterns of sheared suspensions become anisotropic (butterfly) (fig1) : the anisotropy increases with shear rate up to a certain shear rate and then decreases again. Butterfly shaped patterns are typical for weakly aggregated systems [1]. Up to now, only large scale anisotropies, as observed by SALS has been observed. The local scale anisotropy has only recently been observed in model colloids [2]. The present experiments are, to out knowledge, the first observation of these structures in particle filled polymers. A quantitiative analysis of the anisotropy is underway.
2) **Particles in Associating polymer/water :** SiO_2 Particles suspendend in Solutions of differring polymer concentration were subjected to shear flow. The influence of polymer concentration and shearing condition on the anisotropy and possible investigated. No butterfly patterns were observed in this case. Flow was shown to induce an alignment of particles into strings. This is in agreement with the stable nature of these suspensions and the observations on non-colloidal systems [3]. The obtained data are the first investigations of particle filled associating polymers during flow. A detailed rheological study is being performed.

Remark : Due to electrical problems at the ESRF no experiments could be performed for half a day. A second run of experiments of flow-induced anisotropy is scheduled for November; Measurements using a novel annular ring device will be performed at that time to complete the Full 3D orientational order in concentrated suspension of rod-like particles during shear flow

References

[1] Hoekstra, H., Vermant, J., Mewis, J. and G.G. Fuller, 2003, "Fow-induced anisotropy and reversible aggregation in two-dimensional suspensions," *Langmui*r, in press.

[2] Vermant et al. ESRF user report http://ftp.esrf.fr/pub/UserReports/23934_A.pdf

[3] R. Scirrocco, J. Vermant and J. Mewis, Effect of the Viscoelasticity of the Suspending Fluid on Structure Formation in Suspensions, submitted to JNNFM (2003]