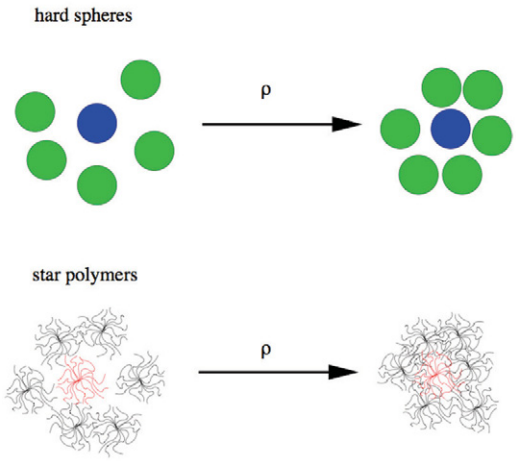
Soft colloidal mixtures freeze asymmetrically

AMORPHOUS MATERIALS

Soft colloidal particles play an important role in large-scale and microfluidic industrial processing applications, as well as in a variety of cosmetic and pharmaceutical products. Such systems undergo a transition to a glassy state through a process known as "caging": owing to crowding, a given particle is trapped by its nearest neighbors in a virtual cage. Understanding the details of the caging process is key to controlling the stability and efficiency of commercially available oils, creams and gels.

In a development that could have significant implications to the way future hybrid soft composite materials are designed, a team of scientists from Europe and Canada has discovered a new asymmetric glassy state, which arises specifically as a result of the soft interactions between the particles [Mayer et al., Nature Materials (2008) 7, 780].

"We have found it is possible to tune the viscosity of a liquid or the elasticity of the corresponding amorphous solid, simply by changing the amount and size of the added polymer in solution", explains Emanuela Zaccarelli, from the Department of Physics at the University "La Sapienza" of Rome, Italy.



Cages for hard-spheres (top) and star polymers (bottom). © Nature Publishing Group

"The elasticity and viscosity of the resulting solution can be greatly affected, by means of an anisotropic re-organization of the particles at a microscopic level".

Zaccarelli stresses the asymmetric glass state can only arise in soft mixtures, as opposed to the more commonly studied hard-sphere mixtures. As a result, her team focused its attention on star polymers - molecules that are multiply branched from a single point - since they allow the softness of the interaction to be easily tuned.

"This work demonstrates that what might at first appear as a modest increase in complexity over well-studied hard-sphere mixtures - softness of interaction - can turn out a number of surprises", comments professor Johan Bergenholtz, from the University of Gothenburg in Sweden.

"The star polymer systems are superb model systems that allow a very detailed understanding of the complex structures and dynamics in concentrated solutions of soft colloids".

The authors continue their work in the laboratory

Andrea Taroni

Electrospinning has nanofibers in alignment

NANOTECHNOLOGY

Up to now, electrospinning has always been accepted as a fast, simple and efficient technique for the production of polymer fibers, with variable dimensions. For example diameters ranging from nano- to microscale, providing a high surface area to volume ratios. [Konghlang et al., *J. Am. Chem. Soc.*, ASAP Article, 10.1021/ja804185s] have successfully demonstrated a new approach to control crystal morphology and molecular orientation in polyoxymethylene (POM) nanofibers, by producing these nanofibers using the electrospinning process with a rotating disk collector.

A simple electrospinning system consists of a charged polymer solution (or melt) that is fed through a small aperture. Due to its charge the solution is drawn toward a grounded collecting plate (a variation on a metal screen) typically 5 -30 cm away from the jet. During the jets travel solvent evaporates leaving the fiber to form on the grounded plate. The charge on the fiber usually dissipates over time to the surrounding environment.

Isotropic and anisotropic electrospun POM nanofibers were successfully prepared by using both a stationary and rotating disk collector, by controlling the voltage and the take-up velocity of the disk rotator the researchers were able by infra red spectroscopy and X-ray diffraction to distinguish between an Extended Chain Crystal (ECC) and a Folded Chain Crystal (FCC). Konghlang et al. showed by controlling the spinning electrical voltage and rotating speed of the disk one can easily control the morphology of the nanoporous nanofiber.

The scientists were able to produce randomly oriented nanofibers of diameter 1000 nm by collecting the fiber from a stationary collector. Aligned POM nanofibers were collected by adjusting the take-up velocity of the rotating disk collector, and it was proved that fiber alignment was a direct function of velocity of the rotating disk.

As the take-up velocity increased from 630 m/min to 1890 m/min, the average diameter decreased from 700 to 350 nm, indicating alignment within the fibers.

To better understand the effects of the electrospinning process on POM the researchers used polarized Fourier Transform Infra-Red spectroscopy (FTIR) and X-ray diffraction to expose the finer morphological changes.

Generally, POM is a highly crystalline polymer with the FCC structure. The work showed that the ECC could be easily achieved by electrospinning process combined with the take-up technique. By controlling the electrical voltage and the take-up velocity of the rotating disk collector, the morphology is interchangeable between the ECC and FCC. Molecular orientation parallel to the fiber axis was observed in both isotropic and anisotropic POM nanofibers. The high rotating disk velocity not only induced the ECC morphology but also enhanced the chain to be parallel to the fiber axis.

These nanofibers and variations of, find application in a wide variety of fields; such as nanoparticle carriers in controlled release, scaffolds in tissue engineering, wound dressings, military wear with chemical and biological toxin-resistance, and many other applications likely only to increase with the latest developments in morphological control.

The present work demonstrated a new approach to control crystal morphology and molecular orientation by producing nanofibers via the electrospinning process with a rotating disk collector.

Jonathan Agbenyega