PRESS RELEASE

Focus on materials creep-fatigue: colloid particle as metal atom model

Berlin, June 18, 2012

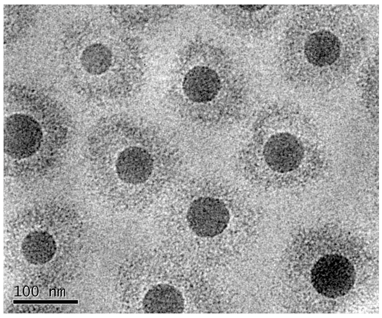
For additional information:

Dr. Miriam Siebenbürger
Institute for Soft Matter and Functional Materials
Ph.: +49 (0)30-8062-43029
miriam.siebenbürger@helmholtz-berlin.de

Public Relations
Dr. Ina Helms
Ph.: +49 (0)30-8062-42034
Fax: +49 (0)30-8062-42998
ina.helms@helmholtz-berlin.de

Soft matter turns out to be the ideal basis for investigations of technical materials aging: scientists develop new physical model.

Together, materials scientists at the Helmholtz Centre Berlin for Materials and Energy (HZB), their colleagues at Germany's Constance University, and fellow researchers at the German Aerospace Centre (DLR) have confirmed that empirical regularities that apply in metallurgical physics also hold true for colloidal suspensions. Consequently, experimental results obtained from these substances can now be reliably compared to theoretical precepts. This makes colloids excellent test substances in the lab that enable scientists to zoom in on creep processes like the ones that occur in strained technical structures. The scientists' findings are now being published in the scientific journal *Physical Review Letters* (DOI: 10.1103/PhysRevLett. 108.255701).



The colloid model that was used in the research: individual small particles (size: approx. 150 nm) suspended in water. The solid core consists of the plastic polystyrene, the surrounding shell of a thermosensitive network made from poly(N-isopropylamide). Lowering the temperature results in a volume increase of the individual particles - and thereby of their packing density. Photo: HZB/M. Siebenbürger

If it occurs on bridges or in airplanes, materials damage can quickly lead to a major catastrophe. To prevent this, engineers expend much time and energy on exploring and pre-emptively warding off conditions that lead to material collapse. Similar predictions are often times more difficult to make for "creep processes" - a form of decay, which results in the slow but steady deformation of materials that ultimately leads to tears or breaks.

"For the past 100 years, researchers and engineers alike have been conducting long-term experiments to investigate material creep deformation," says Dr. Miriam Siebenbürger, a physical chemist at the HZB Institute for Soft Matter and Functional Materials. However, until now the regularities underlying creeping have been only incompletely understood "due to the lack of a good physical model," explains Siebenbürger. Now, researchers have at last successfully filled that gap by working out and testing a reliable model for creep processes in the form of colloidal suspensions.

Colloidal suspensions are solutions containing tiny spherical particles suspended in water or another liquid. "You might compare them to wall paints, which also contain countless solid particles less than one micrometer in size," explains Miriam Siebenbürger. Compared to atoms, these miniature spheres are rather sluggish in the manner in which they move about their liquid medium – however, their behavior basically does resemble that of atoms. At high colloidal or atomic packing densities, a solid body capable of "creeping" when subjected to compressive or tensile stress results. Thanks to these behavioral similarities, colloidal suspensions are useful model systems for experimentally observing the behavior of metal atoms – on a large scale and, essentially, in slow-motion.

To give the experiments a viable basis, the young HZB researcher analyzed how colloids behave under a number of different conditions – for example, if external forces or packing densities change. Siebenbürger used a rheometer to examine the test substance. Inside the device, the suspension was placed within the annulus of two different-sized cylinders, one inside the other, which the scientist then rotated in opposite directions. By measuring the exertion required to rotate the cylinders, she was able to determine the solution's viscosity and other physical properties. Thomas Voigtmann, a Constance University physicist who also studies materials physics in space at the German Aerospace Centre (DLR) in Cologne, Germany, contributes the theoretical premise: a new model, which can be used to qualitatively describe – for the first time ever – the different phases from creeping to materials failure.

"The universal characteristics of non-linear deformation of amorphous solid bodies apply as much to traditional crystalline matter as they do to colloids," explains Miriam Siebenbürger. In the future, these new insights will allow scientists to experimentally analyze in great detail – and explain the theoretical precepts underlying – different kinds of creep processes using colloidal suspensions. Ultimately, this will help with the design of custom-made materials like high-performance steels or lightweight alloys to be used in the construction of buildings, vehicles, or airplanes. It will also help prevent dangerous materials deformation caused by strain.

Next steps now will be to combine the rheological measuring equipment with a small-angle neutron scattering facility. This in turn will prompt the set-up of a new type of experimental facility at the V16 beamline of the Berlin-based BER II neutron source, which will not only allow scientists to shed light on the dynamic properties of colloids but also help them understand important structural changes. This, then, is the requirement for also examining colloidal substances containing spherical, bacillar, as well as other, more complex shaped particles in suspension. These could ultimately serve as model systems for technical materials, whose microscopic framework does not – as is the case for metals – consist of individual atoms but rather of molecules.

Original Scientific Publication:
M. Siebenbürger, M. Ballauff, and T. Voigtmann, „Creep in colloidal glasses", 2012. [DOI: 10.1103/PhysRevLett.108.255701](https://doi.org/10.1103/PhysRevLett.108.255701)