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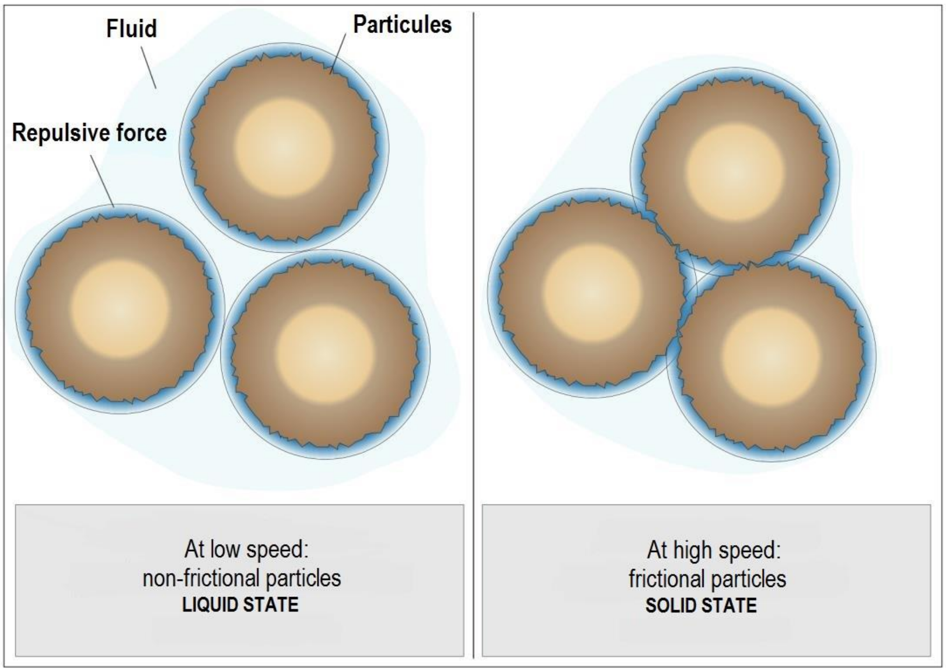
When liquids turn to solids: the mystery of corn starch elucidated

Some particle suspensions, such as grains of starch in water that are liquid at rest, suddenly solidify when they are subjected to vigorous shearing or impact. This fascinating behavior, called shear thickening, can make it possible to "walk on water" or design lightweight and supple jackets that are nevertheless highly shock-resistant. Scientists at the Institut Universitaire des Systèmes Thermiques Industriels (Aix-Marseille Université/CNRS) have now shown experimentally that this behavior results from a transition involving friction between the particles and the presence of short-range repulsive forces (of electrostatic or physicochemical origin). This study was published in *PNAS* on 1st May 2017.

How can some fluids suddenly turn to solids? The origin of this phenomenon has long remained a mystery. Scientists at the Institut Universitaire des Systèmes Thermiques Industriels (CNRS, Aix-Marseille Université) based their work on a very recent theoretical model (Seto et al., PRL 2013, Wyart and Cates, PRL 2014). The idea is as follows: under a weak constraint and in the presence of short-range repulsive forces, particles in a shear-thickening suspension are kept apart and therefore do not touch each other. This lack of solid contact means that there is no friction between the particles, and the suspension flows easily (cf. Figure 1). However, under the effect of an impact, or shearing, the particles make contact. Friction then occurs between them and generates a highly dissipative medium: the suspension suddenly turns into a solid.

To demonstrate this frictional transition, or in other words the frictional or non-frictional behavior of particles, the IUSTI scientists studied the avalanche angles, compaction properties under vibration and the dilatancy effects of different particle suspensions. They were thus able to demonstrate that particles in shear-thickening suspensions did indeed behave like frictionless grains when under low stress. By reducing the range of the repulsive forces between grains in a model shear-thickening suspension of silica beads, they also showed that this frictionless state disappeared and the suspension then recovered a standard rheological behavior.

These findings, which for the first time have linked microscopic contact physics, friction and the macroscopic rheological behavior of suspensions, confirm that shear-thickening results from a frictional transition. Demonstrating the crucial role of friction in suspensions should enable a clearer understanding of, and thus improvements to, the formulation of modern types of polymer-containing concrete, in order to control their flow properties. More generally, this advance may also contribute to the formulation of suspensions with controlled rheological properties that could have medical or sports applications (flexible splints or supports that permit slow movements but offer protection in the event of an impact).



Reference

Revealing the frictional transition in shear-thickening suspensions, Cécile Clavaud, Antoine Bérut, Bloen Metzger, et Yoël Forterre, *PNAS*, 1st May 2017

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