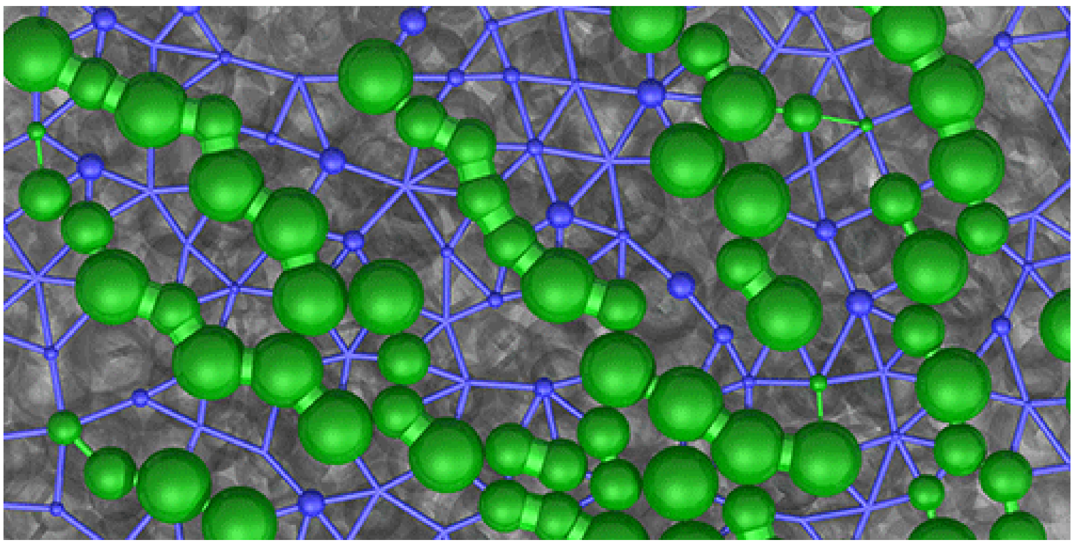
Experiment suggests friction at root of shear force thickening

November 26 2015, by Bob Yirka



Credit: Chris Ness/University of Edinburgh, via *Physics*

(Phys.org)—A combined team of researchers from Cornell University in the U.S. and the University of Edinburgh in the U.K. believes they may have settled the debate on the cause of shear force thickening in colloidal products. In their paper uploaded to the *Physical Review Letters* website, the researches describe their simple experiment and results and why they believe it settles the debate.

Liquids that have particles suspended in them, called colloidal products, such as cornstarch, have a property known very well to grade-school science students—shear force thickening. It is what happens when the liquid is stirred very quickly or when after stirring it acts like a solid when struck with an object such as a hammer. Scientists have debated the nature of the phenomenon for many years and have come up with the two most likely theories. The first is that it happens because fast movement causes the particles to be pushed closer to each other making it more difficult for the liquid to get between them—at some point, it becomes impossible causing the liquid to behave as a solid. The second theory suggests it is all about friction, as the particles move closer to one another, they actually touch and it is the shearing force and friction that keep them that way. In this new effort, the researchers have conducted an experiment that has caused them to believe that the latter argument appears to be the one that is correct.

The experiment consisted of creating a colloid and then putting a cone in it that they caused to turn, measuring the torque as the fluid began to move along with the cone. Then, they suddenly reversed the direction of the cone and immediately measured the torque again—this type of experiment has been used in other applications and is known, quite naturally, as a flow reversal experiment. The idea in this instance is that if the sudden reversal of the cone showed an immediate drop in torque that would indicate that the particles in the solution had immediately come free of one another, something that would not occur if the thickening was due to clustering. The team reports that the torque dropped immediately (after they obtained a machine capable of monitoring such a sudden change) suggesting that the friction theory is the correct theory to describe shear force thickening.

More information: Hydrodynamic and Contact Contributions to Continuous Shear Thickening in Colloidal Suspensions, *Phys. Rev. Lett.* 115, 228304 – Published 25 November 2015. dx.doi.org/10.1103/PhysRevLett.115.228304 . On *Arxiv*: arxiv.org/abs/1509.02750

ABSTRACT
Shear thickening is a widespread phenomenon in suspension flow that, despite sustained study, is still the subject of much debate. The longstanding view that shear thickening is due to hydrodynamic clusters has been challenged by recent theory and simulations suggesting that contact forces dominate, not only in discontinuous, but also in continuous shear thickening. Here, we settle this dispute using shear reversal experiments on micron-sized silica and latex particles to measure directly the hydrodynamic and contact force contributions to shear thickening. We find that contact forces dominate even continuous shear thickening. Computer simulations show that these forces most likely arise from frictional interactions.