Yielding and Shear Banding in Soft Glassy Materials

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Many materials around us are yield stress fluids: materials that respond elastically to small applied stresses; but flow once a threshold stress (the yield stress) is exceeded. Perhaps the most ubiquitous problem encountered by scientists and engineers dealing with typical yield stress materials such as food products, powders, cosmetics, foams and concrete is that the yield stress of a given material has turned out to be very difficult to determine 1,2. There are a variety of experimental methods and techniques for measuring the yield stress 3. While each method has its own merits and limitations, no single method has been universally accepted as the standard for measuring the yield stress. It is not unusual to find variations in the results obtained from different methods even on the same material, prepared and tested in the same laboratory 4. The variable nature of yield stress measurements has led to a suggestion that an absolute yield stress is an elusive property and any agreement of results from different techniques is accidental 5. We show that many of these problems disappear provided one distinguishes between two classes of yield stress fluids: thixotropic and non-thixotropic (or simple) materials. A simple yield stress fluid is one for which the shear stress (and hence the viscosity) depends only on the shear rate, while for thixotropic fluids the viscosity – and hence also the yield stress- depends also on the shear history of the sample. The complex rheological behavior of thixotropic materials can be understood on the basis of a percolated microstructure that also depends on the shear history 1. The rheological behavior is then determined by the competition between a spontaneous build-up of the microstructure at rest ('aging') and its breakdown by flow ('shear rejuvenation'). Simple yields tress materials show no significant aging or shear rejuvenation; hence the yield stress is a material property. To do this, we study the flow properties of yield stress materials with variable thixotropy, allowing us to have both simple and thixotropic yield stress materials in a single system. We show that a pure emulsion behaves as a simple yield stress material. However the same emulsion loaded with clay particles that act as a glue between the emulsion droplets becomes very thixotropic. This shows that the yield stress of 'simple' emulsions can be attributed to repulsions between the droplets, whereas on the other hand a percolated structure due to attractive interactions leads to thixotropy.

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