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On different ways of measuring "the" yield stress*

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Abstract

Yield stress materials are ubiquitous, yet the best way to obtain the value of the yield stress for any given material has been the subject of considerable debate. Here we compare different methods of measuring the yield stress with conventional rheometers that have been used in the literature on a variety of materials. The main conclusion is that, at least for well-behaved (non-thixotropic) materials, the differences between the various methods are significant; on the other hand, the scaling of the measured yield stress with the volume fraction of dispersed phase shows the same dependence independently of the way in which the yield stress is obtained experimentally. The measured yield strain is similarly found to depend on the method employed. The yield stress values obtained for a simple (non-thixotropic) yield stress fluid are only similar for Herschel-Bulkley fits and stress-strain curves obtained from oscillatory measurements. Stress-strain curves with a continuous imposed stress or strain rate differ significantly, as do oscillatory measurements of the crossover between G' and G'' or the point where G' starts to differ significantly from its linear response value. The intersection of the G' and G" curves as a function of strain consistently give the highest value of the yield stress and yield strain. In addition, many of these criteria necessitate some arbitrary definition of a crossover point. Similar conclusions apply for a class of thixotropic yield stress materials, with the stress-strain curve from the oscillatory data giving the dynamic yield stress and the Herschel-Bulkley fit either the static or dynamic yield stress, depending on how the measurement is carried out.

Keywords: Yield stress materials, Rheological measurements, Oscillatory measurements, Herschel-Bulkley model

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I. INTRODUCTION

Many materials found in daily life exhibit properties characteristic of either solids or liquids, depending on the imposed stress. At small stresses these materials deform essentially in an elastic manner, but flow once a critical stress is exceeded; this critical value is called the *yield stress* (σ_y), and materials exhibiting a yield stress are called *yield stress materials*. Examples of yield stress materials include concentrated emulsions like cosmetic creams or margarine, toothpaste, foams, polymer gels like Carbopol, slurries, and