

Effects of a non-ionic surfactant on the rheology of silica suspensions

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Abstract:

Dispersing agents are widely used to formulate high-solids pastes that remain fluid enough to be easily transported and placed. In the cement industry, superplasticizers are used to control the workability of fresh cement pastes containing high volume fractions of solid particles enabling the formulation of concretes with higher mechanical strength, better durability and also lower carbon impacts by substituting cement particles with mineral additions (fly ashes, slag, silica fumes...).

Although dispersing agents are commonly used, the mechanism by which they impact the interaction between particles, and thus the paste rheology, remains obscure so that process optimization relies almost essentially on empirical or trial-and-error processes. In order to improve our understanding of these systems, we experimentally investigate the influence of a non-ionic surfactant that mimics superplasticizers on the yield stress and storage modulus of model suspensions containing silica beads suspended in an ionic solution. By combining rheometry, Total Organic Carbon, zeta potential, confocal microscopy and laser tweezers experiments, we show that adding non-ionic surfactant to the suspension strongly alters both the interparticle contact mechanical properties (stiffness and strength) and the overall suspension rheology (yield stress and storage modulus).

Change of the contact rigidity is ascribed to the adsorption of the surfactant on beads, which induces a shift from an adhesive rolling resisting contact to a non-adhesive contact due to steric hindrance. As demonstrated by the perfect agreement between rheometry and 3-point bending tests, drop of the suspensions storage modulus originates from a particle contact shift. Same relationship is observed between the flexural contact resistance and overall suspension yield stress or the ageing of the material.

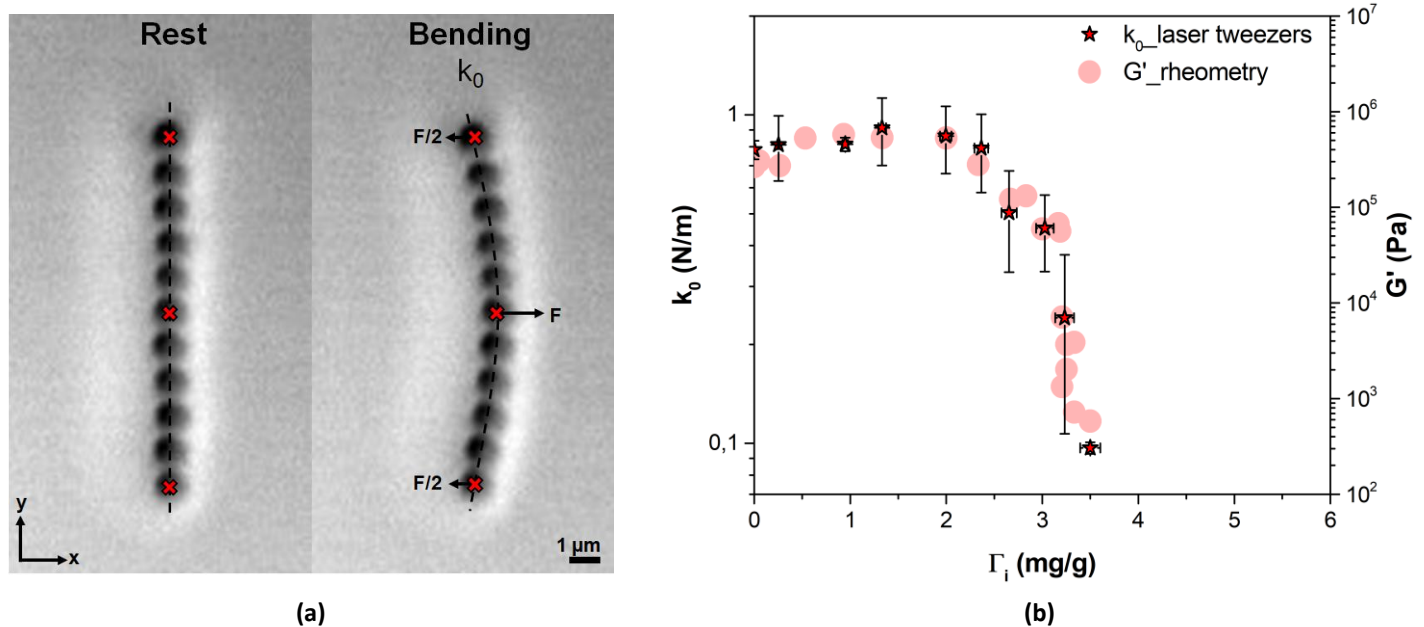


Figure: (a) 3-point bending test on a particle rod using laser tweezers to probe the contact rigidity (k_0). Red crosses represent optical traps used to move the beads and to measure the applied forces. (b) Contact stiffness measured through 3-point bending tests and shear elastic modulus (G') of the suspension (solid volume fraction: 45 % ; ionic strength: 0,15 M) as a function of the mass of surfactant added per unit of bead mass (Γ_i).

Key words: rheology, suspensions, admixtures, laser tweezers, contact.