Fluid gel rheology, tribology and sensory perception as a function of volume fraction and particle stiffness.

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We produce fluid gels by applying a shear force to kappa carrageenan solutions as they undergo gelation on cooling. During this process, the gel nuclei that form during the onset of spinodal decomposition are segregated by shear forces that restrict the molecular ordering to only occur within discrete particles, rather than macroscopically as in quiescently cooled gels. Photographic images are provided in Fig. 1 to illustrate the differences between quiescent gelation (a) where a bulk gel is formed, and sheared gelation (b) where a fluid gel is formed. The influence of the ratio of quiescent to sheared cooling has previously been described [1] and can be used to control gel structures and properties.

![Photographs of gels produced under quiescent (a) and sheared conditions (b). Both gels were produced from 1 wt% kappa-carrageenan with 0.3 wt% KCl.](image)

Fluid gels are solid suspensions and as such, their rheological properties are strongly influenced by volume fraction and particle elasticity. Methods of identifying volume fractions are discussed and controlled through dilution with water. Particle elasticities are controlled by varying the kappa carrageenan concentration, similarly to the behaviour observed with quiescently cooled gels.

We show the effect of these structural parameters (particle elasticity and volume fraction) on rheological properties (small and large deformation), tribological response and their sensory perception on oral consumption.

Zero-shear viscosities are compared with values predicted by models provided by Krieger-Dougherty and Batchelor-Einstein, for high and low volume fractions respectively. We also report storage moduli and phase angles as a function of volume fraction and particle
elasticity, and use these, together with microstructure analysis, to explain the deviations from hard-sphere behaviour.

Tribology (thin-film rheology) concerns lubrication, friction, contact mechanics and wear, and has been shown to be incredibly valuable in relating analytical data with in-mouth textural attributes. In this work, tribology is investigated using a tribometer with PDMS surfaces modified to be hydrophilic [2] thus providing surfaces with a resemblance to oral mucosa in terms of elasticity and wetting behaviour. Fig. 2 shows a schematic (a) and photograph (b) of the tribometer setup.

![Figure 2](image.png)

(a) Schematic of the tribometer setup indicating directions of the ball and disc rotation. Schematic adapted from [3].

The purpose of this work is to understand the structural dependence of fluid gels on rheological and tribological behaviour in order to optimise their use as fat-replacers in soft solid and liquid fast moving consumer goods.

**References**


**Other Key References**

