IFPRI Project Abstract

Simplified industrial formulations - part 2

Jan Vermant and Lucio Isa
ETH Zurich, Department of materiaks
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Project Objective:

Investigating how particle characteristics, which lead to non-central forces, impact the rheological and gravitational properties of colloidal gels. Then to study on model systems, what controls the yielding transition. This requires us to use some more advanced rheological methods which we will be using on simplified industrial systems. Additionally we pursue imaging and micromechanical studies on

Approach:

- Experimental approaches : bottom up – novel systems (shape, roughness, patchiness). Rheological methods (creep/recovery, superposition rheology, high frequency and compression rheology).
- Conceptual : the yielding in colloidal suspensions as a stress activated flow.
- Microscale measurements of the local forces : colloidal probe AFM and optical tweezers.

Recent Results:

- Main result : the toolbox to influence gel rheology, thixotropy, percolation and gravitational stability through subtle changes to the building blocks has been mapped out. Patchiness of the chemical surface can also impart non central forces. Rheological analysis reveals intriguing similarities between patchy particles and smooth or rough particles of comparable size. Notably, the plateau modulus of patchy particles aligns closely with smooth and rough particles across varying volume fractions, which suggest that the aggregation mechanism is the same as for homogeneously coated particles. The results point to a universal role of non-central interparticle forces enhancing gel toughness. We highlight the efficiency of patchy particles in increasing non-central forces and therefore the yield stress while minimizing synthesis complexity (for this specific particle system), positioning them as promising materials for diverse applications in colloidal engineering. For non spherical particles : The aspect ratio of the colloidal building blocks plays a crucial role in the engineering of colloidal gels, impacting various properties such as elasticity, yield stress, gravitational stability, and thixotropic effects. Increasing aspect ratio lowers the threshold of the dilute concentration regime, ands the percolation threshold becomes independent of surface topography. Smooth particles with higher aspect ratios display and enhanced elasticity and stability against sedimentation, attributed to the formation of local isostatic clusters within elongated systems, thereby increasing network stiffness. The addition of surface roughness to elongated particles, which inhibits sliding and alignment, resulting in a more homogeneous and anisotropic network structure, mitigating the aspect ratio's effect on properties like elastic modulus, sedimentation behavior and shear recovery.

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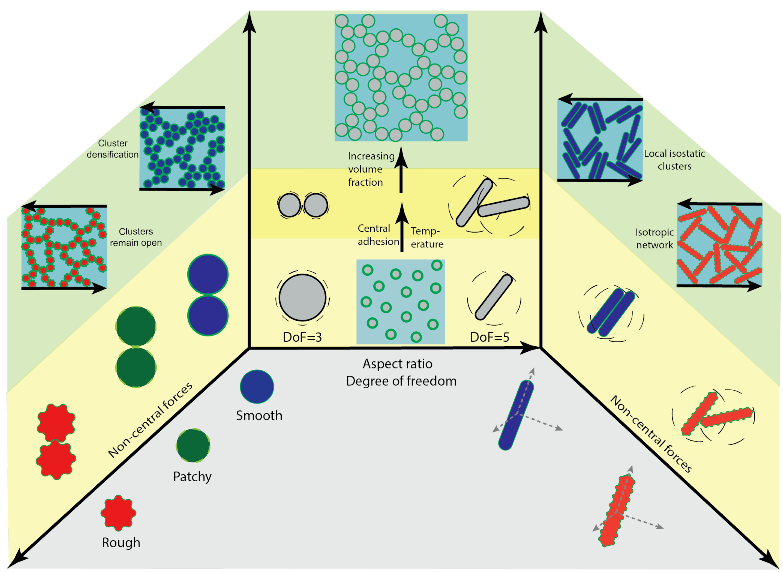

For progress in the other areas of the project we include an intermediate report.

Next Steps:

We will finalize the 4D imaging of the yielding transition, and start with the micromechanical analysis. We have also planned an experimental campaign over summer of the industrial samples using the tools and concepts put forward.