Rheology of suspensions of particles with complex shape

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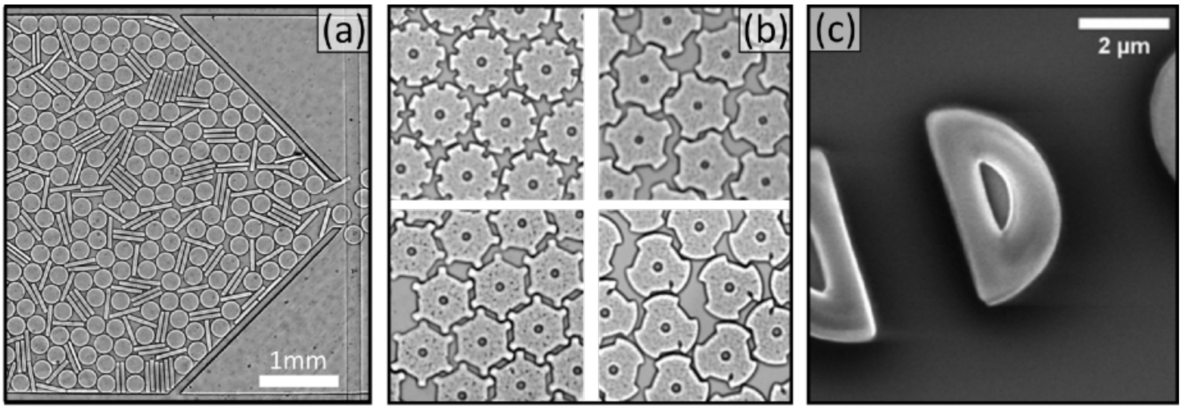
Concrete and cement-based materials are responsible for a significant share of global CO_2 emissions. One way to reduce their environmental impact is to improve how these materials flow during processing, allowing the use of less cement and fewer chemical additives. Like many other dense suspensions, materials for construction often exhibit **complex rheology** such as yield-stress or shear-thickening which affects their mixing and their ability to flow. Unlike ideal spherical particles, real construction materials contain grains with complex, non-spherical and often interlocking geometries that can strongly affect how the material flows.

This PhD project aims to understand how the **shape of solid particles** influences the rheology of dense suspensions. Using modeled experiments, based on microfluidic and 3D-nanoprinter, the project will design suspensions of particles of complex shape. The PhD candidate will first design suspensions of 2D particles of complex shape in microfluidics and study flows in complex geometry. In addition, 3D particles will be obtained using a 3D-nanoprinter. The rheology of suspensions will be investigated by custom 2D experimental setup and conventional rheometry. We aim to study the interplay between microscopic particle organization and macroscopic flow properties in order to understand the relationship between particle shape and macroscopic flow properties of suspensions. The results will provide new design principles for construction materials that are easier to process, more efficient, and more sustainable, contributing to the development of low-carbon building technologies.



Suspensions of particles of complex shape. **(a)** 2D Microfluidic hopper flows of mixtures of fibers and disks. Image adapted from Kool *et al.*, 2025. **(b)** Packings of 2D gear-like particles in microfluidics. Credits: Jules Tampier (PMMH). **(c)** 3D-printed anisotropic colloidal particles, from Maharani *et al.*, 2025.

The applicant should be interested in experiments, fluid mechanics and soft matter. The PhD will take place at PMMH (ESPCI Paris) in close collaboration with Gulliver (ESPCI Paris), and will lead to international collaborations. The funding is provided by the Région Île-de-France (DIM MaTerRE). The PhD will start before December 2026. Feel free to contact Philippe Bourrianne (philippe.bourrianne@espci.fr), Justine Laurent (justine.laurent@espci.fr) and Anke Lindner (anke.lindner@espci.fr) for more information.