M2 internship proposal

Specialties:

M2 de Chimie – Physico-Chimie - Matériaux

Host institution:

Laboratoire Sciences et Ingénierie de la Matière Molle (SIMM)
ESPCI Paris, 10 rue Vauquelin, 75005 Paris

Host team:

Polymer Network Group
Team Leader: Yvette Tran
Supervisor: Costantino Creton, Etienne Barthel, Flora-Maud Le Menn

Internship period: February to June 2022

Keywords: Cavitation, Acrylate networks, Mechanical characterizations

Scientific Project:

Every second, 29 Tb of data are produced on the internet, stocked and exchanged between continents. The vast majority of that data transits via optical fibres, consisting of thin glass fibres which carry light over hundreds of kilometres by total internal reflection. Being exposed to extreme conditions, these fibres are protected by several layers of polymers and metal. The first layer of protection consists of a soft elastomeric acrylate resin. This thin coating is under variable hydrostatic pressures created for example during manufacturing and during use. This may lead over time to the formation of cavities and ultimately to fibre blindness. The mechanisms ruling the nucleation and growth of cavities depend on various material parameters. Several models have been proposed, suggesting that the cavitation resistance is directly linked to the Young modulus[1] or that it depends on the initial defect size[2]. Experimental studies[3] however suggest a more complex cavitation behaviour where the network's fracture toughness and the strain hardening both play a role.

The aim of this study will be to polymerize model networks of simple chemistry based on acrylates monomers (2-ethylhexyl acrylate and 2-phenoxy ethyl acrylate) with various crosslinking ratios. Different mechanical tests (uniaxial traction, fracture measurements, DMA, DSC, swelling) will be used to understand the network architecture and the mechanical properties of the networks. To test their behaviour under hydrostatic stress in order to provoke cavitation, the elastomers will be confined in a sphere on flat geometry (Figure a). This custom experimental set-up allows for the observation of the nucleation and growth of cavities (Figure b). The analysis of the cavitation process in light of the mechanical properties should help to shed light on the cavitation behaviour and on the origins of the nucleation.

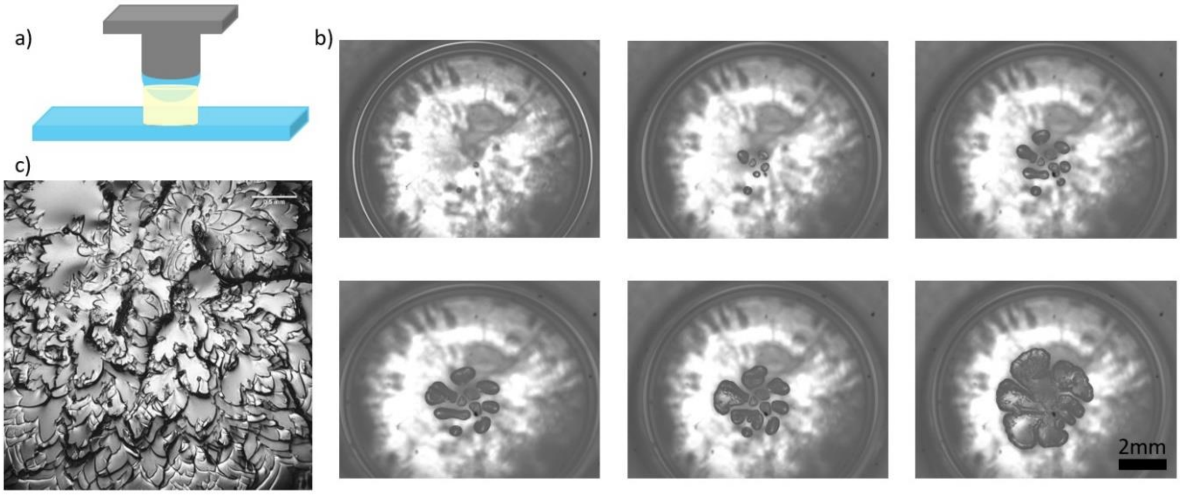

Figure: Inducing hydrostatic stress in thin elastomer layers a) Confinement set-up in sphere on flat geometry: the glass surfaces are represented in blue, the gap between the 2 varies from 20 to 100µm. b) Visualisation of a cavitation experiment in the layer. From left to right, the hydrostatic pressure increases. The cavities appear and lead to the catastrophic fracture of the sample. c) Post-mortem observation of the fracture surface on the glass slide.

References:

[1] Gent, A.N.; Lindley, P.B.; *Proceedings of the Royal Society of London,* **1958**, volume 249 plate 19

[2] Gent, A.N.; Wang, C., *Journal of Materials Science* 1991, 26, 3392-3395

[3] Cristiano, A.; Marcellan, A.; Long, R.; Hui, C-Y.; Stolk, J.; Creton, C.; *Journal of Polymer Science: Part B: Polymer Physics,* **2010**, Vol. 48, 1409-1422

Methods in use:

- Radical polymerization
- Glass surface modification
- Mechanical characterizations of networks (traction, DMA, DSC, swelling, cavitation)

Applicant skills:

- Experimental skills and interest
- General knowledge of polymer mechanics and characterization
- Reporting and communication skills

Industrial partnership: No

Internship supervisor(s):

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Possibility for a Doctoral thesis: To be discussed