MONASH University
Engineering

PhD Position: Constitutive modelling of tough hybrid hydrogels

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A 3-year PhD position in the area of Soft Materials Mechanics is available immediately in the Department of Materials Science and Engineering at Monash University (Melbourne, Australia). We are looking for a highly motivated researcher with a strong interest in theoretical and computational mechanics.

Prerequisites

- A master degree in Mechanical Engineering or in a related area.
- Proficiency in English.
- Solid background in solid mechanics, applied mathematics and numerical methods.
- Good analytical and programming skills (e.g. C/C++, Fortran, Python).
- Experience with the Finite Element Method would be an asset.

Context

Soft materials are quickly growing as future materials for emerging technologies in engineering and medicine, for instance to perform delicate handling tasks or to be integrated within the human body. Among them, hydrogels consisting of a 3D polymer network swollen in water offer unique opportunities owing to their attractive characteristics, including biocompatibility, tuneable mechanical properties and ability to respond to a variety of stimuli. However, the poor mechanical properties of hydrogels often limit their range of applicability in load-bearing applications. These limitations are progressively being alleviated thanks to the development of new classes of gels exhibiting superior mechanical properties, such as high strength and toughness [1]. However, the precise micro-mechanisms underlying the macroscopic response of these new materials are poorly understood. New constitutive models with a strong physical basis and good predictive capabilities are needed to assist the design of advanced hydrogel-based materials and devices.

Research project

This project will focus on hybrid gels that combine ionic and covalent crosslinks. These gels display a complex mechanical behaviour involving large, nonlinear deformations, viscoelasticity, creep, and self-healing [2]. The general objective of this thesis is to elucidate the microscopic origin of these phenomena through the development of a material model, and subsequently to use this model to predict the gel response under complex loading conditions. The model should also provide guidelines towards the development of new gels with superior mechanical properties. The project will involve the development of a new constitutive theory within the framework of continuum mechanics, as well as its numerical implementation in a finite element software.

References:
[1] Sun, J.-Y., Zhao, X., Illeperuma, W.R.K., Chaudhuri, O., Oh, K.H., Mooney, D.J., Vlassak, J.J., Suo, Z., 2012. Highly stretchable and tough hydrogels. Nature 489, 133-136.
[2] Xin, H., Brown, H.R., Naficy, S., Spinks, G.M., 2015. Time-dependent mechanical properties of tough ionic-covalent hybrid hydrogels. Polymer 65, 253-261.

To apply, please send a CV and a cover letter to laurence.brassart@monash.edu.