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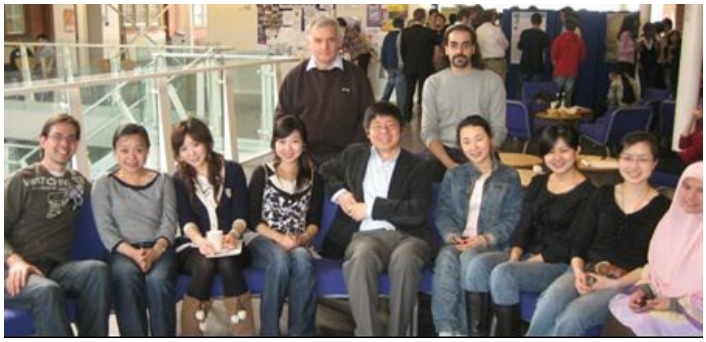
Micromanipulation research

Welcome to the Micromanipulation Research Group



Group members

Academics	PhD Students	
Prof. Zhibing Zhang (/staff/profiles/chemical-engineering/zhang-zhibing.aspx)	**Katie Liu (/research/activity/chemical-engineering/speciality-products/micromanipulation/liu-katie.aspx)**	Xuemiao Pan
Prof. Colin R Thomas (/staff/profiles/chemical-engineering/thomas-colin.aspx)	Angel Fernandez	Yulan Zhang
Research Fellow	Yue Long	W.R. Wan Dagang
Dr. Ruben Mercade-Prieto	**Rachael Manton (/research/activity/chemical-engineering/speciality-products/micromanipulation/manton-rachael.aspx)**	Yanni Tan

- **Research Areas (/research/activity/chemical-engineering/speciality-products/micromanipulation/research-areas.aspx)**
- **Publications (/research/activity/chemical-engineering/speciality-products/micromanipulation/publications.aspx)**

Micromanipulation - Size Matters

There are many functional products containing biological and non-biological microscopic particles (or microparticles) over a wide range of industrial sectors including chemical, agrochemical, food and feed, pharmaceutical and medical, human care and household care. For biological microparticles, understanding their mechanical properties under different physiological states is crucial to bioprocessing and tissue engineering, e.g. animal cell culture to produce monoclonal antibody, mechanical disruption of yeast and bacteria to extract intracellular proteins, and mechanical stimulation of chondrocytes for cartilage tissue engineering. For non-biological microparticles, they should have desirable chemical composition, structures and mechanical properties. Understanding the mechanical properties of such microparticles is essential to predicting their behaviours in manufacturing, handling and performance in end-use applications.

Over the last 20 years, novel micromanipulation techniques have been developed by the Group of Micromanipulation, School of Chemical Engineering, initially led by Prof. Colin Thomas and now by Prof. Zhibing Zhang, to measure the mechanical properties of single microparticles, including animal cells, yeast, bacteria, pollen grains, microspheres and microcapsules, particle-particle adhesion, particle adhesion on surface, adhesion and cohesion of biofilms or food fouling deposits on surfaces, and applied to characterise the mechanical properties of these biological and non-biological materials, which are related to their structures and functions.

The basic principle of micromanipulation is the compression of a single particle (for example, a cell in a drop of medium) between two parallel surfaces. These are usually the flat end of a glass probe and a microscope slide surface. Figure 1 shows a single tomato cell being compressed. As the probe is driven by a micromanipulator towards the slide, a transducer measures the force being imposed on the particle. A force-displacement curve can be generated from the data. Unlike other methods, large deformations are possible, including to bursting for cells. Mathematical modeling of the force-displacement data based on analytical or finite element analysis can be applied to determine the intrinsic mechanical property parameters of the particle materials, e.g. Young's modulus, Poisson ratio, yield stress and stress at failure.

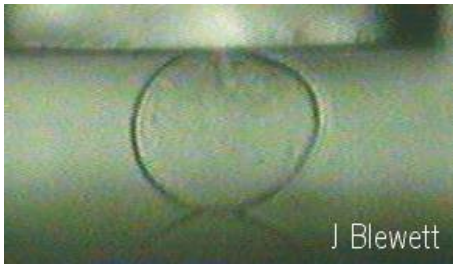


Figure 1: Single plant cells positioned between a force probe and glass slide. Bar = 20 μm.

In addition, the group has established a research area in formulation of particulate functional products for pharmaceutical, nutraceutical, oral care and fabric care applications based on micro/bioencapsulation. For example, dextran-hydroxy-ethyl-methacrylate microspheres with a protein drug embedded, which may be used to achieve sustained release in blood stream, are shown in Figure 2. Different functional microparticles, particularly microcapsules with a core/shell structure, have been formulated using a range of techniques, including polymerization, coacervation, solvent evaporation, extrusion/gelation, fluidised bed coating, and direct compaction. The active ingredients which have been encapsulated included oil soluble droplets, water soluble powders, nutraceutical enzyme and probiotic cells.

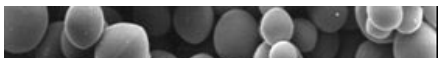
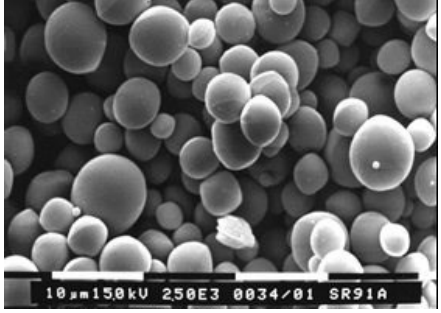


Figure 2: Dextran-hydroxy-ethyl-methacrylate microspheres prepared by emulsion polymerisation for sustained drug



delivery.

Recent work includes development of a novel nanomanipulation technique to measure the mechanical properties of single nano-particles and to understand the rupture mode of microcapsules (Figure 3) in collaboration with Prof. A. M. Donald, FRS, at Cavendish Laboratory, University of Cambridge, using micro/nanomanipulation to study biomechanics of single chondrocytes and chondrons and their biological responses with Dr N. Kuiper and Professor A. El Haj, Keele University, and formulation of smart microcapsules for controlled release of small molecules in collaboration with Prof. J. Preece, School of Chemistry of this University, Prof. B. Vincent, University of Bristol, and two international companies. There are also continuing collaborations with Dr J, Pritchard, School of Biosciences, University of Birmingham, on single plant cell mechanics, and with Dr P, Hartley, School of Mechanical Engineering, University of Birmingham, on mathematical modelling of cell walls.

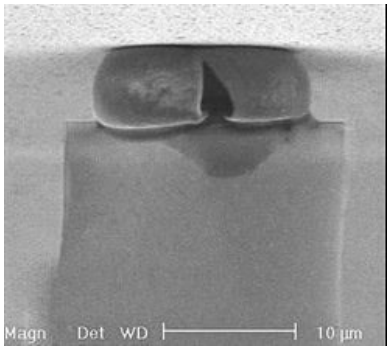


Figure 3: The image of a M-F microcapsule after it was compressed to rupture under high vacuum of ESEM (5kV, spot size 4). The diameter of the microcapsule was 16.50 µm.

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