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In the Lab

Colloidal Particles at Fluid-Fluid Interfaces

***Johnson Matthey Technology Review* features new laboratory research**

Professor Binks' research is primarily concerned with materials chemistry. He is a physical chemist with research interests in surfactants, foams, emulsions and colloidal particles at interfaces. His work looks at the fundamental science that underpins the behaviour of formulations. As such, it has implications for industry applications in areas as diverse as food, cosmetics, oil and gas, pharmaceuticals and coatings. He has received a significant amount of industrial funding from companies including AAK (UK) Ltd, Wacker Chemie (Germany), GSK (UK), Shiseido (Japan), Lubrizol (USA), Nestlé (Switzerland), Unilever (UK), Halliburton (USA), AkzoNobel (Netherlands), Deb Group (UK), Syngenta (Switzerland), Rich (USA) and Johnson Matthey Plc (UK).

He has received a number of honours and awards, most recently being chosen as the Langmuir Lecturer by the Colloid and Surface Chemistry Division of the American Chemical Society (ACS), USA, in 2016 and recipient of the Surfaces and Interfaces Award, Faraday Division of the Royal Society of Chemistry (RSC), UK, in 2014. Binks is currently a Senior Editor of *Langmuir*. He has published over 290 peer-reviewed articles and thirteen patents and has edited three research monographs. He has collaborations with twelve other university and research groups in the UK, China, Israel, France, Australia and Switzerland.

The Researcher

- **Name:** Professor Bernard P. Binks
- **Position:** Professor of Physical Chemistry
- **Department:** School of Mathematics and Physical Sciences, Faculty of Science and Engineering
- **University:** The University of Hull
- **Street:** Cottingham Road
- **City:** Hull
- **Post Code:** HU6 7RX
- **Country:** UK
- **Email:** b.p.binks@hull.ac.uk

About the Research

An understanding of colloidal particles at interfaces is critical to a variety of phenomena of industrial significance. Fluid-fluid interface-containing particles include oil-water, air-water, oil-oil, air-oil and water-water interfaces (1). Janus liquid marbles, for example, can be prepared by coalescing a liquid water droplet with an oil droplet in the presence of omniphobic particles and can then be used to carry out reactions that take place at the oil-water interface (2). Methods are being developed for manipulating such non-wetting droplets (termed 'liquid marbles') which can be applied in biological detection and clinical diagnosis as well as in microreactors for material fabrication and chemical reactions (3). Light and magnetic effects can be used to create a Pickering emulsion microreactor by co-adsorption of light-sensitive titania (TiO_2) and super paramagnetic iron oxide (Fe_3O_4) nanoparticles at the oil-water interface of emulsion droplets (4), enabling improved versatility in this class of microreactor.

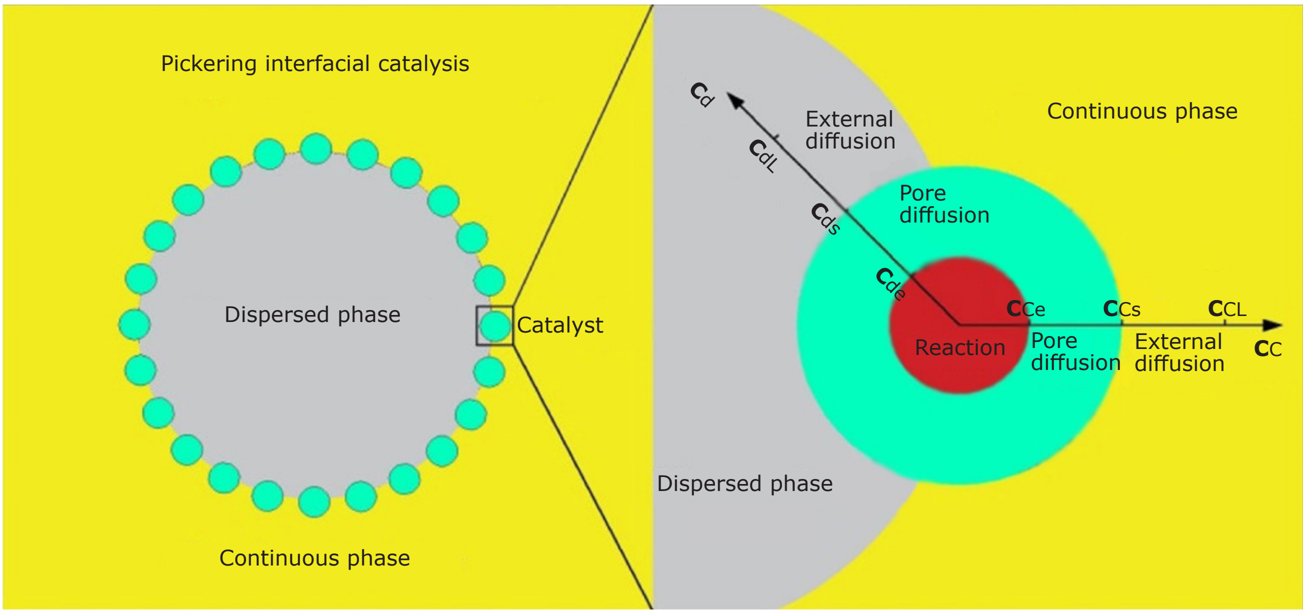

Fig. 1. Schematic of the interfacial catalysis route in a Pickering emulsion. Reprinted with permission from (4). Copyright (2018) American Chemical Society

Flow chemistry is of growing interest to the pharmaceutical among other industries. Its advantages include continuous processing, scalability, reduced solvent use and finer control of reaction products. Pickering emulsions have been explored in the Binks group as part of an EU project looking at a 'compartmentalised smart factory' approach involving heterogeneous palladium (Pd) catalysts and biocatalysts in catalytic cascade synthesis of active pharmaceutical ingredients (APIs) (5). Interfacial catalysis in a Pickering emulsion has also been investigated in the group to elucidate their mechanism with the aim of moving towards solvent-free epoxidation reactions (**Figure 1**) (6). Continuous enzymatic or homogeneous catalysed reactions are also being explored in non-aqueous Pickering emulsions (7).

In the life sciences, Pickering emulsions have raised interest for bone tissue engineering applications with the possibility of forming biocompatible and biodegradable porous scaffolds with adjustable pore structure (8). Water-in-water (w/w) emulsions are attractive micro compartmentalised systems for applications in the life sciences including drug delivery and encapsulation as well as synthesis due to biocompatibility (9).

Current projects in the Binks group at the University of Hull include stabilisation of emulsions with polyelectrolyte complexes or organic pigments, the effects of polymers and surfactants on oils and oil-water emulsions, aqueous and oil-based foams and catalysis in microparticle stabilised emulsions.

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