Stratification in Films of Binary Colloidal Mixtures

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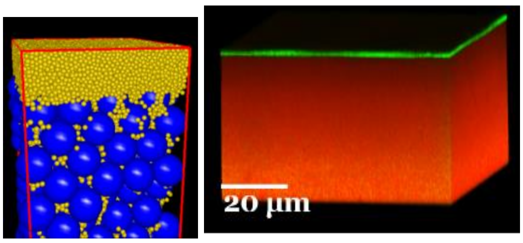
Waterborne colloidal films are used in a wide range of everyday applications, such as adhesives, inks, pharmaceutical coatings, agricultural treatments, paints and varnishes. For some applications, it is advantageous for a film's top surface to have a structure and properties that differ from the bulk. For instance, there have been reports that the segregation of hard particles at the surface of a waterborne polymer film increases the scratch resistance.[1] In another example, gold nanoparticles have been stratified at the top of a polymer film to create photonic and plasmonic effects.[2] In binary mixtures of particles of two different sizes, there are fundamental questions concerning the conditions under which there will be stratification of the particles by size (i.e. layering) and by which mechanisms.[3] Within the past couple of years, our research group has discovered – via simulations and experiments[4] – that when binary blends of waterborne particles are dried in a film, self-stratification occurs with a layer of small particles developing at the top interface with air (as shown in the figures below). The stratification is driven by an osmotic pressure, created by a concentration gradient of the small particles, acting on the large particles. In this lecture, I will present our experiments and simulations showing that the stratification mechanism is more favourable with higher size ratios, with a greater concentration of small particles, and in more dilute suspensions.[5] A new diffusion model has recently been developed[6] that provides a framework to understand the parameters that determine the stratification in the dilute limit. I will present new results that support the theory for dilute suspensions but show deviations from the theory for concentrated systems. Our deeper understanding opens up new strategies to manufacture stratified coatings with targeted properties.

1. J.S. Nunes *et al*. (2014) *Prog. Org. Coat*. **77**, 1523-1530.
2. A. Utgenannt *et al.* (2016) *ACS Nano*, **10**, 2232-42.
3. A. F. Routh (2013) *Rep. Prog. Phys*., **76**, 1.
4. A. Fortini *et al*. (2016) *Phys. Rev. Lett*., *116*, 118301.
5. I. Martín Fabiani *et al.* (2016) *ACS Appl. Mater. Interf*., **8**, 34755–61.
6. J. Zhou *et al.* (2017) *Phys. Rev. Lett*., **118**, 108002.



Langevin dynamics simulations (left) and confocal microscopy (right) showing statification in films of binary colloidal mixtures.

Preferred Presentation:

Oral Presentation: X

If oral presentation Which session

Thomas Graham Lecture

Colloids 2017 Themes

1. **Wetting** | Chairs: Prof Alex Routh, Dr Stuart Clarke
2. **Nanoparticles** | Chairs: Prof Nguyen T.K Thanh, Dr Tapas Sen
3. **Foams/Bubbles/Emulsions & microemulsions** | Chairs: Dr Alison Paul, Prof Brian Vincent, Dr Olivier Cayre
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5. **Programmable self-assembly** | Chairs: Dr Dwaipayan Chakrabarti and Prof Stefano Sacanna
6. **Biocolloids and Biointerfaces** | Chairs: Dr Chris Blanford, Prof Vitaliy Khutoryanskiy
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9. **Formulation Science and Engineering** | Chairs: Dr Seung Yeon Lee, Dr Simon Gibbon

Poster: ☐ Flash Poster: ☐