Membrane stability models in the presence of methacrylate esters

The Challenge

This project originates from an interest by Lucite International in the sustainable production of Methacrylate esters (MAEs). Lucites ultimate goal is to convert renewable feedstocks directly into saleable products using completely new, white biotechnology processes. MAEs are at the heart of multibillion dollar industry, supplying a global demand of polymethyl methacrylate primarily using petrochemical sources. Green production of MAEs by fermentation of sugars and using engineered bacterial strains is limited by the tolerance of the selected organisms to the build-up of the product to commercially viable concentrations. Limiting factor in the survival of industrial bacterial strains is membrane structure and stability in the presence of MAEs.

We aim at improving the lifetime of cell factories and engineering efficient transport of reactants and products. Understanding membrane stability is also pivotal to understanding MAE toxicity to human cells, essential to conducting responsible innovation and managing the risks of our work.

The Research

Dr Boyan Bonev is an Associate Professor of Biophysics and Structural Biology at the University of Nottingham and co-Director of the Dynamic Nuclear Polarization NMR Facility. Research in his laboratory focuses on understanding the structure, function and regulation of cell membranes.

Dr Bonev applied for a CBMNet Vacation Scholarship, which provided funding for an undergraduate student to gain experience in applications of advanced solid state NMR techniques to studies of membrane stability in the presence of MAEs.

Understanding the limits of membrane stability and the role of membrane composition in the presence of increasing MAE concentrations was sought to inform engineering of production bacterial strains with increased tolerance to MAEs.

The Result

MAE concentrations limiting membrane stability were determined by phosphorus NMR for three different membrane models. Using carbon NMR, MAEs were observed directly in membranes and shown to incorporate into the hydrophobic membrane interior at unprecedented high levels.

Significant insights were obtained into changes of membrane structure in the presence of MAEs. Membrane toxicity levels of MAEs were interpreted in relation to membrane composition.

"The summer placement has given me a deep insight into the advanced research techniques involved in Solid State NMR and its applications in bioengineering, something which will prove an invaluable skill in my future research or education."

Jack Mathews, Undergraduate Student

The Future

With the CBMNet vacation scholarship funding, Dr Bonev now has clear guidelines for bacterial strain engineering in a major CBMNet-initiated and BBSRC-funded collaborative project on engineering universal bacterial factories for biotechnology.

The study produced very interesting novel understanding of the fundamental principles of cell membrane structure and stability, which was complemented by a follow-on X-ray scattering experiment, sponsored by the Diamond Light Source.

"This CBMNet Scholarship has funded an excellent student giving him the opportunity to experience cutting edge research in magnetic resonance. It provided us with unprecedented insights into the capacity of cell membranes to accommodate environmental compounds and their ability to serve as buffers protecting the cells from toxins."

Dr Boyan Bonev, University of Nottingham