FUTURE FOOD FORMULATION FACTORIES

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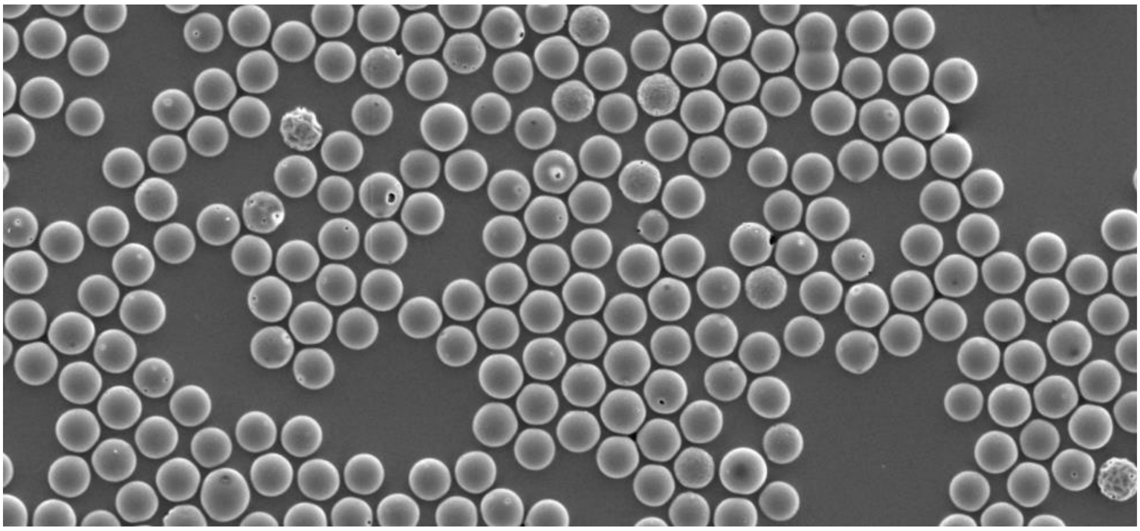

With the advent of nanotechnology and the food industry looking for novel applications to maximise the benefits of food nutrition, there have been key advancements in the nutraceutical market. A Food Standards Agency (FSA) report in 2007 highlighted that the industry is always "looking out for new technologies to improve nutritional value, shelf life [and] nanotechnology can provide the answer to these needs".[1]

Nutraceutical is a broad term used to describe any compound found in food that is thought to add nutritional value. They are extracted from food and concentrated to enhance their therapeutic effect. This can range from lycopene found in tomatoes, caseins in milk to carotenoids found in saffron, which have been linked with preventing heart disease, reduce muscle breakdown, and neutralising harmful free radicals, respectively.

The nutraceutical or 'functional food' market is also a rapidly growing sector. In 2013 the nutraceutical market was valued at an estimated $117 billion[2] and projected to grow even larger. Mainly due to the rise of improved healthcare systems, an ageing population and an increased public understanding of the importance of a healthy lifestyle. Therefore, with advancements in biotechnology and pharmaceutics, such as nanotechnology and polymer encapsulation, we are fast approaching the event horizon of the *Future Food Formulation Factories*.

Nanotechnology is the science of everything in the nanometre scale. For perspective, a human hair is approximately 80,000-100,000 nanometers thick, whereas a single carbon atom is less than a third of a nanometre in diameter.[3] Nanoparticles are already in use in many cancer drug formulations. These special particles can encapsulate medicines and through the optimisation of their surface charge or functionality, smart nanoparticles can be produced to target specific diseased tissues.

Targeted therapeutics can reduce harmful drug side effects, improve drug absorption to maximise benefit while also increasing patient satisfaction through reducing the frequency of medicine intake. A few exciting examples where nanotechnology has been used in the development of food include improving the food appearance, controlled release of flavours and nutrients, fat content reduction, nanofiltration of impurities and utilising nanosensors[4] in food packaging. Opportunities for the development food nanotechnology are limitless, creating a nutraceutical "all you can eat buffet."

A research project conducted by our team in the Advanced Materials & Healthcare Technologies (AMHT) Group at the School of Pharmacy, University of Nottingham produced biodegradable polymeric nano and microparticles to encapsulate nutraceuticals.

Our project focused on encapsulating a nutraceutical from saffron. Saffron is not only used in food as a tasty spice but it's also thought to carry many health-promoting benefits, many of which have been attributed to the main two carotenoids crocetin and crocin. Research suggests these carotenoids can act as antioxidants, antidepressants and have antiproliferative action against cancer cells[5]. Therefore, our studies focused on the production of nanoparticles encapsulating crocin. This was achieved by using polymeric nano and microparticle composed of PLGA (poly (lactic-co-glycolic acid) a US FDA (Food and Drug Administration) approved formulation polymer.

These particles were produced using microfluidics. Microfluidics is an emerging multidisciplinary research area which combines a number of very diverse disciplines such as engineering, physics, chemistry, biochemistry, biotechnology and nanotechnology. By controlling fluids through micrometre scale channels microfluidics technology allows the continuous manufacture of uniform micro and nanoparticles. Check this link for a video showing particles produced by an array of microfluidic chips.

Our method used syringes injecting an oil into a stream of water at high speeds and pressure. The oil contained the dissolved PLGA polymer such that as the water meets the oil at high speeds, it causes the precipitation of the polymer to controllably produce same size spherical particles. Particle size can be controlled by a number of parameters, for example; polymer concentration, the solvent type or the injection flow rate.

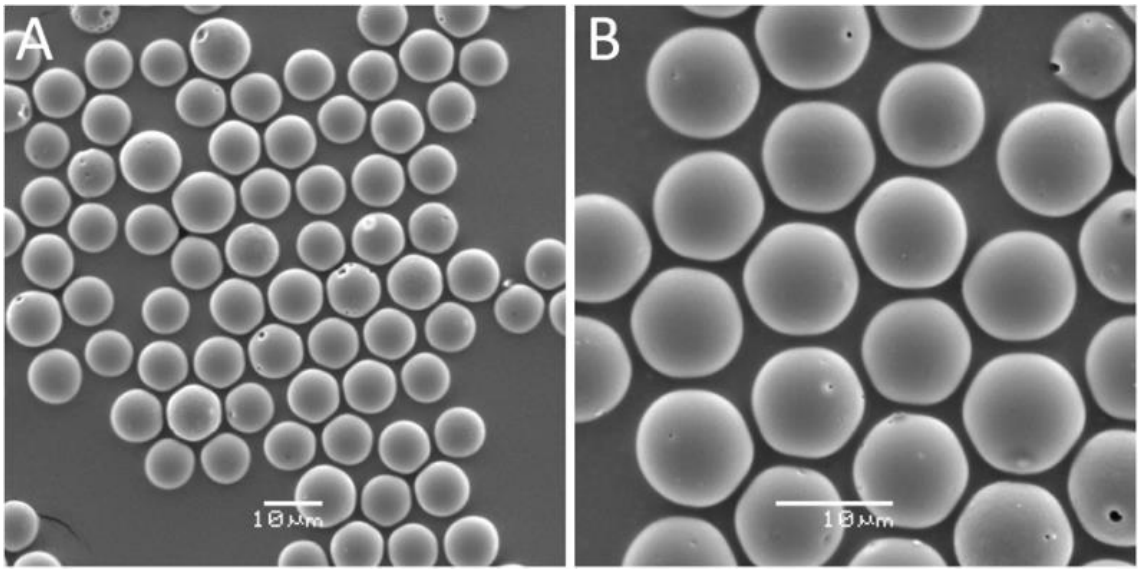

Figure 1. *Scanning Electron Microscopy image of uniform PLGA microparticles produced on a microfluidic chip.*

During our project we were able to produce microparticles ranging from 100 nm to 500,000 nm in diameter by controlling polymer concentration and the flow rate, in order to encapsulate crocin.

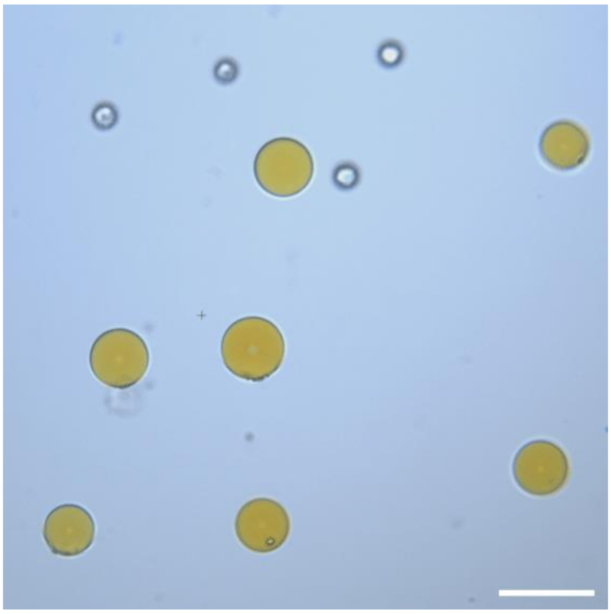

Figure 2. *Encapsulation of nutraceutical crocin in PLGA particles, imaged using optical brightfield microscopy. Scale bar = 100 µm*

Additionally, an array of diverse & interesting particles can also be produced, Figure 3. These particles may be small but their nutraceutical potential is enormous!

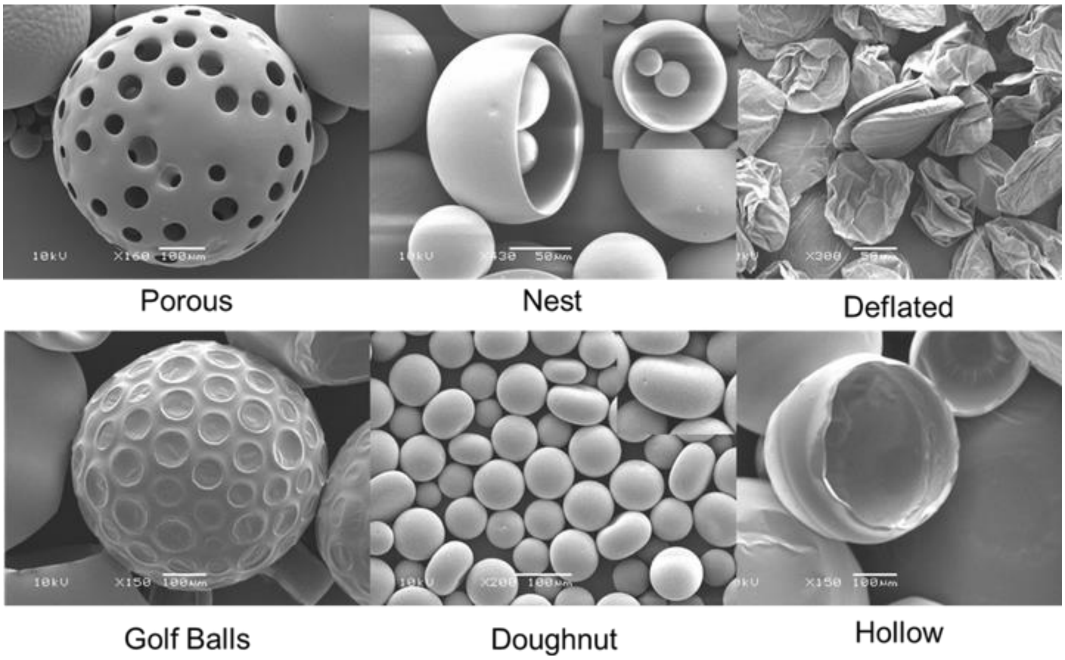

Figure 3. *Diverse structures produced using microfluidics. Credit Amjad A Selo (University of Nottingham).*

The researchers at the University of Nottingham's School of Pharmacy have an in depth understanding of the fundamental formulation parameters. We are now enhancing particle formulation by preparing custom designed polymers. These polymers permit targeted delivery of therapeutics and nutraceuticals to specific cellular systems. We believe that the research being conducted at our school is paving the way to transform food security of an ever-growing world population with a limited number of resources.

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