Membrane Emulsification for the Continuous Production of Cellulose Beads

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Cellulose Dissolution
An estimated 1.5 × 10^{12} tons of cellulose is generated every year making it the most abundant biopolymer on the planet. However, the wide scale sustainable use of this almost inexhaustible raw material is hindered by its low solubility by virtue of an extensive hydrogen bonding network (Figure 1, A).

Figure 1: A = Diagram of the inter and intra-chain bonding of cellulose. B = the ionic liquid 1-ethyl-3-methylimidazolium acetate

Ionic liquids (ILs) — molten salts with a melting point <100°C — can solvate cellulose opening up a potential processing avenue especially when used with a co-solvent such as DMSO (i.e. reduced viscosity, faster dissolution, less ionic liquid).

This research shows the use of such a solvent system (EMIMAc, DMSO, Figure 1 B) to process cellulose solutions via a membrane emulsification technique into sustainable and industrially important cellulose beads often used in water filtration, chromatography as well as solid supports.

Membrane Emulsification
Emulsions, a mixture of two immiscible liquids, are usually formed via high shear force processes but there is a drive towards lower energy and less harsh membrane emulsification techniques which also provide greater control over dispersity and droplet size (Figure 2).

Water in Oil emulsions (W/O) were used as a precursor to cellulose bead products. Specifically, solvated cellulose solutions were dispersed in a continuous sunflower oil phase then subject to an anti-solvent producing solid cellulose beads (Figure 3).

Results
Membrane hydrophobisation
A hydrophobic membrane was required to reduce the interaction of the aqueous phase (EMIMAc, DMSO, cellulose) with the membrane. Shirasu Porous Glass (SPG) membranes were hydrophobised with 5 vol% octadecyltri-chlorosilane (ODS), a functionality that was found to be stable in the solvent system (DMSO, EMIMAc—42 hrs 80°C).

Figure 2: A comparison between the dispersity and average size of cellulose beads made via two techniques.

Figure 3: Optical Micrograph of cellulose beads—scale bar = 400µm

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<tr>
<th>Conditions</th>
<th>Cellulose wt%</th>
<th>Conti. Phase</th>
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<th>Cont. Phase Temp (°C)</th>
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References