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Supplementary information files for Lego-inspired glass capillary microfluidic device: a technique for bespoke microencapsulation of phase change materials

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Supporting Information

Lego-Inspired Glass Capillary Microfluidic Device: A Technique for Bespoke Microencapsulation of Phase Change Materials

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Supplemental material S1

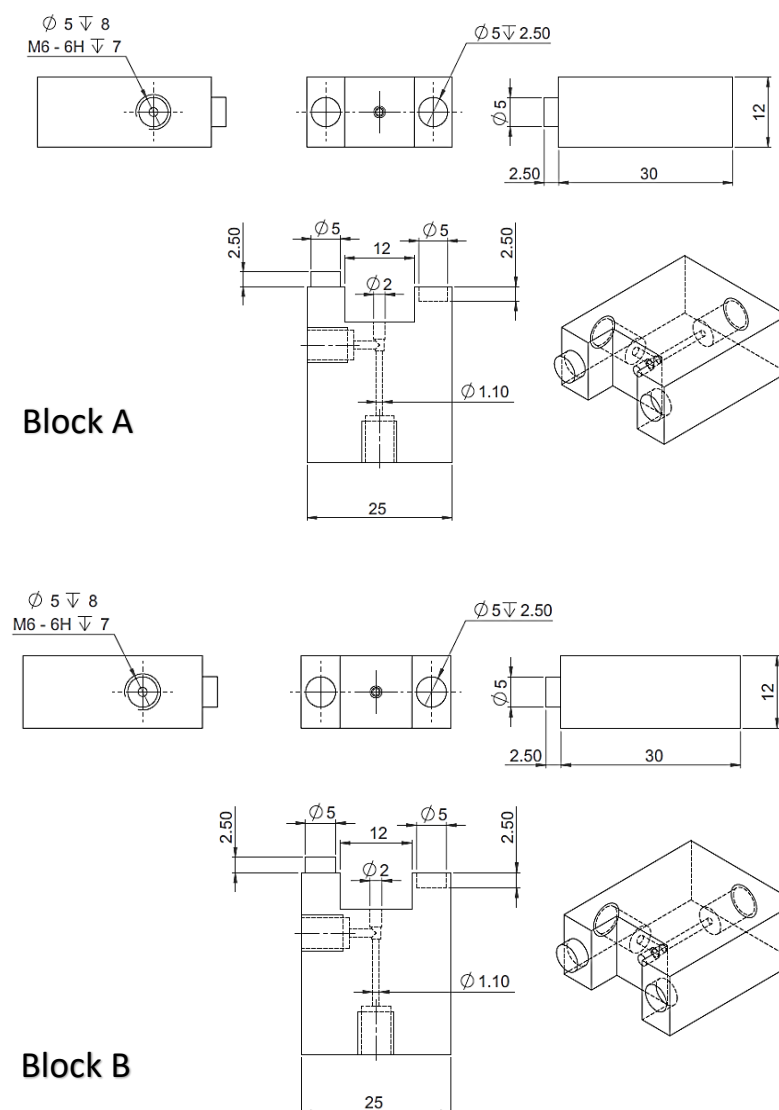


Figure S1. Engineering drawing of Lego blocks.

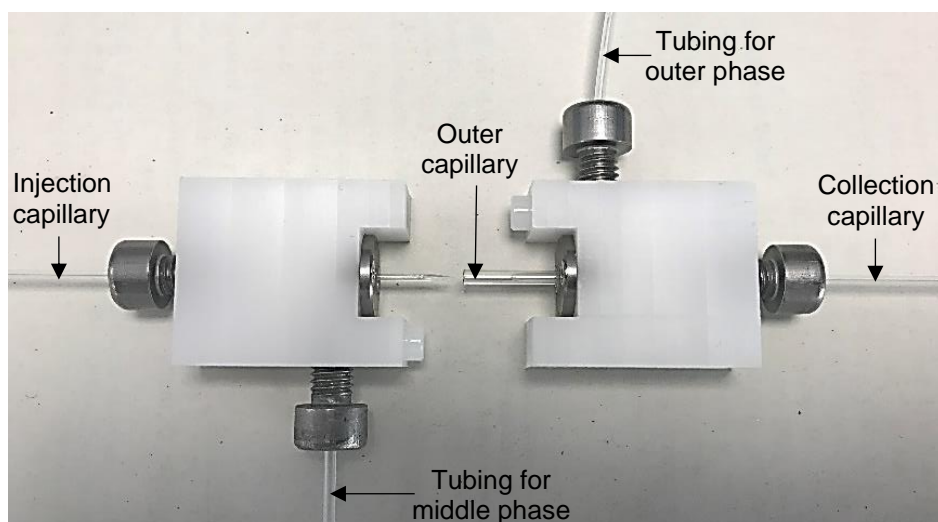


Figure S2. A dismantled microfluidic device with interchangeable Lego-inspired blocks. Glass capillaries, polyethylene tubing, and stainless-steel tube connectors are also shown.

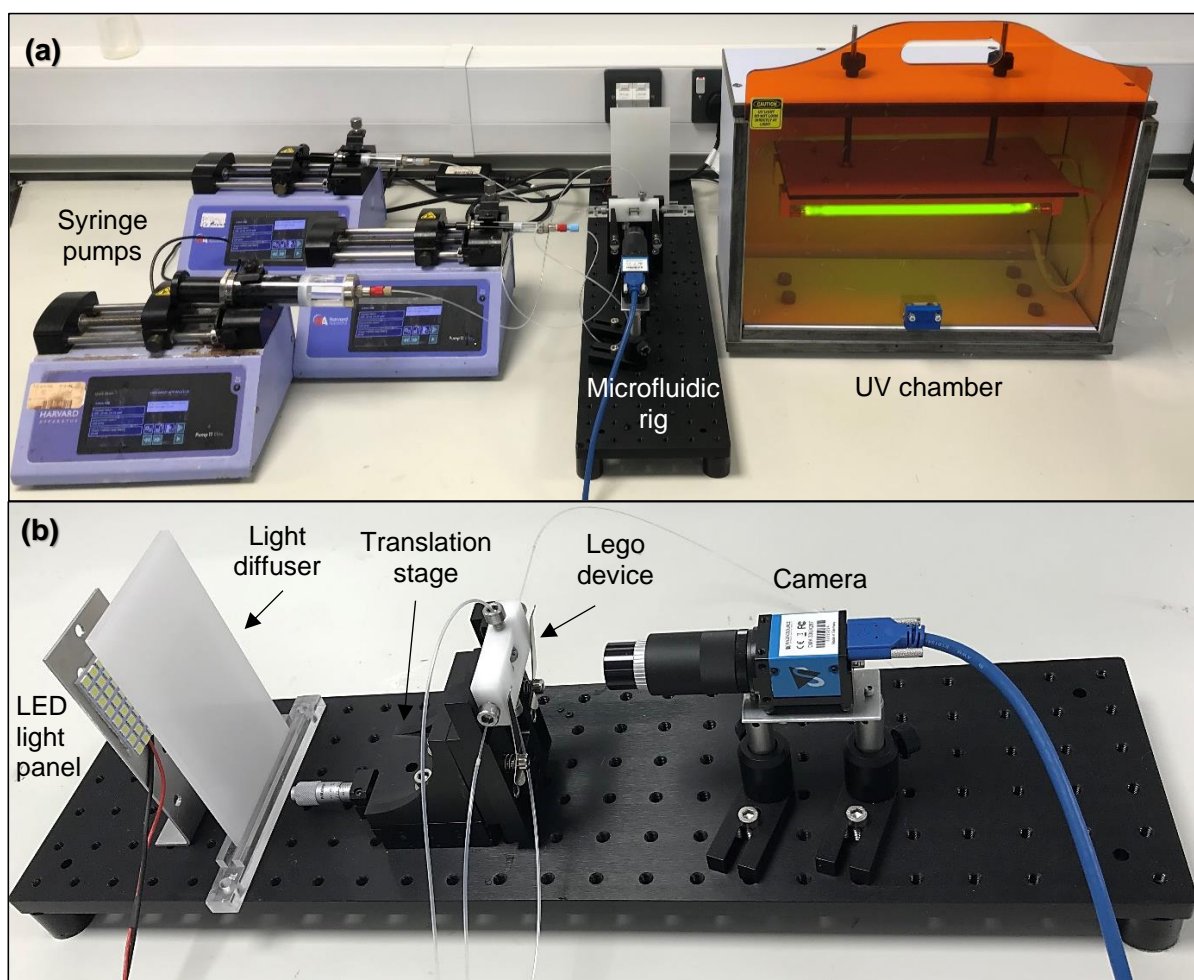
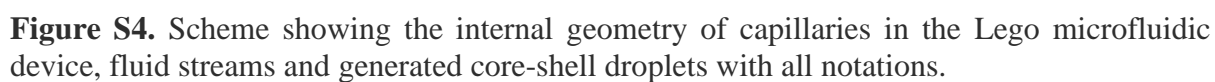


Figure S3. (a) Complete experimental set-up for microencapsulation of PCMs using Lego-inspired microfluidic device; (b) Side view of microfluidic test rig.



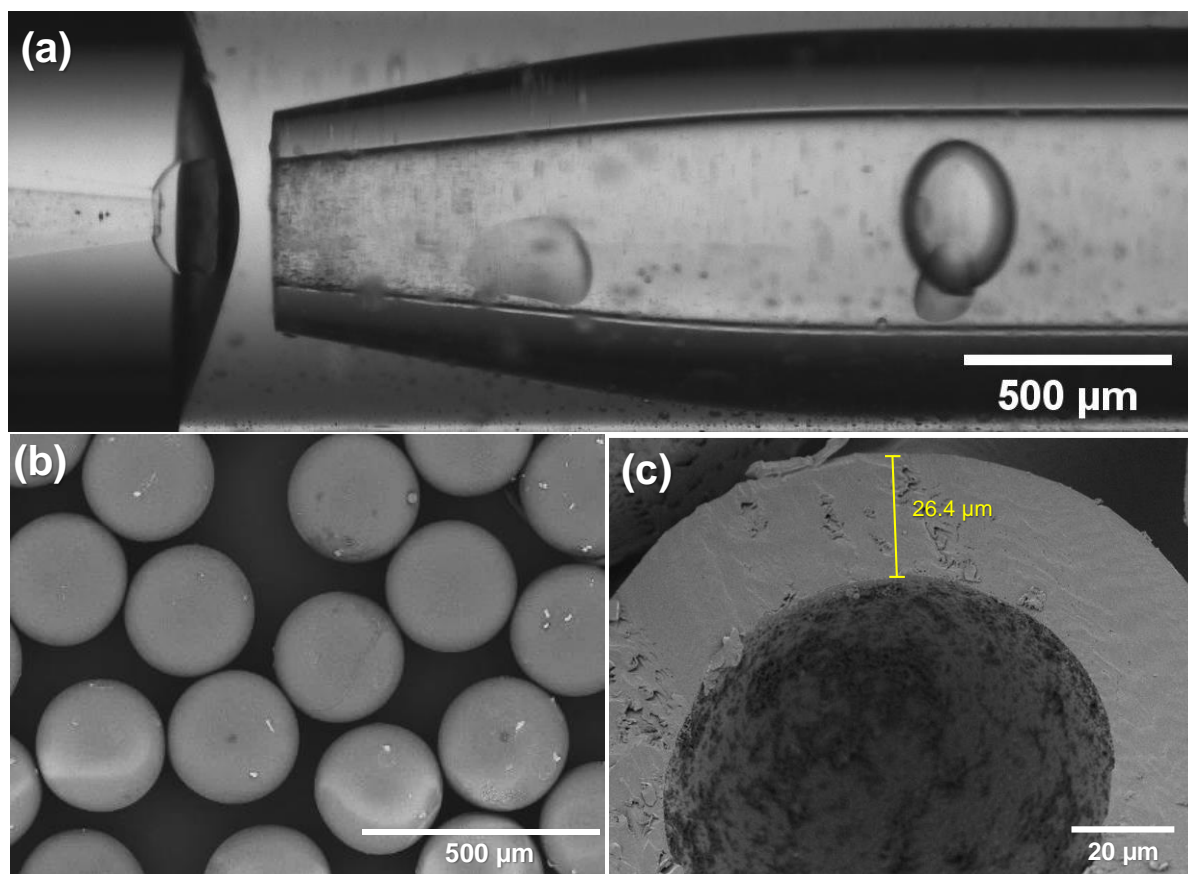


Figure S6. (a) Microfluidic process for the synthesis of microcapsules enclosing salt hydrate SP21EK (SP21EK-MC); (b) SEM image of SP21EK-MC microcapsules; and (c) SEM image of cross-sectioned SP21EK-MC microcapsule.

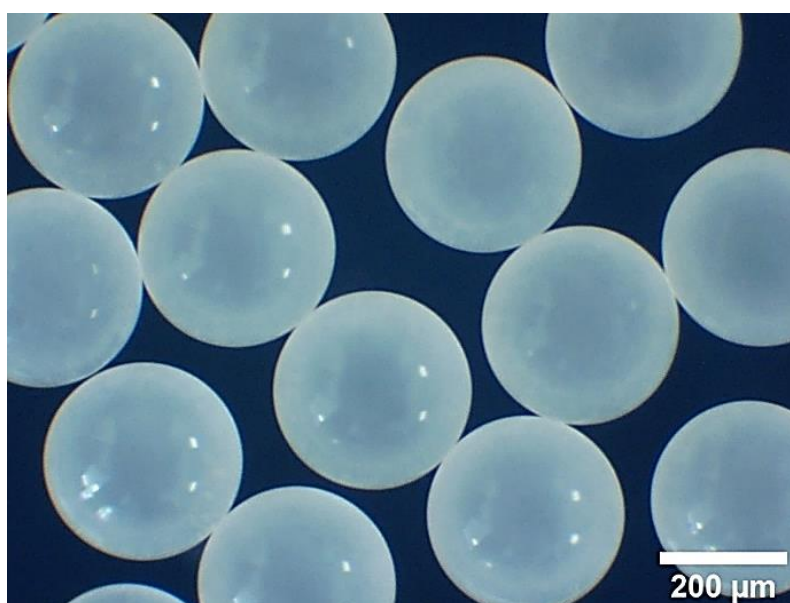


Figure S7. Optical microscopy image of HD-based microcapsules with opaque NOA shells confirming the presence of embedded TiO_2 NPs. Relatively uniform opacity confirms that TiO_2 is homogeneously distributed on the particle surfaces.

Supplemental material S2

Movie S1. The free-flowing final PCM microcapsules obtained after drying.

Movie S2. Double emulsions (O/O/W) with controlled droplet diameters formed using the three-phase Lego microfluidic device at $Q_i = 1.5$ mL/h, $Q_m = 1.5$ mL/h, $Q_o = 20$ mL/h using orifice diameters $D_{ii} = 50$ μm and $D_{ci} = 200$ μm (upper movie, HD-MC1); $D_{ii} = 100$ μm and $D_{ci} = 400$ μm (middle movie, HD-MC2); and $D_{ii} = 200$ μm and $D_{ci} = 500$ μm (lower movie, HD-MC3). The videos were slowed down 40 times.

Movie S3. Double emulsions (O/O/W) with controlled shell thicknesses formed using the three-phase Lego microfluidic device at orifice diameters $D_{ii} = 100$ μm and $D_{ci} = 400$ μm and flow rates $Q_i = 0.75$ mL/h, $Q_m = 1.5$ mL/h, $Q_o = 20$ mL/h (upper movie, HD-MC4); $Q_i = 1.5$ mL/h, $Q_m = 1.5$ mL/h, $Q_o = 20$ mL/h (middle movie, HD-MC2); and $Q_i = 3$ mL/h, $Q_m = 1.5$ mL/h, $Q_o = 20$ mL/h (lower movie, HD-MC5). The videos were slowed down 40 times.

Movie S4. Microfluidic process for synthesis of microcapsules enclosing salt hydrate SP21EK (SP21EK-MC) at $D_{ii} = 100$ μm and $D_{ci} = 400$ μm and flow rates $Q_i = 1.5$ mL/h, $Q_m = 1.5$ mL/h, $Q_o = 20$ mL/h. The video was slowed down 40 times.

Movie S5. Polarization microscopy (thermo-optical) video showing a single representative cycle of phase change of sample HD-MC4. During melting, HD inside the microcapsule appears transparent in the pictures while the shell shows a maltese cross structure in green and yellow, indicating the ordered structure of the polymerized NOA. During cooling, HD shows a dark green colour, appearing black in the middle of the capsule where the layer thickness is highest.

Movie S6. Real-time microfluidic process for synthesis of TiO_2 -HD-MC (PCM microcapsules with TiO_2 NPs embedded shell) at $D_{ii} = 100$ μm and $D_{ci} = 400$ μm and flow rates $Q_i = 3$ mL/h, $Q_m = 1.5$ mL/h, and $Q_o = 20$ mL/h.

Movie S7. Analysis of mechanical properties by compressing a single HD-MC- TiO_2 microcapsule *via* micromanipulation technique.