Supplementary Material (ESI) for Lab on a Chip

Supporting Information

Lock Release Lithography for 3D and Composite Microparticles

Ki Wan Bong[†], Daniel C. Pregibon[†], Patrick S. Doyle[*,†]

[†]*Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA*

**e-mail: pdoyle@mit.edu*

1. Materials

All of the particles shown in figure 1, 2, and 3 were made using solutions of 5% (v/v) Darocur 1173 (Sigma Aldrich) initiator, 35% (v/v) 1X TE buffer and 60% (v/v) poly(ethylene glycol)(700) diacrylate (PEG-DA, Polysciences). Twenty base pair oligonucleotide probes, #1 (5´-ATA GCA GAT CAG CAG CCA GA-3´) and #2 (5´-CAC TAT GCG CAG GTT CTC AT-3´) were purchased from IDT with Acrydite modifications and mixed into the monomers for a final concentration of 50 μM. To distinguish between chemistries for multifunctional particles, we added 5% (v/v) food color into desired chemistries. For swelling particle regions, we used solutions of 15% (v/v) acrylic acid (Polysciences), 15% (v/v) PEG-DA (700), 30% (v/v) poly(ethylene glycol)(200) (PEG, Sigma Aldrich), 5%(v/v) Darocur 1173 and 35% (v/v) 1X TE. Finally, particle regions with encapsulated entities were made from solutions comprised of 30% (v/v) PEG-DA (700), 3.5% (v/v) Darocur 1173, 59.5% (v/v) 1X TE buffer, 5% (v/v) Tween 20 (Sigma Aldrich) with 2% (v/v) fluorescent protein (streptavidin-phycorytherin, Invitrogen) or 5% (v/v) 2 μm fluorescent beads (FITC, Polysciences) in 5% (v/v) Darocur 1173, 30% (v/v) 1X TE buffer and 60% (v/v) PEG-DA. Solutions, 0.01% wt, of the fluorescent methacryloxyethyl thiocarbamoyl rhodamine B (Polysciences) in PEG-DA were used to fluorescently label the hydrogel.

2. Microfluidic Device

Devices were fabricated by spreading polydimethylsiloxane (PDMS, Sylgard 184,Dow Corning) on a silicon wafer containing positive-relief channels patterned in SU-8 photoresist (Stanford Foundary). The devices were 1,000 μm wide channels with varying heights (20, 30 or 60 μm) and various negative or positive topologies (10 or 30 μm tall) on their ceiling. These devices were placed on PDMS-coated glass slides or plasma sealed to patterned PDMS surfaces after placing thin sacrificial layers of PDMS on the channel alone and on the region of the PDMS surfaces which sits right under the channel. This is to ensure that the oligomer was only exposed to the PDMS surfaces. The devices were mounted on an inverted microscope (Axiovert 200, Zeiss), and the formation of the microparticles was visualized using a charge-coupled-device

camera (KPM1A, Hitachi). Images were captured and processed using NIH Image software or a digital camera (D200, Nikon) and Nikon Capture software.

3. Stop flow lithography Setup

The setup for SFL requires the use of pressure provided by a compressed-air source to drive flow inside the microfluidic channels. To generate controlled pressure in the range of 0–15 psi, a compressed air source (~ 40 psi) in the laboratory was first connected to either a T3510 I/P transducer (Marshbellofram) or a Type 100 LR manual pressure regulator (Control Air). Downstream of the transducer/regulator, a 3-way solenoid valve (Burkert) was used to switch rapidly between atmospheric pressure (stop) and the input pressure (flow). The output from the 3-way valve was connected to the microfluidic device using Tygon tubing connected to a 10 ml pipette tip (Biosciences). The pipette tip was filled with the desired fluid and inserted into the inlet hole punched in the microfluidic device. The transducer, 3-way valve and shutter were all controlled using VIs written in Labview 8.1 (National Instruments). The 3-way valve was controlled using a 1024-HLS digital I/O board (Measurement Computing) and a relay. The transducer and the shutter were controlled using serial connections.

4. Photopolymerization Setup

Photomasks were designed in AUTOCAD 2005 and printed using a high-resolution printer at CAD Art Services (Bandon, OR). The mask was then inserted into the field-stop of the microscope. A 100W HBO mercury lamp served as the source of UV light. A filter set that allowed wide UV excitation (11000v2: UV, Chroma) was used to select light of the desired wavelength and a VS25 shutter system (Uniblitz) driven by a computer-controlled VMM-D1 shutter driver provided specified pulses of UV light. Typical exposure times used were 30–100 ms and pressures ranged from 0.05 to 15 psi. A reservoir was cut in the PDMS to collect the particles.