Researchers use low-cost 3D printer to develop new method for creating microspheres

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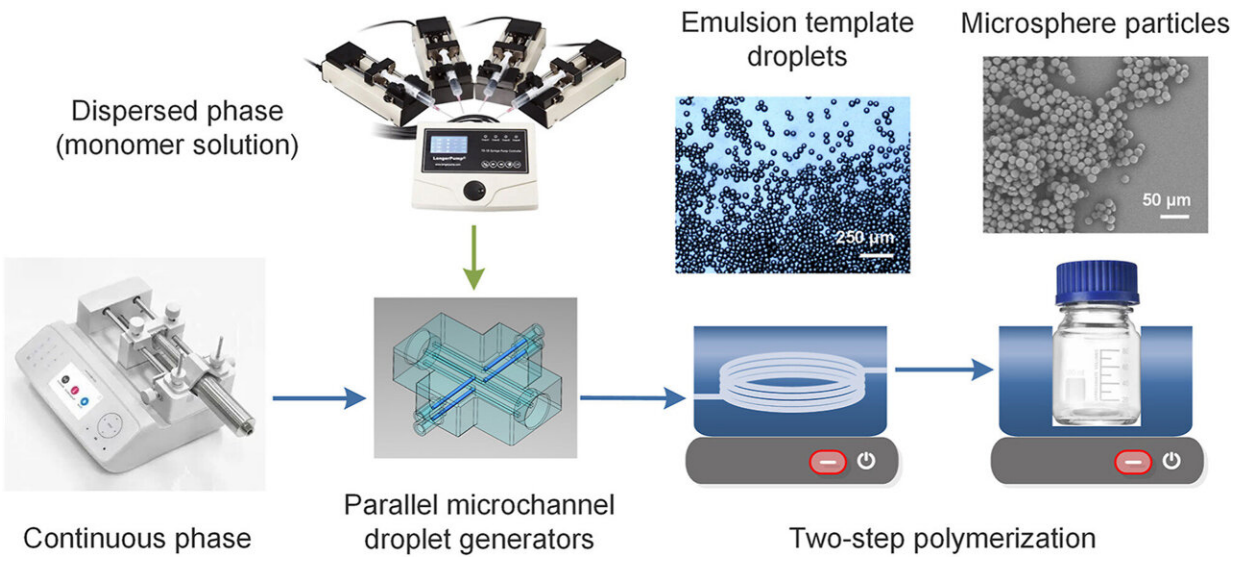

Graphical abstract. Credit: *Particuology* (2022). DOI: 10.1016/j.partic.2022.10.010

Researchers use powerful microchannel droplet generation equipment to create uniform polymer microsphere materials, which have high economic values. These microspheres are spherical microparticles that can be used in many applications including medical devices, biotechnology, the construction industry, veterinary science, and environmental studies.

A team of researchers has developed a novel method for building high throughput microchannel droplet generation equipment, which greatly reduces the numbers of integrating droplet generators inside, and can be easily realized via commercial low-cost 3D-print fabrication.

Their findings are published in the journal *Particuology* on October 22.

The team built a prototype device with only four parallel droplet generators using a low-cost 3D print method. The prototype device worked with the same capacity as a conventional microchannel device containing hundreds of parallel droplet generators. In addition to developing the advanced microchannel droplet generation equipment, the team also developed a two-step emulsion template polymerization procedure that turns the droplets into solid particles.

The team's newly developed device works much more efficiently than conventional microfluidic devices. "We found that the capillary-assembled stepwise microchannel was special, because of its robustness for the flow rate variation of the continuous phase and the fabrication error of its microchannel structure. When operated in the jetting flow condition, it generated droplets that are ten microns in diameter with very high frequency," said Kai Wang, associate professor at Tsinghua University.

The four-channel capillary-assembled stepwise microchannel droplet generation equipment the team fabricated can contribute 2.8×10^4 Hz droplet generation frequency of ten microns of droplets. To achieve this quantity with the conventional parallel scaled microchannel device working with dripping flow would have required hundreds of microchannel droplet generators.

"The core scientific discovery of our study is the understanding of the flow rate and fabrication error robustness of a capillary-assembled

stepwise micro-channel in jetting flow, which largely reduces the difficulties in fabrication and operation of those microchannel devices," said Guangsheng Luo, a professor at Tsinghua University.

The conventional methods of making uniform droplets or particles with microchannel devices require rigorous and expensive fabrication technology, such as the soft lithography or ion etching process. The limited yield of particles from a single microfluidic droplet generator makes it challenging to scale up the process to a faster, increased production. This challenge has driven the continued research to develop more efficient microfluidic droplet generator methods.

Using the 3D-print technology to fabricate the droplet generation device provided the team with a convenient way of making complex microchannel structures without the requirements of complicated layer sealing procedures. They used their device to prepare 32-52 mm average diameter droplets with 4.5 percent to 8.4 percent diameter variation coefficients. Then they turned the droplets into solid particles via their two-step polymerization in the microfluidic platform.

These microsphere materials have significant economic value. Their applications are wide ranging, such as the spacers of liquid crystal displays or the standard particles for calibrating particle size analyzers. Microsphere particles with good dispersibility can be used in the medical field for microencapsulation and drug delivery carriers. Microspheres are made of different kinds of materials. The polymer particle is an important variety that can be conveniently prepared from monomer polymerization and cross-linking technologies.

Looking ahead to future research, the team aims to further scale-up the capillary-assembled stepwise microchannel device with more droplet generators and a more precisely controlled method, based on deep learning of droplet image recognition. "It is also important to promote

the industrialization of particle preparation technology to serve the international market of uniform microsphere materials," said Kai Wang.

More information: Shenglong Zhang et al, High-throughput generation of uniform droplets from parallel microchannel droplet generators and the preparation of polystyrene microsphere material, *Particuology* (2022). DOI: 10.1016/j.partic.2022.10.010

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