One-step fabrication of polymersomes and emulsions using inkjets

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Due to their ability to encapsulate and protect sensitive and valuable active ingredients, polymersomes and emulsions are of high interest in pharmaceuticals, cosmetics and nutraceuticals. Many fabrication methods enable formation and loading of narrow distributed polymersomes or emulsions. Several require the application of high shear or extensional forces, which apply intense mechanical and thermal stress on the ingredients. Other methods require several sequential or time consuming preparation steps. A new one-step process using current inkjet printing technologies enables preparation of unilamellar polymersomes and liposomes in a reproducible manner under mild conditions. [1]

When the droplets of the amphiphile solution are shot through the inkjet nozzles into the water, they dissolve, which results in a nucleation and growth process leading to the desired polymersomes. Their size can be controlled via several parameters like polymer concentration, solvent and the characteristics of the inkjet printer. This was studied for the block copolymers poly-(2-vinylpyridine-block-ethylene oxide) (P2VP-PEO), poly-(isoprene-block-ethylene oxide) (PI-PEO), and for the first time for poly-(butadiene-block-ethylene oxide) (PB-PEO) and poly-(dimethylsiloxane-block-ethylene oxide) (PDMS-PEO).

![Schematic of the inkjet method (left), Cryo-TEM image of printed PDMS-PEO polymersomes (right).](image)

The inkjet method is also applicable to produce nanometer sized emulsions, which can additionally be loaded with active ingredients, fragrances and flavours. [2] Therefore, a mixture of an oil, surfactant, cosolvent and the valuable additive is filled into the printer cartridge and printed into water, where the emulsion directly forms. This has been investigated for various combinations of oils, surfactants and cosolvents. The size of the droplets can be controlled in the same manner like for the polymersomes and nanometer sized emulsions can easily be prepared.