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# Visualization of pore formation during polymerization-induced phase separation

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Additive Manufacturing techniques become increasingly important in the fabrication of geometrically complex structures. In particular, 3D-printing allows the production of curved and overhanging geometries, which are otherwise difficult to obtain. In order to produce membranes with this degree in freedom of design, this requires the development of inherently porous 3D-printable materials.
With the principle of polymerization-induced phase separation (PIPS), porous networks can be produced from UV-active resins of different compositions.[1][2] While these materials enable the fabrication of porous objects, the polymerization kinetics and the associated development of the pore system are not yet fully understood. While pore formation and phase separation phenomena were previously investigated for systems containing vesicles, nanoemulsions or colloidal gels, polymerization-induced phase separation from homogeneous solutions such as those needed for 3D-printing is not yet fully understood.[3]
In this work, a resin for porous printing was developed and modified to enable the study of pore formation by use of confocal laser scanning microscopy. Pore formation during PIPS was tracked in real-time, giving insight into the development of porosity of the printed parts. We show the different pore structures of the final cured part that can be obtained by slight alterations to the resin composition. During the PIPS process, the development of porosity and tortuosity shows distinct differences in these samples, giving further insight into the role of different components of the resins. Here, we vary the amount of porogenic solvent and are able to show, that printing times as well as pore structure are drastically influenced. Comparing the time it takes to fully 3D-print a sample object and perform detailed analysis on the final part, e.g. by electron microscopy, our method gives the opportunity to investigate small samples in a short amount of time. One measurement with our proposed method takes less than ten minutes, while a typical 3D-print of a test piece alone can take up to an hour. Thus, this technique enables rapid screening of different resins as well as furthers the understanding of pore-forming processes such as PIPS.

## Participation

In-Person

## References

[1] Z. Dong, H. Cui, H. Zhang, F. Wang, X. Zhan, F. Mayer, B. Nestler, M. Wegener, P.A. Levkin, 3D printing of inherently nanoporous polymers via polymerization-induced phase separation, Nat. Commun. 12 (2021) 247. https://doi.org/10.1038/s41467-020-20498-1.
[2] Z. Dong, M. Vuckovac, W. Cui, Q. Zhou, R.H.A. Ras, P.A. Levkin, 3D Printing of Superhydrophobic Objects with Bulk Nanostructure, Adv. Mater. 2106068 (2021) 2106068. https://doi.org/10.1002/adma.202106068.
[3] a) Y. Gao, J. Kim, M.E. Helgeson, Microdynamics and arrest of coarsening during spinodal decomposition in thermoreversible colloidal gels, Soft Matter. 11 (2015) 6360–6370. https://doi.org/10.1039/C5SM00851D. b) L.C. Hsiao, P.S. Doyle, Celebrating Soft Matter's 10th Anniversary: Sequential phase transitions in thermoresponsive nanoemulsions, Soft Matter. 11 (2015) 8426–8431. https://doi.org/10.1039/C5SM01581B. c) J. Sibold, V.E.

Tewaag, T. Vagedes, I. Mey, C. Steinem, Phase separation in pore-spanning membranes induced by differences in surface adhesion, Phys. Chem. Chem. Phys. 22 (2020) 9308–9315. https://doi.org/10.1039/D0CP00335B.

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