SELF-ORGANIZING MATTER

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The Self-Organizing Matter group focuses on the dynamic interplay between chemical reactions and crystallization phenomena to control the emergence of complexity in the solid state. In particular, we aim to design physical/chemical schemes to self-organize complex materials and develop new chiral amplification methods for the synthesis of enantiomerically pure building blocks. Current research includes the development of new routes to control crystallization, material composition, shape and hierarchical organization of mineralized structures and the design of physical/chemical feedback mechanisms to self-correct and amplify the emergence of complexity.

Highlights

- We demonstrated new chiral amplification mechanisms and developed practical synthesis routes towards a wide range of molecules including block buster pharmaceuticals.
- We introduced light-controlled steering of self-assembly following user-defined light-patterns.
- We developed shape-preserving ion exchange reactions to more than 50 chemical compounds including catalysts and semiconductors, in addition resulting in the founding of the startup company LumetalliX.
- We combined reaction/diffusion processes with mechanically mediated transport phenomena to achieve simple and scalable pattern formation of complex motifs that can serve for instance as for optomechanical sensors and tunable diffraction grating.

Plans

Future research will be aimed at the following two directions:

1. We aim to develop new chiral amplification mechanisms: in particular by exploiting non-equilibrium conditions. A breakthrough in this field would open new routes to important molecular building blocks and reveal unexplored mechanism for manipulating crystallizing materials.

2. We will pursue the development of new light-controlled reactions to steer self-assembly processes with spatiotemporal control and develop new mechanochemical feedback mechanisms to create complexity according to exact designs. Ultimately, these results may be exploited for developing new materials with advanced next generation functionalities.

Key research items

1. S.W. van Dongen, I. Ahlal, M. Leeman, B. Kaptein, R.M. Kellogg, I. Baglai and W.L. Noorduin, *Chiral Amplification through the Interplay of Racemizing Conditions and Asymmetric Crystal Growth*, J. Am. Chem. Soc., 145, 436 (2023)

2. C. van Campenhout, D. ten Napel, M. van Hecke and W.L. Noorduin, *Rapid formation of uniformly layered materials by coupling reaction–diffusion processes with mechanical responsiveness*, PNAS, 119, e2123156119 (2022)

3. M.H. Bistervels, M. Kamp, H. Schoenmaker, A.M. Brouwer and W.L. Noorduin, *Light-controlled nucleation and shaping of self-assembling nanocomposites*, Adv. Mater., 34, 210784 (2022)

4. L. Helmbrecht and W.L. Noorduin, *Method for detecting lead*, EP Patent Application EP21166957, filed April 6 (2021)

5. H.C. Hendrikse, A. van der Weijden, M. Ronda-Lloret, T. Yang, R. Bliem, N. Raveendran Shiju, M. van Hecke, L. Li and W.L. Noorduin, *Shape-Preserving Chemical Conversion of Architected Nanocomposites*, Adv. Mater., 32, 2003999 (2020)

Conversion of a sand dollar skeleton into a green light-emitting perovskite.