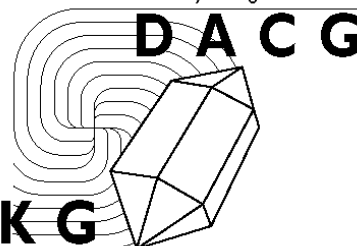


# FACET

dutch association for crystal growth



DACG NEWSLETTER

NVKG

nederlandse vereniging voor kristalgroei

February 2021

issue 1

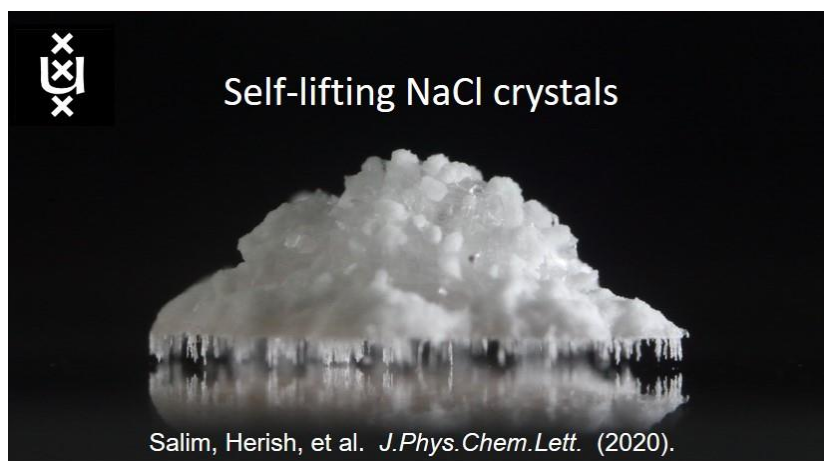
## FACET

Newsletter of the Dutch

Association for Crystal Growth

(DACG), section of the KNCV and

the NNV.



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## DACG Secretary

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## Cover figure

Self-lifting NaCl crystals.

Image from the group of Dr. Noushine Shahidzadeh, Institute of Physics-WZI, University of Amsterdam. See List of publications and [zoutkristal-op-stelten](#) for details.

## From the editor

New year, new opportunities. Hopefully with the vaccinations well on the way we will soon see each other face to face. In the meanwhile, our spring symposium will be online on Friday April 9<sup>th</sup>! Sign in by April 2<sup>nd</sup> to receive the link.

Our 50-year jubileum is about a year away. We would like to ask you to have a look in your archives and send us photos that highlight 50 years of crystal growth events in the Netherlands. Or probably you have pictures of your historical crystal growth or crystallization installations. These photos are very welcome.

Remember to nominate your candidates for the KNCV Piet Bennema Prize for Crystal Growth!

Also please take a few minutes to fill in the communication survey. You can find the link on page 4.

As always, it is easy to contribute to the FACET: recently published articles and theses, photos for cover figure, relevant announcements, ... Contributions may be delivered by mail, [e-mail](#), or telephone. Your ideas are welcome, please notify the editor: Marketta Uusi-Penttilä

*Marketta Uusi-Penttilä*

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## Upcoming events

- DACG Spring Meeting, 9 Apr 2021, Online.
  - DACG Fall Meeting, Oct 2021, Geleen
-

## Professional Appointments

**Dr Noushine Shahidzadeh** has been appointed professor of Crystallization in Porous Media at the Faculty of Science at the University of Amsterdam (UvA). Follow the [link to the UvA website](#) for the announcement. Her research group focuses on novel experimental approaches for a better understanding of flow and phase transitions in complex liquids combined with the control of crystal nucleation and growth.



Noushine Shahidzadeh (photo: Dirk Gillissen)

**Professor Shahidzadeh** is also the leader of CRYSTINART project (CRYSTALLIZATION Damage at the INTERfaces of ARTworks). Within this cooperation between exact scientists and conservation specialists, fundamental research will be done on the topic of crystallization as one of the major causes of degradation of porous objects – and art in particular. The project is financed by the Joint Programming Initiative on Cultural Heritage and Global Change (JPICH), the Netherlands Organisation for Scientific Research (NWO) and the Netherlands Institute for Conservation Art and Science (NICAS). See the [UvA](#) and [NICAS](#) websites for details.



Wim Noorduin (photo: Lukas Helmbrecht)

**Dr Wim Noorduin** has been appointed professor by special appointment of Self-Organising Matter at the Faculty of Science at the University of Amsterdam (UvA). Follow the [link to the UvA website](#) for the announcement. As an UvA professor, Wim will focus on research at the interface of chemistry and physics, in which fundamentally new principles for chemically driven assembly and organisation of functional molecules on a microscopic scale can be found.

**Professor Joop ter Horst** will leave University of Strathclyde and succeed Professor Gérard Coquerel, who is retiring, at the University of Rouen.

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## Nominations for KNCV Piet Bennema Prize for Crystal Growth

Please nominate your candidates for the KNCV Piet Bennema Prize for Crystal Growth. The submission period is from **1 October 2020 to 30 April 2021**. Supervisors can nominate candidates by means of a letter of recommendation with the thesis or other scientific publications, as well as a motivation. The nomination must be submitted in triplicate to the secretary of the DACG.

For candidates who want to be considered on the basis of their dissertation, the dissertation must have been successfully defended at a Dutch university in the three years prior to the closing of the submission deadline (**1 May 2018 – 30 April 2021**). For academic publications, it also applies that these must have been published for the most part in the preceding three-year period.

For details on the announcement and regulations, please see the [DACG website](#).

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## Communication Survey

Dear Dutch Association Crystal Growth member,

Crystals with a well-established covalent network, such as diamonds, are the strongest because of their well-established network. Therefore, I like to bring your attention to a new idea of the DACG where we want to improve its members' connection and I write you this email to inventory the needs and wishes in the communication.

My name is Marloes Bistervels, and I am a Ph.D. student in the group of Wim Noorduin at AMOLF. Recently I thought it was time to contribute a bit more to the association. Together with the DACG board, we came up with the idea to set up something to achieve more and easier communication among the association members.

To get there, we like to set up an interactive dynamic online platform. The forum's goal is to keep you more updated, let you make more comfortable contacts, and create knowledge around you more accessible.

The platform can contain a newsfeed with exciting updates about newly published work, upcoming events, and developments in the field. And function as a stable and easily accessible platform to quickly contact your peers for answering questions, setting up collaboration, or finding needed equipment.

Most of all, we want this platform to serve your needs and bring you closer to each other. Therefore I would like to ask you to fill in a short survey (10 minutes max.); see the following link:

[https://docs.google.com/forms/d/e/1FAIpQLScR\\_d7N8uZleRoj7szsudRAwZGwwdK5gY004JbmHP7eG-bWaBq/viewform?usp=sf\\_link](https://docs.google.com/forms/d/e/1FAIpQLScR_d7N8uZleRoj7szsudRAwZGwwdK5gY004JbmHP7eG-bWaBq/viewform?usp=sf_link)

Thank you very much, and I hope to get back to you soon with a prototype!

Kind regards,

Marloes Bistervels on behalf of the DACG-board

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## Annual membership fee 2021

Just a friendly request for all members to check that you have paid your membership fee for 2021. Being a member you can participate our symposia for a reduced price.

The membership fee in 2021 is € 15 for professionals, € 10 for 65+ and € 5 for (PhD) students. Please mention "DACG membership fee 2021" in your payment.

The bank account of the NVKG is:  
Ned. Ver. Van Kristal Groei.  
NL60INGB0004305158

*The annual membership runs from 1 January 20XX to 31 December 20XX.*

*Participating in one of the two annual DACG symposia paying the full participation fee includes the membership for that year (20XX) and the following calendar year (20XX + 1).*

# DACG Spring Symposium

*Online, 9 April 2021*

- 13:00 – 13:05 **Welcome and introduction**  
Hans te Nijenhuis
- 13:05 – 13:30 **Nature inspired multi-mineral salts for iron fortification**  
Simon Lepinay (Institute of Physics, University of Amsterdam)
- 13:30 – 13:55 **Binary icosahedral clusters of hard spheres in spherical confinement**  
Ernest van der Wee (Soft Condensed Matter Group, University of Utrecht / Delft University of Technology)
- 13:55 – 14:05 **Coffee break**
- 14:05 – 14:30 **Growth of pure polytypes in GaAs nanowires**  
Marco Vettori (Dept of Applied Physics, Advanced Nanomaterials & Devices, TU Eindhoven)
- 14:30 – 14:55 **Self-lifting NaCl crystals**  
Herish Salim (Institute of Physics, University of Amsterdam)
- 14:55 – 15:00 **Closing remarks**  
Hans te Nijenhuis

## **REGISTRATION**

For registration, please send an email to [a.e.d.m.vanderheijden@tudelft.nl](mailto:a.e.d.m.vanderheijden@tudelft.nl), ultimately **by April 2<sup>nd</sup>, 2021**. You will receive a link to participate in the meeting.



## Announcement

Unfortunately we received the announcement that Prof. dr. ir. Gerda Maria van Rosmalen passed away on January 18th 2021.

During her scientific career, Prof. Gerda van Rosmalen was professor Industrial Crystallization at the Delft University of Technology. In this role, she helped building the bridge between chemical technology and mechanical engineering. She taught many engineers who have found their way in leading process industries. Also after their PhD they stayed in close contact with her for advice.

As a woman in the world of process technology she was a role model. Shortly before her 80th birthday, Gerda was co-author of the textbook "Industrial Crystallization: Fundamentals and Applications".

Between 1980 and 1987 Gerda was in various functions, amongst others president, member of the board of the DACG.

With the passing of Gerda, the crystal growth community loses a committed and highly esteemed colleague.

On behalf of the board of the DACG

Hans te Nijenhuis



*"Als je een groenende twijg in je hart  
 bewaart zal de zangvogel zeker komen"*

Na de vele jaren die wij samen hebben doorgebracht heeft mijn maatje, onze moeder, oma, tante en vriendin afscheid van ons genomen. Gerda leefde een druk en boeiend bestaan. Wij zullen haar erg missen.

### Prof. dr. ir. Gerda Maria van Rosmalen

Jakarta, 27-05-1936

Delft, 18-01-2021

Koos	Annet en Rob	Quinten en Femke	Léon
	Annemarie en Nick	Romany en Pim	Camiel
			Dorota
			Lorenzo

We hebben in familiekring afscheid genomen van Gerda. Reacties, berichten en herinneringen zijn van harte welkom. Haar stoffelijk overschot is ter beschikking gesteld van de medische wetenschap.

Correspondentieadres: J.C. Jansen, Grabijnhof 1, 2625 LL Delft



## Recent publications

- H. Salim, P. Kolpakov, D. Bonn, N. Shahidzadeh, [Self-Lifting NaCl Crystals](#). *The journal of physical chemistry letters* **11** (2020), No. 17, 7388-7393.
- And related press releases:
  - [Chemistry World](#)
  - [C<sub>2</sub>W](#)

### Affiliation

- Van der Waals-Zeeman Institute, Institute of Physics, University of Amsterdam, 1098 XH Amsterdam, The Netherlands

We show that macroscopic crystals of NaCl that form from evaporating drops of aqueous salt solutions can spontaneously lift themselves up and away from a hydrophobic surface. At the end of the evaporation process, tiny crystals of NaCl grow onto larger ones and form “legs” that push the large crystals away from the surface. The temperature dependence of the lifting speed is found to exhibit Arrhenius behavior with an activation energy similar to that of crystals growing in solution: the crystal growth itself determines the lifting speed that can be up to half a centimeter per minute. We show that surface hydrophobicity is a necessary but not a sufficient condition to obtain this “self-lifting” behavior.

- M. Mauriaucourt, S. Jiang, A. Soare, A. Zwijnenburg, N. Shahidzadeh, [Multiscale Study on the Mechanism of a Bio-Based Anticaking Agent for NaCl Crystals](#). *ACS Omega* **5** (2020), No. 49, 31575–31583.

### Affiliations

- University of Amsterdam, Van der Waals-Zeeman Institute, Institute of Physics, Science Park 904, 1098 XH Amsterdam, The Netherlands.
- Nouryon, Research, Development & Innovation Salt, Industrial Chemicals, Zuthpenseweg 10, 7418 AJ Deventer, The Netherlands.

Caking constitutes a major problem for the flowability, transport, packaging, and consumption of hygroscopic granular crystalline materials such as salt. Sodium chloride is the most abundant salt on the earth and known to form strong lumps, mainly due to cycles of water uptake and water evaporation. We report on a multiscale study of the anticaking effect of the bio-based additive Fe-mTA, a metal-organic complex of iron (III) and meso-tartrate. Drying-deliqescence cycling experiments are performed to reproduce the situation in which the salt undergoes repeated humidity fluctuations. Our results show that Fe-mTA acts as a nucleation promoter and growth inhibitor by inducing roughness on the surface of crystals. To directly study the effect of Fe-mTA down to the micrometer scale, we study liquid capillary bridges between two macroscopic salt crystals by applying droplets of salt solution with various levels of additives. Scanning electron microscopy and three-dimensional (3D) laser scanning confocal profilometry results show that Fe-mTA produces a surface roughness at the micron scale. This roughness decreases the effective contact area between crystals and promotes the spreading of the liquid bridge; consequently, the formation of a solid bridge between grains with water evaporation is avoided, thus preventing the caking phenomenon and, in addition, preventing adhesion of the crystals to solid substrates.

- F. Ibis, P. Dhand S. Suleymanli, A.E.D.M. van der Heijden, H.J.M. Kramer, H.B. Eral, [A Combined Experimental and Modelling Study on Solubility of Calcium Oxalate Monohydrate at Physiologically Relevant pH and Temperatures](#), *Crystals* **10** (2020), No. 10, 924.

#### Affiliations

- Intensified Reaction & Separation Systems, Process & Energy Department, Delft University of Technology, Leeghwaterstraat 39, 2628 CB Delft, The Netherlands
- Van't Hoff Laboratory for Physical and Colloid Chemistry, Debye Institute for Nanomaterials Science Utrecht University, 3584 CH Utrecht, The Netherlands

Accurate Calcium Oxalate Monohydrate (COM) solubility measurements are essential for elucidating the physiochemical mechanism behind the formation of kidney stones, nephrolithiasis. Yet the reported solubility values of COM in ultrapure water, arguably the simplest solvent relevant for nephrolithiasis, vary significantly depending on implemented method. To address this variation, we present an experimental study of the solubility of COM validated by a model based on the Debye–Hückel theory describing the solution chemistry and the complex formation. We also carefully monitor potential pseudopolymorphic/hydrate transitions during the solubility measurements with in-situ and ex-situ methods. Our results indicate that the solubility of COM in ultrapure water is a weak function of temperature. However, the measured solubility varies significantly in buffer solutions across physiologically relevant pH values at body temperature. The proposed model explains observed trends as a combined effect of ionic strength, protonation reactions, and soluble complex formation. Moreover, it predicts solubility of COM in buffer solutions remarkably well using our measurements in ultrapure water as input, demonstrating the consistency of presented approach. The presented study parleying experiments and modelling provides a solid stepping stone to extend the physiochemical understanding of nephrolithiasis to more realistic solutions laden with biological complexity.

- D. Irimia, J.J. Shirley, A.S. Garg, D.P.A. Nijland, A.E.D.M. van der Heijden, H.J.M. Kramer and H.B. Eral, [Influence of laser parameters and experimental conditions on non-photochemical laser induced nucleation of glycine](#), *Crystal Growth & Design* **21** (2021), No. 1, 631.

#### Affiliation

- Intensified Reaction & Separation Systems, Process & Energy Department, Delft University of Technology, Leeghwaterstraat 39, 2628 CB Delft, The Netherlands

Nonphotochemical laser-induced nucleation (NPLIN) is a promising primary nucleation control method, yet its underlying mechanism remains elusive. To contribute to the discussion on whether the polarization of laser irradiation in NPLIN experiments influences the polymorphic outcome, we revisit NPLIN experiments with aqueous glycine solutions with supersaturations ranging between  $S = 1.5$  and  $S = 1.7$  irradiated by nanosecond pulses ( $\sim 7$  ns) of near-infrared wavelength (1064 nm). Systematically altering laser light excitation properties, including the number of pulses and type of polarization, we quantified the nucleation kinetics and characterized the polymorphic form that crystallized upon laser irradiation. Due to the stochasticity of the nucleation process, a large number of samples ( $>100$  per each experimental point) were studied under carefully controlled experimental conditions such as the ambient temperature, cooling rate, and aging period. We observed significant differences among laser-irradiated, spontaneously nucleated, and crash-cooled samples in terms of nucleation kinetics and polymorphic form. This result indicates that laser irradiation provides a different polymorph-forming pathway in comparison to crash-cooling and spontaneous nucleation. However, no clear dependence between the polymorphic form and the polarization of laser irradiation is observed. We discuss our results in the context of previous reports supported thorough quantification of sample heating in NPLIN experiments.



- B. Song , Z. Tian , R.D. van der Weijden , C.J.N. Buisman , J. Weijma, [High-rate biological selenate reduction in a sequencing batch reactor for recovery of hexagonal selenium](#), *Water Research* 193 (2021), 116855.

#### Affiliation

- Department of Environmental Technology, Wageningen University and Research, P.O. Box 17; 6700 AA Wageningen, the Netherlands

Recovery of selenium (Se) from wastewater provides a solution for both securing Se supply and preventing Se pollution. Here, we developed a high-rate process for biological selenate reduction to elemental selenium. Distinctive from other studies, we aimed for a process with selenate as the main biological electron sink, with minimal formation of methane or sulfide. A sequencing batch reactor, fed with an influent containing 120 mgSe L<sup>-1</sup> selenate and ethanol as electron donor and carbon source, was operated for 495 days. The high rates (419 ± 17 mgSe L<sup>-1</sup> day<sup>-1</sup>) were recorded between day 446 and day 495 for a hydraulic retention time of 6h. The maximum conversion efficiency of selenate amounted to 96% with a volumetric conversion rate of 444 mgSe L<sup>-1</sup> day<sup>-1</sup>, which is 6 times higher than the rates reported in the literature thus far. At the end of the experiment, a highly enriched selenate reducing biomass had developed, with a specific activity of 856±26 mgSe<sup>-1</sup> day<sup>-1</sup> g<sub>biomass</sub><sup>-1</sup>, which was nearly 1000-fold higher than that of the inoculum. No evidence was found for the formation of methane, sulfide, or volatile reduced selenium compounds like dimethyl-selenide or H<sub>2</sub>Se, revealing a high selectivity.

Ethanol was incompletely oxidized to acetate. The produced elemental selenium partially accumulated in the reactor as pure (≥80% Se of the total mixture of biomass sludge flocs and flaky aggregates, and ~100% of the specific flaky aggregates) selenium black hexagonal needles, with cluster sizes between 20-200 μm. The new process may serve as the basis for a high-rate technology to remove and recover pure selenium from wastewater or process streams with high selectivity.

- G. Valenti, G. Valenti , P. Tinnemans, I. Baglai, W. L. Noorduin, B. Kaptein, M. Leeman, J. H. ter Horst, R. M. Kellogg, [Combining Incompatible Processes for Deracemization of a Praziquantel Derivative under Flow Conditions](#), *Angew. Chem. Int. Ed.* **60** (2021) 1-5.

#### Affiliations

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- AMOLF, Science Park 104, 1098 XG Amsterdam, The Netherlands
- InnoSyn BV, Urmonderbaan 22, 6167 RD Geleen, The Netherlands
- EPSRC Centre for Innovative Manufacturing in Continuous Manufacturing and Crystallisation (CMAC), Strathclyde Institute of Pharmacy and Biomedical Sciences, Technology and Innovation Centre, University of Strathclyde, 99 George Street, Glasgow, G1 1RD UK

An efficient deracemization method for conversion of the racemate to the desirable (*R*)-enantiomer of Praziquantel has been developed by coupling incompatible racemization and crystallization processes. By a library approach, a derivative that crystallizes as a conglomerate has been identified. Racemization occurs via reversible hydrogenation over a palladium on carbon (Pd/C) packed column at 130 °C, whereas deracemization is achieved by alternating crystal growth/dissolution steps with temperature cycling between 5–15 °C. These incompatible processes are combined by means of a flow system resulting in complete deracemization of the solid phase to the desired (*R*)-enantiomer (98 % *ee*). Such an unprecedented deracemization by a decoupled crystallization/racemization approach can readily be turned into a practical process and opens new opportunities for the development of essential enantiomerically pure building blocks that require harsh methods for racemization.

- E. Grothe, H. Meekes, R. de Gelder, [Chirality and stereoisomerism of organic multicomponent crystals in the CSD](#), *CrystEngComm*, **22** (2020) 7380-7388.

#### Affiliation

- Institute for Molecules and Materials, Radboud University, Heyendaalseweg 135, 6525 AJ Nijmegen, The Netherlands

With the current interest in multicomponent crystals containing chiral residues, a wide variety of studies could benefit from a comprehensive inventory of chirality in multicomponent crystals. We combined computational approaches for identifying chiral carbon atoms and methods for identifying residue types in order to make such an inventory for all organic multicomponent entries in the Cambridge Structural Database (CSD). [Groom et al., *Acta Cryst. B*, 2016, 72, 171–179] This inventory provides a new and extended view on multicomponent classification by including chirality. We classified 66355 multicomponent CSD-entries into one of seven multicomponent classes and one of seven stereoisomerism classes, based on the residue type and the presence of chirality in each entry. We present reference lists of the 49 resulting subclasses, and examples of applications of the combined classification.

- Weiwei Li, M. de Groen, H. J. M. Kramer, R. de Gelder, P. Tinnemans, H. Meekes, and J. H. ter Horst, [Screening Approach for Identifying Cocrystal Types and Resolution Opportunities in Complex Chiral Multicomponent Systems](#), *Cryst. Growth Des.*, **21** (2021) 112–124.

#### Affiliations

- Delft University of Technology, Department of Process and Energy, Leeghwaterstraat 39, 2628 CB Delft, The Netherlands;
- Institute for Molecules and Materials, Radboud University, Heyendaalseweg 135, 6525 AJ Nijmegen, The Netherlands

Cocrystallization of racemic-compound-forming chiral molecules can result in conglomerate cocrystals or diastereomerically related cocrystals, which enable the application of chiral separation techniques such as preferential crystallization and classic resolution. Here, a systematic method to identify the types and phase diagrams of cocrystals formed by chiral target compounds and candidate cofomers in a particular solvent system is presented, which allows the design of suitable chiral resolution processes. The method is based on saturation temperature measurements of specific solution compositions containing both enantiomers of chiral molecules and a cofomer. This method is applied to analyze three different systems. For racemic phenylalanine (Phe) in water/ethanol mixtures one of the enantiomers selectively cocrystallizes with the opposite enantiomer of valine (Val), forming the more stable diastereomerically related cocrystal. The racemic compound ibuprofen crystallizes with the nonchiral cofomer 1,2-bis(4-pyridyl)ethane (BPN) as racemic compound cocrystals. More interestingly, when it is combined with trans-1-(2-pyridyl)-2-(4-pyridyl)ethylene (BPE), the racemic compound ibuprofen cocrystallizes as a conglomerate, which in principle enables the application of preferential crystallization of this racemic compound. The systematic method shows the benefit of using pseudo-binary phase diagrams. Such pseudo-binary phase diagrams depict the saturation temperature on a very specific route through the quaternary phase diagram, allowing the identification of various cocrystal types as well as the corresponding cocrystallization conditions. The systematic method can be used to identify a suitable solid phase for chiral separation, and the obtained phase diagram information enables the performance of a crystallization-mediated chiral resolution process design. Such a guideline for a chiral resolution process design has never been reported for conglomerate cocrystal systems such as IBU:BPE, presented in this study.

- Hao Su, Paul H. H. Bomans, Heiner Friedrich, Yifei Xu, Nico A. J. M. Sommerdijk, [Crystallization via Oriented Attachment of Nanoclusters with Short- Range Order in Solution](#), *The Journal of Physical Chemistry C* **125** (2021), No. 1, 1143

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- School of Chemistry, University of Leeds, Woodhouse Lane, LS2 9JT, Leeds, U.K.
- Department of Biochemistry, Radboud Institute of Molecular Life Sciences, Radboud University Medical Center, Geert Grooteplein 6525 GA Nijmegen, The Netherlands

The self-assembly of amphiphilic molecules in solution is a ubiquitous process in both natural and synthetic systems. The ability to effectively control the structure and properties of these systems is essential for tuning the quality of their functionality, yet the underlying mechanisms governing the transition from molecules to assemblies have not been fully resolved. Here we describe how amphiphilic self-assembly can be preceded by liquid–liquid phase separation. The assembly of a model block co-polymer system into vesicular structures was probed through a combination of liquid-phase electron microscopy, self-consistent field computations and Gibbs free energy calculations. This analysis shows the formation of polymer-rich liquid droplets that act as a precursor in the bottom-up formation of spherical micelles, which then evolve into vesicles. The liquid–liquid phase separation plays a role in determining the resulting vesicles’ structural properties, such as their size and membrane thickness, and the onset of kinetic traps during self-assembly.

- Mohammad-Amin Moradi, E. Deniz Eren, Massimiliano Chiappini, Sebastian Rzadkiewicz, Maurits Goudzwaard, Mark M. J. van Rijt, Arthur D. A. Keizer, Alexander F. Routh, Marjolein Dijkstra, Gijsbertus de With, Nico A. J. M. Sommerdijk, Heiner Friedrich, Joseph P. Patterson, [Spontaneous organization of supracolloids into three-dimensional structured materials](#), *Nat. Mater.* (2021).

#### Affiliations

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- Institute for Complex Molecular Systems, Eindhoven University of Technology, Eindhoven, The Netherlands
- Laboratory of Physical Chemistry, Department of Chemical Engineering and Chemistry, Eindhoven University of Technology, Eindhoven, The Netherlands
- Soft Condensed Matter, Debye Institute for Nanomaterials Science, Utrecht University, Utrecht, The Netherlands
- Department of Chemical Engineering and Biotechnology, University of Cambridge, Cambridge, UK

Periodic nano- or microscale structures are used to control light, energy and mass transportation. Colloidal organization is the most versatile method used to control nano- and microscale order, and employs either the enthalpy-driven self-assembly of particles at a low concentration or the entropy-driven

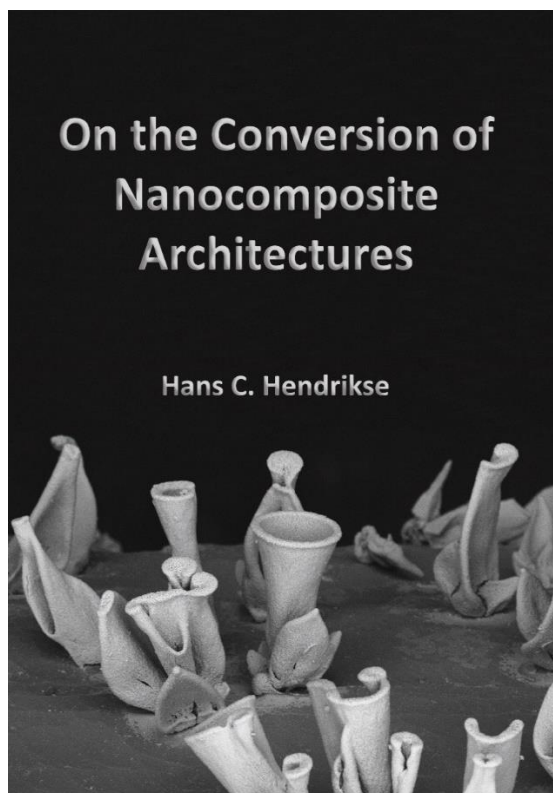
packing of particles at a high concentration. Nonetheless, it cannot yet provide the spontaneous three-dimensional organization of multicomponent particles at a high concentration. Here we combined these two concepts into a single strategy to achieve hierarchical multicomponent materials. We tuned the electrostatic attraction between polymer and silica nanoparticles to create dynamic supracolloids whose components, on drying, reorganize by entropy into three-dimensional structured materials. Cryogenic electron tomography reveals the kinetic pathways, whereas Monte Carlo simulations combined with a kinetic model provide design rules to form the supracolloids and control the kinetic pathways. This approach may be useful to fabricate hierarchical hybrid materials for distinct technological applications.

## PhD thesis

- Hans Hendrikse, On the Conversion of Nanocomposite Architectures  
PhD defense: 26 February 2021, University of Amsterdam, Amsterdam

Promotor: Prof. H.J. Bakker

Co-promotor: Dr. W.L. Noorduin



Imagine if a house would not need effort to be build, but rather assembled on its own. Or if a car would repair itself if it broke down. This might sound like a futuristic perspective, but in nature it is quite a common phenomenon: a chick 'assembles' itself inside an egg without any outside interference, and a broken bone can repair itself over time. What if we could unravel the processes behind this self-assembly and use it to build our own materials?

In this thesis, a bioinspired strategy is used to bring self-assembly processes to man-made materials. In this strategy, barium carbonate ( $\text{BaCO}_3$ ) co-precipitates with silica ( $\text{SiO}_2$ ) to form nanocomposites: a material where nanocrystals of  $\text{BaCO}_3$  are embedded in a supporting matrix of  $\text{SiO}_2$ . These nanocomposites have two particular properties that we exploit in this thesis: First, their shape can be sculpted during the co-precipitation, allowing the overall nanocomposite's architecture to be tailor-made for its intended application. Second, the small size of the  $\text{BaCO}_3$  crystals makes them very reactive, whereas the  $\text{SiO}_2$  gives the nanocomposites mechanical stability. This combination of chemical reactivity and mechanical stability is used here to change the composition of the nanocomposites, where the new composition inherits the shape of the original nanocomposite. This allows for materials suited for specific applications to be sculpted, which is demonstrated in this thesis for materials suitable for catalysis and photovoltaics. Moreover, this thesis shows that the material's inherited shape can boost their performance in their intended application.