ICMS Highlights

Edition 5
October 2015

Sensing with single-molecule resolution

INTERVIEW
/ Dave Mooney

SPINOZA PRIZE FOR RENÉ JANSSEN

INTERVIEW
/ Luc Brunsveld

& more...

Institute for Complex Molecular Systems

TU/e Technische Universiteit Eindhoven University of Technology

Where innovation starts

ICMS Highlights

Dear reader,

ICMS is as strong as its members are. Therefore we are grateful that many excellent scientists have found their way to the Institute and participate in the many activities. In this fifth edition of our magazine, we like to take a moment to highlight some of our members' recent milestones.

Illustrated with an artist impression on the cover is the work of René Janssen. We like to congratulate René with winning the 2015 Spinoza Premium! Congratulations also go to Dick Broer (ERC Advanced Grant) and Ilja Voets (ERC Starting Grant), while NWO has awarded Luc Brunsveld a Vici Grant and both Ilja Voets and Peter Zijlstra a Vidi Grant for their exciting research programs. Patricia Dankers was selected to join The Young Academy. Next to all of this many members benefit from the enormous boost the Minister of Education has given to research groups from Nijmegen, Groningen and Eindhoven with the 27 million euro Gravity Grant for research on Functional Molecular Systems.

The interdisciplinary nature of the work is a common factor between these awardees and grants. Facilitating excellent scientific research outreaching disciplines will thus continue to be our main goal. It is therefore a pleasure that Mikko Karttunen, introduced to you in Edition 4, has now moved his group and started the first collaborations. Finally we welcome Reinder Coehoorn as a full member; he recently started after a long career with Philips Research.

We hope you enjoy reading,

Sagitta Peters
Managing director

Bert Meijer
Scientific director

Calendar

November 6, 2015, 15.00 hr
ICMS Discussion meeting
Location: Ceres

November 20, 2015, 15.00 hr
ICMS Discussion meeting
Location: Ceres

December 4, 2015, 15.00 hr
ICMS Discussion meeting
Location: Ceres

December 14-18, 2015
ICMS/KNAW Complexity Science Winter School
Location: Ceres

January 21 & 22, 2016
ICMS Outreach Symposium including lectures of prof. George Whitesides and prof. Joanna Aizenberg
Location: Zwarte Doos

The complete calendar can be found on our website.

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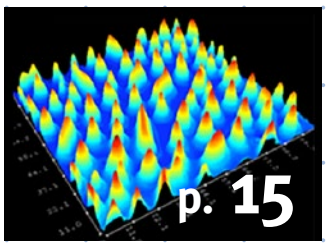
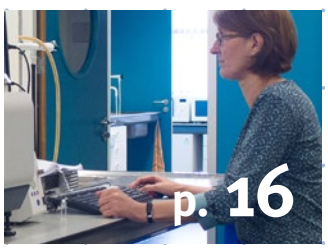
In-situ training center for cancer immunotherapy
An interview with ICMS Distinguished Professor Dave Mooney.

Cover
Artist impression of an artificial leaf inspired by the work of René Janssen

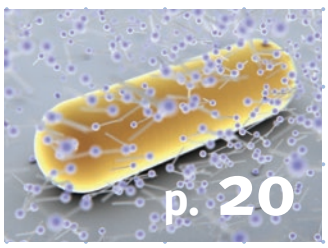
Solving biology's secrets from a chemist's perspective



Digital Holographic Microscopy (DHM)



Folding polymers into enzymes

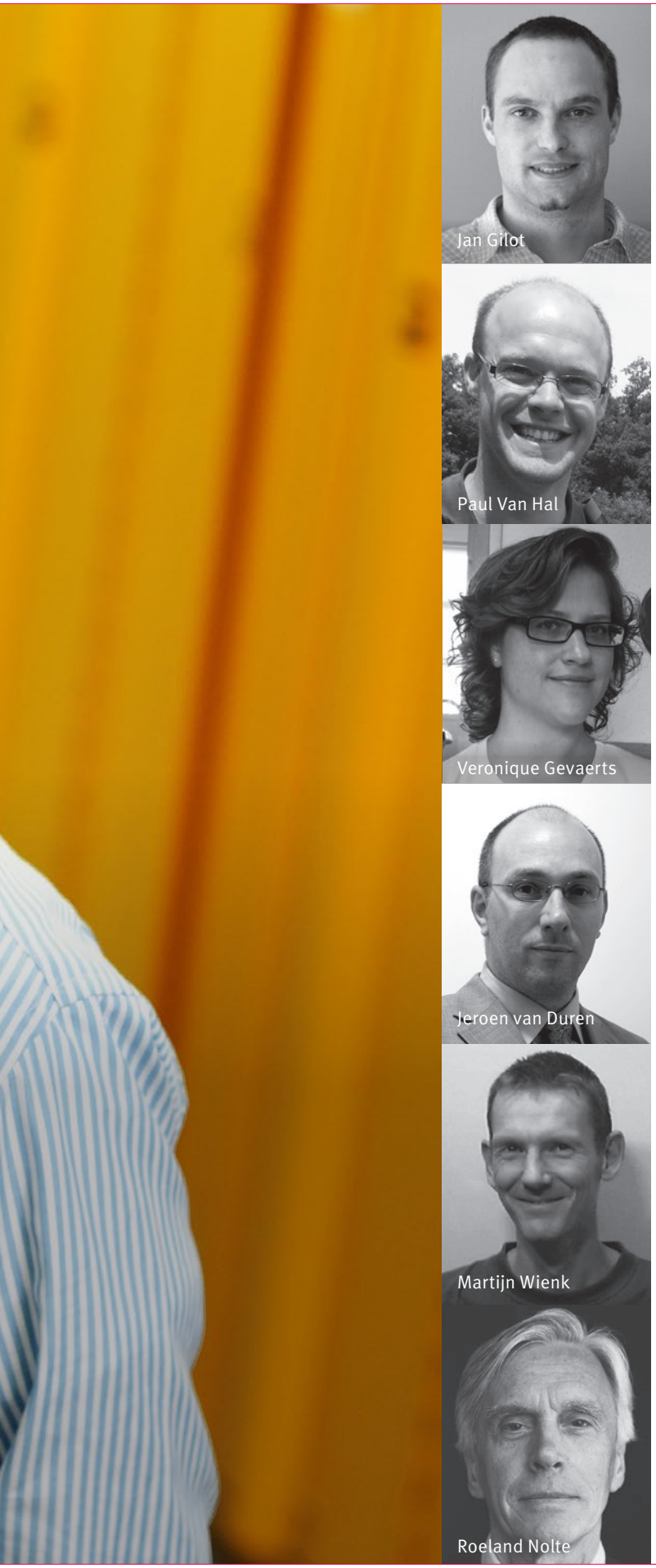


Sensing with single-molecule resolution

/ René Janssen

Spinoza prize winner René Janssen

The Dutch philosopher Baruch Spinoza is considered one of the great rationalists of the seventeenth century. The NWO (Netherlands Organisation for Scientific Research) Spinoza Prize, the highest Dutch award in science, was named in his honour. Also known as the "Dutch Nobel Prize", this award is given to internationally renowned Dutch scientists who are an inspiration for younger scientists. This year, NWO honours René Janssen, professor of Molecular Materials and Nanosystems, for being a world leader in the field of organic solar cells.



Jan Gilot

Paul Van Hal

Veronique Gevaerts

Jeroen van Duren

Martijn Wienk

Roeland Nolte

The successful career remembered through the eyes of some of his past and present collaborators

René Baruch Spinoza Janssen
Spinoza claimed that reality in its complexity is entirely intelligible, and that there is nothing that can be considered incomprehensible a priori. With the powerful yet limited human intellect and the unlimited force of intuition, human beings can reach absolute knowledge in seeking the truth. Instinctively averse to clamour and self-promotion, Spinoza published most of his writings anonymously.

The parallelism with René Janssen is as striking as it is inevitable. “René is one of the most smart, creative and talented organic chemists I have ever met. However, he does not like to be in the spotlight”, says Roeland Nolte, professor of physical-organic and supramolecular chemistry at Radboud University and Janssen’s partner in the ambitious Gravity program on functional molecular systems. Veronique Gevaerts, former PhD student of Janssen in the M_2N group, follows on that: “When I read about René receiving the Spinoza Prize, I immediately thought about the way he would have reacted to it.” Jan Gilot, a cum laude PhD who worked with Janssen on polymer tandem solar cells, knows the answer. In response to Jan’s congratulations for the

> “ALL THINGS EXCELLENT ARE AS DIFFICULT AS THEY ARE RARE
>
> Baruch Spinoza

prestigious personal achievement, René replied: “I realise now more than ever how the contributions of talents like you were crucial in achieving this prize.”

René as a supervisor

Veronique Gevaerts and Jan Gilot still remember their PhDs as some of the best times of their lives, with Janssen being a crucial piece in solving the intricate PhD puzzle. “Every time I was stuck, that was the right moment to knock at the door of René”, says Veronique Gevaerts. “He always knows how to handle his students, and the way he can sink his teeth into something is simply impressive.” Jan Gilot adds: “It was a pity being a PhD student with René for only four years.” It is well known among former PhD students that you can survive the PhD experience once, not twice. Jan Gilot seems to have forgotten it, though. “Some PhD students just do work for their supervisors”, says Martijn Wienk, PhD student with Janssen in 1991 and now assistant professor of macromolecular and organic chemistry at TU/e. “Having René as a supervisor is way more than that. It is constant exchange of views, with good and bad moments shared together, as well as equal goal commitment.” The early stages of Martijn Wienk’s PhD coincided with Janssen’s prolific sabbatical year in Santa Barbara, USA. “In 1992, René had the unique chance to perform his research in the group of Nobel Prize winner Alan J.Heeger. I have lost the count of pioneering papers he wrote in one year only”, says Martijn Wienk. “However, we managed to stay in contact despite his workload, the distance, and an incredibly user-unfriendly e-mail text editor.”

Last but not least, Janssen gives credit to his PhD students, opening up with them new horizons for their future. This was the case of Jeroen van Duren, the first PhD student on solar cells in Janssen’s group and now director of the Advanced Battery team at the Californian company Intermolecular, with 15 years of experience in solar cell thin-films to date. “It was 2004, and together with René we published a study on the interplay between solar cell morphology and performance. That article was cited so many times in such a short time that it raised the attention of the scientific and entrepreneurial audience worldwide. Right before the ending of my PhD,” says Jeroen van Duren “I received an email from a very successful CEO in Silicon Valley with an offer that totally changed my life. Without René and his team, it would have never been possible.”

Searching for the pot of gold at the end of the rainbow

With the impressive result of a 10% increase in the efficiency of converting light energy into electricity, René Janssen’s group has achieved a leading position internationally in the field of thin-film photovoltaic technology.

Jan Gilot, still remembering the brainstorming sessions in hard times: “Big steps were made worldwide in solar cells, but without in-depth understanding and efficiency improvement.” At that time, Jan Gilot was involved in stacking plastic solar cells with different compositions on top of each other, which eventually yielded efficiency improvements by using a broader portion of solar spectrum. “We could either lean comfortably on what the rest of the world was doing,” says Jan Gilot “or take new, challenging routes. We opted for the second option.”

For those that believe last year’s ideas are successful enough, new ideas are not celebrated. But René Janssen believes otherwise. New ideas are vital, with dissatisfaction being an important precursor to successful innovation, as perfectly summarized by his words at the opening of the current academic year: “Excellence is searching for the pot of gold at the end of the rainbow, even while knowing that pot of gold might not be there. Satisfaction is good, but only for few moments.”

Multidisciplinarity

What also makes René Janssen and his research group unique is their philosophy of multidisciplinarity. “If you understand things on a multidisciplinary level, you can become number one”. This is the secret of Janssen’s success for Paul Van Hal, another former PhD student from the M2N talent

pool. Plastic solar cells, and, more recently, solar fuels are important portions of a much broader painting. The fruitful collaboration with ICMS leads to new fascinating research areas that merge traditional chemistry disciplines with the field of bio-inspired engineering. This collaboration brings together a concert of biologists, chemists, and physicists, with René being the director of the orchestra.

The funny side of research

Although science has always been a serious endeavour, Janssen had always found room for joking around. “In 1993, during the first year of my PhD”, says John Van Haare “the group organized three days off to visit DSM and the south of Germany. I still remember this cabaret show we attended, and the whole team stayed up very late. At 5 am René hastily went back to his hotel room, no one knew to do what. He had prepared breakfasts for all the ladies of the group, and at 6am he was ready for the service.” Or in the case of the long-lasting collaboration with Bert Meijer, professor of Organic Chemistry at TU/e, who is as different as he is close to Janssen. His first “explosive” meeting with Janssen is still engraved in Meijer’s memory. “It was quite some time ago, in 1991, on the occasion of the Open Day at TU/e”, says Bert Meijer. “I was a possible candidate for a full professorship at TU/e, and I went to visit the laboratory of molecular chemistry, which René was in charge of. René was demonstrating small experiments to the audience, having a student perform the biggest explosion just as I stepped in.” Coincidence perhaps, or maybe premonitory sign of their still ongoing Monday morning diatribes about soccer. “René is an outstanding scientist, but he has no idea about what constitutes good soccer. But as a colleague, I cannot dream of someone better.”

/ Luc Brunsveld

Solving biology's secrets from a chemist's perspective

Diseases always have a molecular cause. Chemical knowledge is needed to understand biological problems such as the development of tumors. In his research, prof.dr.ir. Luc Brunsveld uses chemical biology approaches to study protein-protein interactions involved in disease development. "The goal in this field of research would be to invent a molecule that aids in medical diagnosis or treatment of diseases like cancer."

Working in circles. It sounds futile, but it's the way the research of Luc Brunsveld is pushed forward. Brunsveld is professor of chemical biology in the Department of Biomedical Engineering at TU/e. In chemical biology, the driving force behind research is a biological or biomedical question, as he explains. "First, we translate this biological question into a molecular definition of the problem in order to unravel the molecules, proteins and materials that play a role in disease development. Then we try to bring forward a chemical solution for the molecular question by making new molecules." Those molecules close the circle by intervening in the initial biological disease process. "The inspiration for our research is very oriented in drug discovery. But we have to take a big step back to the fundamental level in order to understand what's going so that we can eventually work towards an application."

Chemistry in the kitchen

Where does Brunsveld's affinity for chemistry come from in the first place? "I was always fascinated by inventing and putting ingredients together to make something new", says Brunsveld. "My father and my grandfather were bakers. Since I was twelve years old, I spent every free hour in my father's bakery. As a baker, you bring ingredients together all the time to make potable products. In fact, cooking and baking are a continuous series of reactions. You might say my taste for assembling chemical products was kindled at an early age."

Today, the biological questions focus on two classes of proteins: nuclear receptors, like the estrogen receptor, and caspases, which have the ability to bind to many functionally diverse signaling proteins.

Last year, Brunsveld's group wrapped up a project studying the phosphorylation of the estrogen receptor. This process is involved in chemotherapy resistance, especially in breast cancer. There is a lot of biological knowledge on the subject, but what happens at the molecular level is relatively unknown. "We know that there is a higher degree of phosphorylation in breast cancer, but that's it", says Brunsveld. "Figuring out what happens at the protein level might give us new clues on how to intervene. The ultimate aim is to make small molecules that switch such a phosphorylation process on or off. Together with assistant professor Lech Milroy in our group, we are taking interesting steps here. It is my dream to develop a molecule that will aid in the treatment of a disease. Our collaborations with the departments of Clinical Chemistry at the Catharina Hospital and Maxima Medical Centre will hopefully accelerate the translation of our results. But I am realistic, not many people succeed in developing a medical molecule. Annually, only twenty to thirty new molecules reach the market."

Molecular phenomena

Not all molecules that Brunsveld and his colleagues make act as intervening agents. Sometimes small molecules just help in figuring out why some things happen at the molecular level in a cell, according to Brunsveld. For example, together with associate professor Christian Ottmann, Brunsveld's group makes use of molecular scaffolds such as cucurbituril and 14-3-3 proteins to artificially switch caspase proteins on and off. However, these proteins do also have a natural role in the cell that is worth studying. Brunsveld: "One of the research topics we're working on with Christian Ottmann concerns the role of these proteins in cystic fibrosis. Compared to breast cancer, the clinical aspects of this disease couldn't be more different. But translate the biomedical challenges concerning cystic fibrosis into a molecular problem and these two diseases suddenly start to look alike. Both have to do with protein interactions and phosphorylation events. The molecular phenomena are always the same."

Matters to digest

In science, it usually takes a while before scoring the so-called 'goal'. How to stay motivated? You must learn to appreciate the little triumphs along the way, Brunsveld thinks. "For example, it motivates me when someone at my lab performed an experiment and was able to realize something intriguing from that. Sometimes students put steps forward in a certain direction based on those new insights. That fills me with satisfaction."

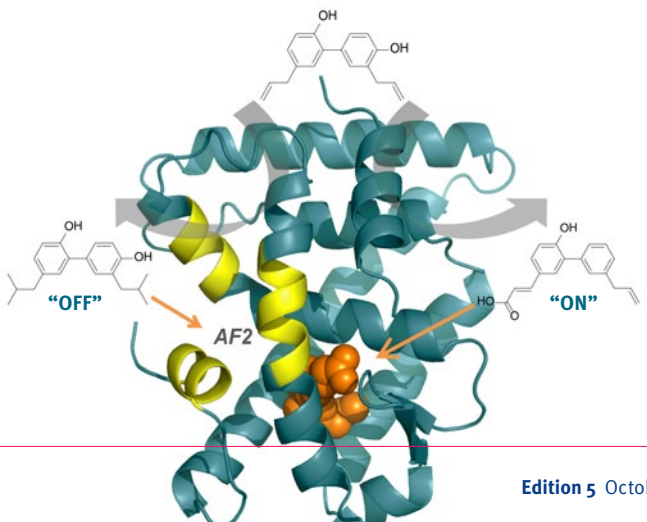
To deal with the occasional frustrations, Brunsveld likes to put on his running shoes and go for a run around the block. "So far, running a few miles never led to truly inspiring ideas for my research. But it gives me the opportunity to clear my head and to digest some matters."

More about this research

I.M. Tharun, L. Nieto, C. Haase, M. Scheepstra, M. Balk, S. Möcklinghoff, W. Adriaens, S.A. Dames, L. Brunsveld (2014). ACS Chem. Biol., 10, 475

M. Scheepstra, L. Nieto, A.K.H. Hirsch, S. Fuchs, S. Leysen, C.V. Lam, L. in het Panhuis, A. A. van Boeckel, H. Wienk, R. Boelens, C. Ottmann, L. Milroy, L. Brunsveld (2014). Angew. Chem., 53, 6443

D.T. Dang, H.D. Nguyen, M. Merkx, L. Brunsveld (2013). Angew. Chem., 52, 2915



/ David Mooney

In-situ train for canc immuno

"I am an engineer. Once you know the parts, you can start exploring how to use them and drive the outcomes that you want." These are the pragmatic words of professor Dave Mooney, one of the founding fathers and Core Faculty Member of the Wyss Institute for Biologically Inspired Engineering at Harvard University. Last spring, Dave Mooney visited the ICMS as Distinguished Professor presenting a number of lectures, and exploring bio-engineering approaches with the researchers at the institute.

Dave Mooney: "A couple of years ago I met Frank Baaijens through a Dutch research program, which gave me the opportunity to see a lot of the biomaterials research being done in the Netherlands. This spring he asked me to come and visit the ICMS. A nice chance that I grabbed enthusiastically. I have met a lot of people during my visit and learned about the strategies they use and the materials they are developing. I have seen some amazing things!

In return I gave a series of lectures on my vision and current work in bio-engineering. The common theme I am working on, is the utilization of biomaterials to regulate cell behaviour in the human body. With the team, we work, among others, on cancer vaccines, musculoskeletal regeneration strategies, and mechanotransduction research. Our ultimate goal is to make cell therapies more effective. With the use of biomaterials we are trying to influence the trafficking of cells so we can induce them to perform regeneration of cells/tissue or to drive immune cell behaviour to destroy tumours or other undesirable cell masses.

We are currently progressing in the translation of this research into an application that can be seen as a training center, teaching cells to counter specific forms of cancer. In general terms, it works as follows. Cancer cells are mutated, which makes them different from normal

cells. We try to enable the immune system to better recognize and respond to those differences. Therefore we place a small polymer depot - the size of an aspirin tablet - under the skin. This device attracts one particular kind of immune cell, the dendritic cell. Once inside the device, we have the advantage to be able to completely control the environment of these cells. First, we start to provide fragments of the tumour cells to them: so they can 'see' what's different about them. To further enhance a favourable outcome we stimulate the dendritic cells simultaneously with signals that mimic bacterial or viral infection. The cells start to associate these signals with the tumour cell fragments. The trained cells then leave the depot and travel to the lymph node where they 'talk' to T-cells, let's say the soldiers of our immune system. Once the instructions are passed, the T-cells take-off into the body to attack the tumour.

This application is currently in a clinical trial and nine patients have been treated to date. So these are very exciting times to me. With the immunotherapy approach we found, we are already thinking ahead. It might be possible to apply the strategy for the treatment of other diseases such as infectious diseases, autoimmune disease and diverse regenerative medicine applications."

Interested in Mooney's work?
See: **mooneylab.seas.harvard.edu**

ICMS TOP PUBLICATIONS

May 2015 – September 2015

1. *A. van Reenen, A.M. de Jong, M.W.J. Prins*
Transportation, dispersion and ordering of dense colloidal assemblies by magnetic interfacial rotaphoresis
Lab Chip 15, 2864-2871 (2015)

2. *M.B. Baker, L. Albertazzi, I.K. Voets, C.M.A. Leenders, A.R.A. Palmans, G.M. Pavan, E.W. Meijer*
Consequences of chirality on the dynamics of a water-soluble supramolecular polymer
Nat. Commun. 6, 6234 (2015)

3. *J.J.M. Lenders, H.R. Zope, A. Yamagishi, P.H.H. Bomans, A. Arakaki, A. Kros, G. de With, N.A.J.M. Sommerdijk*
Bioinspired magnetic crystallization directed by random copolypeptides
Adv. Funct. Mat. 25, 711-719 (2015)

4. *B.E. McKenzie, H. Friedrich, M.J.M. Wirix, J.F. de Visser, O.R. Monagham, P.H.H. Bomans, F. Nudelman, S.J. Holder, N.A.J.M. Sommerdijk*
Controlling internal pore sizes in bicontinuous polymeric nanopheres
Angew. Chem. Int. Ed. 54, 2457-2461 (2015)

5. *S. Cantekin, A.J. Markvoort, J.A.A.W. Elemans, A.E. Rowan, R.J.M. Nolte*
Allosterically controlled threading of polymers through macrocyclic dimers
J. Am. Chem. Soc. 137, 3915–3923 (2015)

6. *D. Liu, P.R. Onck, D.J. Broer*
Reverse switching of surface roughness in a self-organized polydomain liquid crystal coating
Proc. Natl. Acad. Sci. U.S.A. 112, 3880-3885 (2015)

7. *W.G. Ellenbroek, V.F. Hagh, A. Kumar, M.F. Thorpe, M. van Hecke*
Rigidity loss in disordered systems: three scenarios
Phys. Rev. Lett. 114, 135501 (2015)

8. *M.A. Beuwer, M.W.J. Prins, P. Zijlstra*
Stochastic protein interactions monitored by hundreds of single-molecule plasmonic biosensors
Nano Lett. 15, 3507-3511 (2015)

9. *S. Grundner, M.A.C. Markovits, G. Li, M. Tromp, E.A. Pidko, E.J.M. Hensen, A. Jentys, M. Sanchez-Sanchez, J.A. Lercher*
Single-site trinuclear copper oxygen clusters in mordenite for selective conversion of methane to methanol
Nat. Commun. 6, 7546 (2015)

10. *N. Hosono, A.M. Kushner, J. Chung, A.R.A. Palmans, Z.B. Guan, E.W. Meijer*
Forced unfolding of single-chaing polymeric nanoparticles
J. Am. Chem. Soc. 137, 6880-6888 (2015)

11. *G.A. Filonenko, M.J.B. Aguila, E.N. Schulpen, R. van Putten, J. Wiecko, C. Muller, L. Lefort, E.J.M. Hensen, E.A. Pidko*
Bis-N-heterocyclic carbene aminopincer ligands enable high activity in ru-catalyzed ester hydrogenation
J. Am. Chem. Soc. 137, 7620-7623 (2015)

12. *D. van der Zwaag, T.F.A. de Greef, E.W. Meijer*
Programmable supramolecular polymerizations
Angew. Chem. Int. Ed. 54, 8334-8336 (2015)

13. *J.J. De Yoreo, P.U.P.A. Gilbert, N.A.J.M. Sommerdijk, R.L. Penn, S. Whitelam, D. Joester, H.Z. Zhang, J.D. Rimer, A. Navrotsky, J.F. Banfield, A.F. Wallace, F.M. Michel, F.C. Meldrum, H. Colfen, P.M. Dove*
Crystallization by particle attachment in synthetic, biogenic, and geologic environments
Science 349, 498 (2015)

14. *J.J. van Franeker, S. Kouijzer, X.W. Lou, M. Turbiez, M.M. Wienk, R.A.J. Janssen*
Depositing fullerenes in swollen polymer layers via sequential processing of organic solar cells
Adv. Energy Mater. 5, 1500464 (2015)

15. *D. Liu, D.J. Broer*
New insights into photoactivated volume generation boost surface morphing in liquid crystal coatings
Nat. Commun. 6, 8334 (2015)

16. *R. Timmreck, T. Meyer, J. Gilot, H. Seifert, T. Mueller, A. Furlan, M.M. Wienk, D. Wynands, J. Hohl-Ebinger, W. Warta, R.A.J. Janssen, M. Riede, K. Leo*
Characterization of tandem organic solar cells
Nature Photonics 9, 478-479 (2015)

17. *C.H. Duan, A. Furlan, J.J. van Franeker, R.E.M. Willems, M.M. Wienk, R.A.J. Janssen*
Wide-bandgap benzodithiophene-benzothiadiazole copolymers for highly efficient multijunction polymer solar cells
Adv. Mater. 27, 4461-4468 (2015)

18. *D. van der Zwaag, E.W. Meijer*
Self-organization. Fueling connections between chemistry and biology
Science 349, 1056-1057 (2015)

19. *Y. Gao, J. Beerens, A. van Reenen, M.A. Hulsen, A.M. de Jong, M.W.J. Prins, J.M.J. den Toonder*
Strong vortical flows generated by the collective motion of magnetic particle chains rotating in a fluid cell
Lab Chip 15, 351-360 (2015)

20. *J.E. Stumpel, E.R. Gil, A.B. Spoelstra, C.W.M. Bastiaansen, D.J. Broer, A.P.H.J. Schenning*
Stimuli-responsive materials based on interpenetrating polymer liquid crystal hydrogel
Adv. Funct. Mater. 25, 3314-3320 (2015)

This overview lists publications in high end journals with ICMS as affiliation.

NEWS, AWARDS & GRANTS

ICMS Fellowship for

DANQING LIU

Because of her excellent scientific track record in an interdisciplinary field of science and engineering, dr. Danqing Liu has been awarded an ICMS Fellowship. The ICMS Fellowship will support her during the next three years as a step towards an independent academic career. Danqing works in the field of functional polymers. Specifically, she studies dynamic surface topographies.

CHRISTIAN OTTMANN AND NATAL VAN RIEL

receive European grants

Dr. Christian Ottmann and dr.ir. Natal van Riel both received a European grant from the Marie Curie program of Horizon 2020. The consortium, coordinated by Christian Ottmann, received 3.3 million euros for research into a new type of medical molecule and accompanying research method. Natal van Riel is part of a consortium that investigates the effect of ageing and lifestyle on metabolism in skeletal muscle.

Taminco Green Footsteps Award 2015 for

GEORGY FILONENKO

Former ICMS PhD student dr. Georgy Filonenko has been selected as winner of the 2015 Taminco Green Footsteps Award for his paper in the category 'Manufacturing and Applications of Carboxylic Acids'. The paper was entitled "Hydrogenation of Carbon Dioxide to Formates: Curiosity-Driven Development of a Highly Active Catalyst". A prize of € 500 came with the award as well as the possibility to present his work to the Taminco-Eastman innovation team. Georgy Filonenko's dissertation On the Catalytic Hydrogenation of CO_2 and Carboxylic Acid Esters received the distinction cum laude.

NICO SOMMERDIJK

wins the 2015 Soft Matter and Biophysical Chemistry Award

The Royal Society of Chemistry (RSC) has awarded prof. dr. Nico Sommerdijk the 2015 Soft Matter and Biophysical Chemistry Award. Nico Sommerdijk received this award for his seminal contributions towards a mechanistic molecular-scale understanding of macromolecular assembly and biomineral formation.

TRAVIS BAILEY AND JIM DE YOREO AT ICMS

It was a great honor to welcome two renowned guest scientists to the ICMS this fall. Dr. Travis Bailey is a professor in the Department of Chemical and Biological Engineering at Colorado State University. His research interests focus on the thermodynamics of nanoscale self-assembly processes in block copolymer composite materials and their applications in a variety of environments. Travis Bailey's visit is part of the Inter-Country Travel Grant Program of the U.S. Fulbright Scholars 2015-2016 and he will be at ICMS during this academic year.

Dr. Jim De Yoreo is Chief Scientist for Materials Synthesis and Simulation Across Scales at Pacific Northwest National Laboratory (PNNL) and an Affiliate Professor of Materials Science and Engineering at the University of Washington. The research interests of his group can be broadly categorized as understanding and manipulating the physics of interactions and assembly at solid-liquid interfaces in nanoscale, biological, biomimetic, and environmental systems. The primary techniques used in support of this work are in situ scanned probe microscopy and in situ transmission electron microscopy (TEM), in combination with theoretical analysis. Jim De Yoreo is at the ICMS this fall.

Theirs visits are a great opportunity to discuss the most recent progress in two important areas of science.

SENSUS

student competition goes live

SensUs is the first international student competition on molecular biosensors for healthcare applications. It was developed by prof.dr.ir. Menno Prins together with TU/e honors students. To stimulate the development of technologies in the field of molecular biosensing, the SensUs competition brings together talented young people from different scientific disciplines and countries. The technical challenge to be addressed, in particular the biomarker and the sample matrix, will be announced in January 2016. All participating teams will convene in Eindhoven and will demonstrate their biosensing systems during the contest days in September 2016. Students from University of Leuven, Imperial College London, Uppsala University, Danish Technical University, and Eindhoven University of Technology can participate. SensUs 2016 is a pilot year with a limited number of universities participating; more universities will be able to join in 2017.

Interested? See **www.sensus.org**

OPENING OF MICROFAB LAB

at Eindhoven University of Technology

Rector prof.dr.ir. Frank Baaijens and the Mayor of Eindhoven, Rob van Gijzel, have officially opened the new Microfab lab on Wednesday, July 1st. This state-of-the-art laboratory enables researchers and students to use advanced microfabrication facilities, and to produce microsystems for use in research and education. One of the key goals is the development of technology for organs-on-a-chip by bringing together engineers, cell biologists, and medical researchers in the lab. The lab measures around 700 square meters, and is the best equipped facility of its kind in the Netherlands.

Digital Holographic Microscopy (DHM)

3D Real-Time Optical Imaging at the Nanometer Scale

Surfaces with well-controlled, non-flat topologies are relevant to applications ranging from optics to mechanics to air/hydro dynamics. Researchers in the ICMS are interested in making dynamic (sub)-micro sized surface topographies. The surface structures can be switched 'on' and 'off' by external means (e.g., light and electric fields) at frequencies ranging from several to a hundred Hertz.

Watch our recording of a real-time deformation of the sample:
youtu.be/T5klQYQCZgo

Background

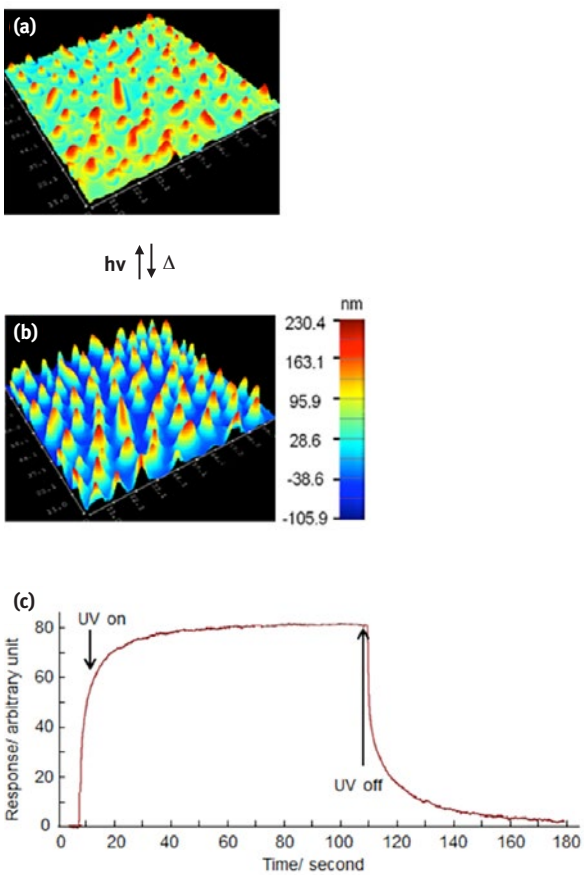
One of the key challenges is how to visualize and characterize dynamics of the surface topographies on the time scales of interest. Conventionally, three dimensional measurements can be performed by AFM (atomic force microscopy), interferometers, and other scanning microscopes. However, the major limitation for all these methods is that the time required for the measurements is on the order of minutes because of scanning mode principles. Moreover, integrating an external light illumination during the measurement is not practical in these equipment setups.

Therefore, we are looking for a method that enables time resolved 3D surface measurements in a non-contact, non-scanning manner. The Digital Holographic Microsopy (DHM) has the possibility to perform real-time measurements while keeping the vertical resolution to the nanometer range.

The DHM captures the hologram of the sample surface. In contrast to other techniques, neither vertical nor lateral scanning is necessary. The time to capture one hologram is micro-seconds. The capture of only one single hologram is sufficient to record all the information pertaining to the sample.

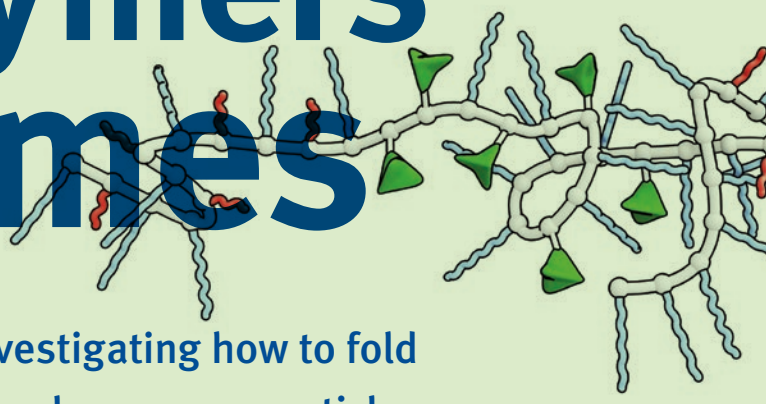
Dynamic observations

An example of measuring surface deformation of a fingerprint sample is shown here. It is based on a chiral-nematic liquid crystal polymer network in which the molecular helix axis orients parallel to the substrate. The in-activated coating has a rather flat surface (see (a)). When actuated, protrusions form where the molecules are aligned parallel to the surface, and depressions form where the molecules are orientated perpendicular to the surface (see (b)). The dynamics of the height change upon actuation, and the subsequent relaxation is monitored as a function of time (see (c)).



/ Anja Palmans

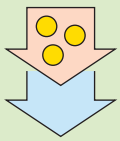
Folding polymers into enzymes

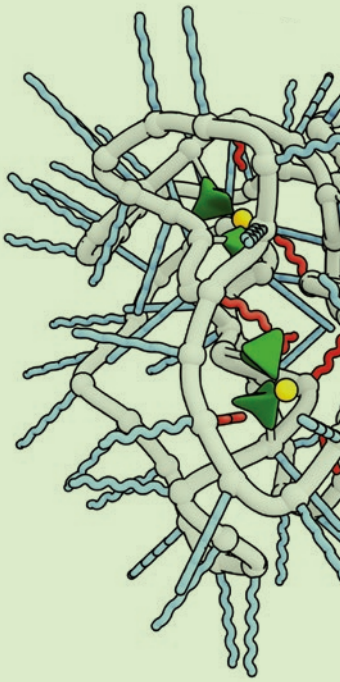


Anja Palmans is a molecular chemist investigating how to fold single polymer chains into single chain polymer nanoparticles that can mimic the functions of an enzyme. This research has potential applications in the fields of chemical processing and targeted drug delivery.

Palmans likes to be in the practical course laboratory

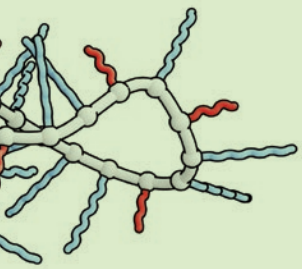
"I want to understand how something works on a fundamental level. If you achieve fundamental understanding of a system, you can then extend or improve it. To see how far you can then push such a system, that is what I like to do. I'm not a scientist that wants to improve the world, but I think I do contribute a little bit by teaching."

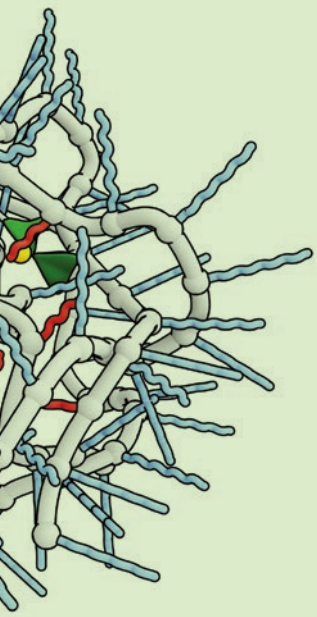




"What fascinates me about enzymes," says Palmans, "is the origin of their activity and selectivity. At some point, we came up with the idea of folding synthetic polymers in a particular way and to give them catalytic properties. I was curious if such a precisely folded polymer could afford catalysts that rival those that occur in nature."

Palmans' research specifically focuses on the folding of hydrophilic polymers. "In my opinion, water is more elegant than organic media. I think it is more useful as well, especially if you want to combine it with natural enzymes that work preferentially in water. In the long term, hydrophilic polymers are advantageous for applications envisaged inside living cells. Besides accelerating chemical processes, there is another





advantage to the folded polymeric catalysts Palmans is developing. Because these polymers are significantly larger than the molecules they convert, it is very easy to separate them for re-use.

ICMS

Palmans: "It is crucial to work in an interdisciplinary environment. To construct synthetic enzymes, you need so much more than what chemistry alone can offer. For example, you also need mathematicians to compose models of the folding processes that enable a deeper understanding. That way, you can better predict the effect one specific mutation will have on the catalytic properties. Hereby, our research can become more focused and will give results faster."

"Working in an interdisciplinary environments means," continues Palmans, "that your own limitations are not restrictive to the research anymore. My weak point can be someone else's strong point. In that way, you move forward more quickly."

Control

In the process of constructing synthetic enzymes, the length of the polymer chain and the order of the elements in the chain are very important. These conditions give the resulting synthetic enzyme its characteristic properties. Palmans: "It is inherent to the synthesis of natural enzymes that they have one specific chain length and exact control of the location of the monomer units along the chain. Perfect control over both the length and the sequence of a synthetic polymer is therefore also crucial to producing the perfect synthetic enzyme. If we achieve length and sequence control during the preparation of the synthetic polymer, " continues Palmans, "we know exactly where each functional group is located. The idea is that by making such perfectly controlled polymers, they will show more reproducible and better defined properties." Because of the wide range of possible implementations, Palmans and her colleagues recently received a European ITN-grant to fund this research.

Surprise

The production of polymers with a specific length is going as planned, but that is not how science always works. Sometimes, you are surprised with how something turns out, Palmans experienced. "We replaced the amide bonds in a small molecule with a different bond to see how this affected the aggregation behaviour of that specific molecule. Well, that turned out to be much smaller than expected."

"However," continues Palmans smiling, "a Spanish postdoc, Miguel García, wondered if those newly made molecules could have ferroelectric properties. Ferroelectric materials show a permanent electric polarization. These materials are applied in for example, memory devices. Palmans: "I don't even remember why he looked into that, but it turned out that the measured polarization value represented the highest response achieved for organic ferroelectric materials to date!"

Serendipity

Palmans acknowledges that many research projects are working towards a goal via predetermined schemes, but it is important to her that serendipity is not excluded from science. "Most of the revolutionary inventions were actually mistakes: someone put the wrong things together but was intelligent enough to investigate what happened."

"That is why it is important to have young people working in science," continues Palmans. "They don't have biases on what will work and what will not. The younger you are, the less biased you are and the higher chances you have of stumbling upon something interesting." This is why Palmans emphasizes the importance of not ruling out serendipity in research funding.

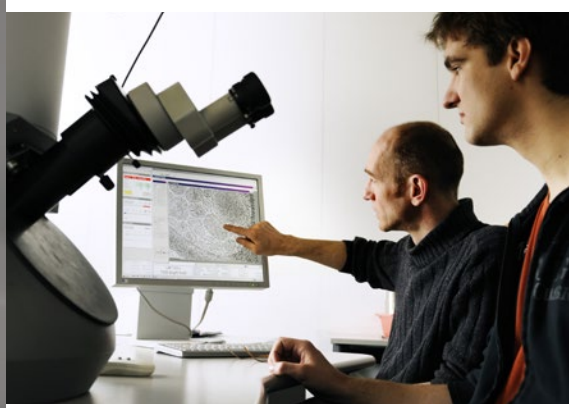
Education

Palmans is not only a scientist, she teaches as well. She gives several classes and a practical course to students at the TU/e. "I love to see how fast the students go through a gigantic learning curve. When they first start with the practical course," explains Palmans, "they don't know how to start an experiment. Or they do start, but it goes completely wrong. After a couple of weeks, they know exactly what to do. I love seeing that process."

Palmans is teaching her students not only how to perform practical work, but also how to think critically. "In the beginning, they take everything you say for granted. The moment they ask me 'is that really the case?', is my highlight of the practical course."

EPL Update

EPL groups successful in 3TU.HTM call

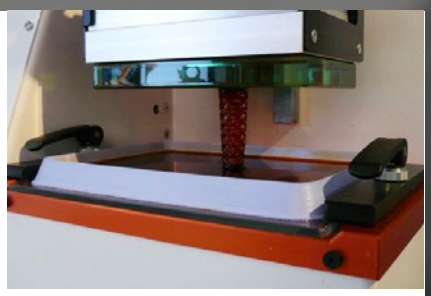


Three proposals from the EPL research groups at the Eindhoven University of Technology have received funding in the recent call “New horizons in designer materials,” which is organized by the 3TU Research Centre High-Tech Materials. This call aims to support research projects that are expected to lead to new research lines in materials science and engineering at the three Dutch universities of technology.

The three EPL projects are: Danqing Liu - Communicating surfaces; Nico Sommerdijk - Structure formation in hierarchical hybrid materials through in situ liquid phase microscopies; and Kees Storm and Wouter Ellenbroek - Reversible crosslinking: a potent paradigm for designer materials. The research will be performed by talented postdocs with tenure-track potential. A special feature of the 3TU program is that postdocs will work in close collaboration with an internationally renowned expert in their respective fields. These experts will spend significant time as visiting scientists at the respective host institutes.

The entire program, which consists of six projects across the three technical universities, has officially started with a kick-off meeting on October 6 in Utrecht, where the projects were introduced by their applicants. The keynote lecture was given by Costantino Creton (ESPCI ParisTech), who will collaborate with Storm and Ellenbroek.

EPL researchers focus on improved properties for additive manufacturing



Researchers from the Eindhoven Polymer Laboratories (EPL) started working on new research topics in the area of additive manufacturing (AM) with partners from TNO and Brightlands Materials Center (BMC). Additive manufacturing, or 3D printing as used as a hype description, is advertised as the new processing route that is expected to enable key benefits for industrial high tech, embedded electronics and a wide variety of medical applications.

Global trends show opportunities for small scale and flexible production, but also personalized manufacturing like hearing aids, dental prostheses, medical implants. Despite some of the success stories, AM technology is still in its infancy and major challenges are to drastically improve biocompatibility, mechanical and thermal properties (impact strength, life time properties) etc. New trends also require the use of multi materials that bring functionality.

Photocurable AM materials

Within EPL a group of PhD students will work on photocurable AM materials for 3D printing. They will study the relation between the chemistry (cross-linking, selection of monomers, double bonds) of photo-polymers and the final, after 3D printing, resulting mechanical properties (impact strength, fracture toughness, failure tensile stress). Layer-to-layer adhesion might be improved by using reactive copolymers, non-covalent and dynamic/reversible covalent network formation. Any of these can include stimuli-responsive building blocks. UV curable end functional polymers are used to modify flow properties and/or morphology formation: for example by using hyper branched, comb and block copolymers. Other targets are to increase the temperature resistance of AM polymers and to increase the chemical resistance against acids, bases, organic solvents.

Thermal AM materials

Another set of projects is defined in the area of thermal AM materials (Selective Laser Sintering) with focus on improved mechanical, chemical and other functional properties. The viscous sintering of individual drops is studied as a model problem, but using realistic viscoelastic rheological properties, the presence of particles and non-isothermal effects. The general goal is to increase the structural integrity of the bed by the reduction of the porosity and control of interfacial properties. The use of functional polymer particles of different core-shell morphologies will be considered (e.g. lower Tg shell and higher Tg core), possibly containing inorganic fillers (e.g. TiO2, magnetite).

FACTS

At this moment more than

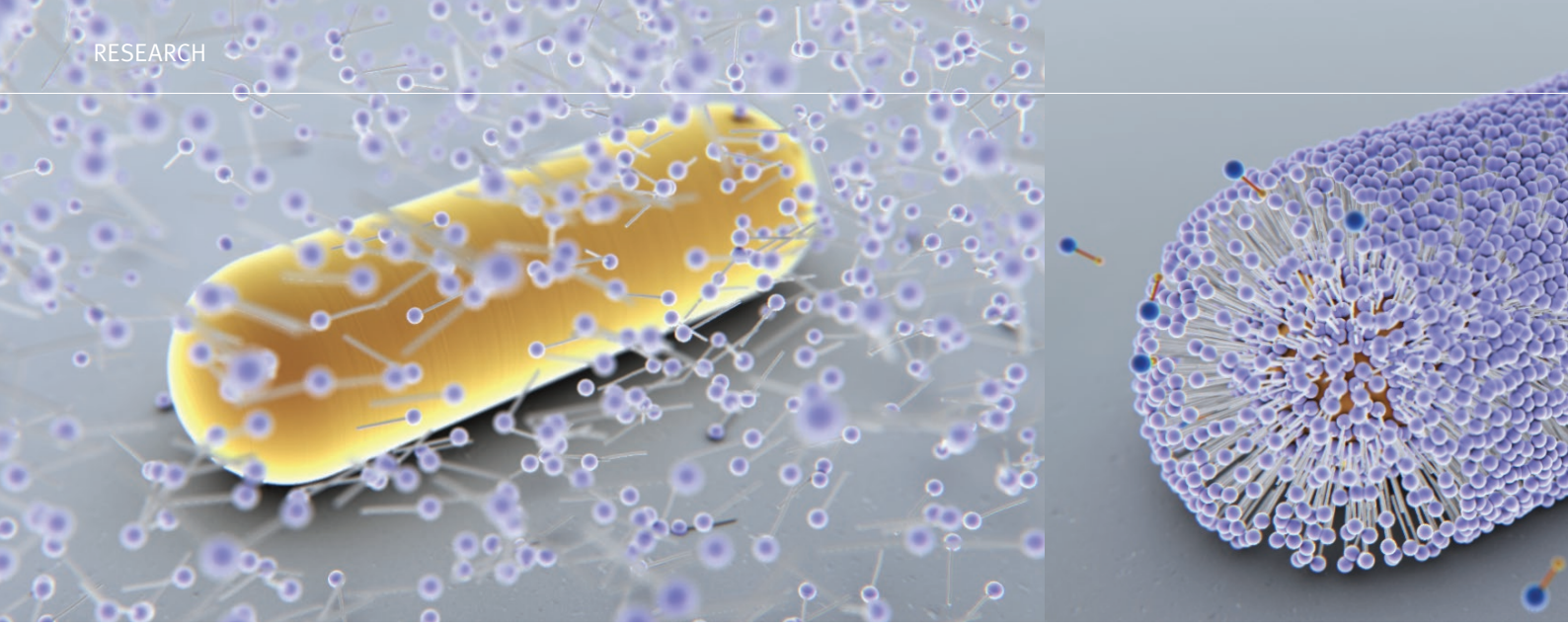
ten million hearing aids

are priced via additive manufacturing.

The global 3D printing market is expected to reach

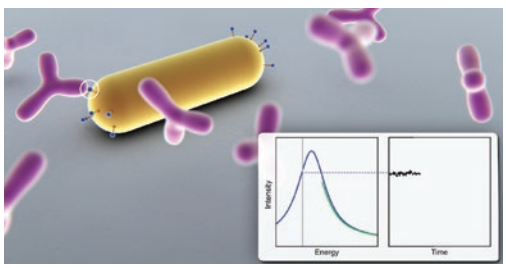
8.6 billion dollar

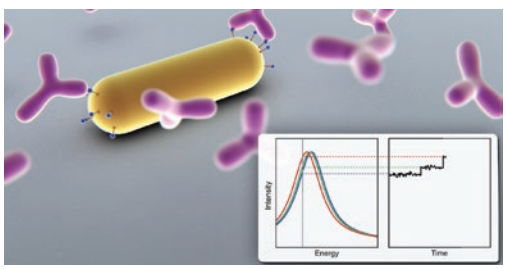
by 2020.



Sensing with single-molecule resolution

In living systems a wealth of dynamic molecular processes are active. A very challenging goal is to develop technologies that would allow the real-time monitoring of such dynamic molecular processes, at the fundamental resolution limit of biology, namely at the level of single molecules.

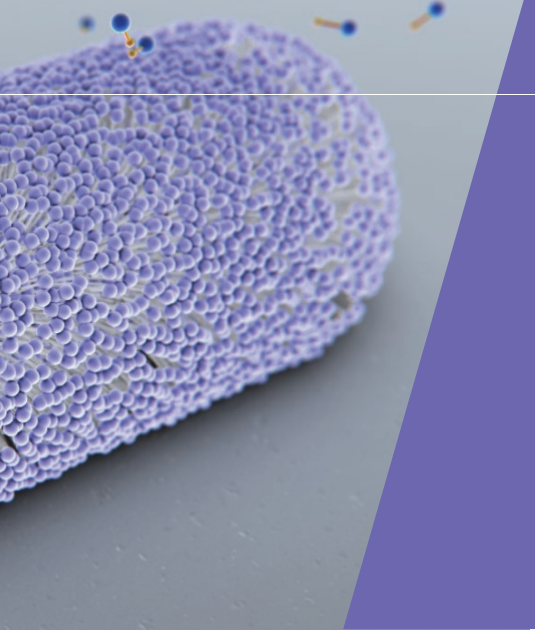




Single-molecule sensors have advantages over traditional ensemble averaged sensors because they give insight into distributions of molecular properties instead of just averages. Knowing the differences between individual molecules (i.e. the heterogeneity of the sample) is especially advantageous in heterogeneous samples such as blood, saliva and other bodily fluids. These samples contain large numbers of different proteins, small molecules, and other cellular structures. Single-molecule resolution would then for example allow for the isolation of specific interactions among a background of non-specific interactions that typically exhibit different characteristics.

Single molecule detection

Different techniques have emerged in the past decades that allow for the detection of single molecules. The most used technique is perhaps fluorescence microscopy in which specific molecules are chemically modified with a dye and subsequently detected in a



"Biological processes need to be ***understood*** from the behavior of their basic building blocks: **single molecules** within their **COMPLEX BIOLOGICAL ENVIRONMENT.** Plasmon ***enhanced detection*** will be one of the avenues to achieve this."

Watch our computer animation: **youtu.be/HCdMXhvRD9A**

microscope. The advantage of fluorescence microscopy is that the contrast in the images is high, but the drawback is that it requires chemical modification of the molecule to be detected. Chemical modification is not an easy feat and requires new labelling techniques to be developed for different species. This is not needed in label-free detection techniques, which have emerged in the past decade. Label-free techniques with single-molecule resolution can be built around for example carbon nanotubes or nanopores.

Plasmon resonance

Peter Zijlstra and colleagues work on a different approach for the label-free detection of single molecules that is based on plasmon resonances in metal nanoparticles. A plasmon resonance is the coherent oscillation of the conduction electrons in a metal nanoparticle in response to impinging light, which gives the particles a strong color. This phenomenon has been used unknowingly already in Roman times to color glass, prime examples are the Lycurgus cup in the British Museum in London and the red parts in church windows.

The color of these metallic particles not only depends on the material they are made of and their shape, but also on the local environment of the particle. Plasmon sensors can thus be used to detect the binding and unbinding of biomolecules by measuring tiny color changes in an optical microscope. We managed to measure the color changes of individual gold nanorods induced by the binding of a single protein. This sensing technique does not require any labelling of the analyte, and can in principle be used to detect any molecule by functionalizing the nanoparticle with receptors.

Applications

The fact that we can now measure distributions of molecular properties and thus quantify the heterogeneity will allow us to study single molecules in a complex environment. This is one of the aims of the ICMS, and we closely collaborate with other researchers in the institute on the functionalization of nanoparticles and the study of single enzymes and single supramolecular polymers.

In the future we hope that these collaborations will lead to breakthrough insights into the effects of complexity on single-molecule interactions. From an application perspective the techniques that we develop can lead to more sensitive and more specific biosensors that may form the basis of future diagnostic platforms.

More about this research

T. Ha, P. Tinnefeld, Annu. Rev. Phys. Chem. 63, 595-617 (2012)

M.A. Beuwer, M.W.J. Prins, P. Zijlstra, Nano Letters 15, 3507-3511 (2015)

NEWS, AWARDS & GRANTS

ERC Advanced Grant for

DICK BROER

Prof.dr. Dick Broer was awarded a prestigious Advanced Grant by the European Research Council. By means of this subsidy, amounting to almost 2.5 million euro, he will in the next five years try to develop 'oscillating' coatings on the basis of liquid crystals which are capable, among other things, of making surfaces self-cleaning.

Dick Broer intends to use the ERC Advanced Grant for designing materials that make oscillating movements under the influence of light or heat. On the basis of liquid crystals he wants to make a coating in which minuscule oscillating ribs are generated when they are exposed to light or put under electric tension.

NOBEL PRIZE LAUREATE LEHN AT ICMS

Nobel Prize winner prof. Jean-Marie Lehn delivered a lecture at TU/e on September 29. The Frenchman's visit ties in with the first Netherlands Award for Supramolecular Chemistry, which Lehn will be awarded in Nijmegen on September 30. Prof. Lehn is one of the founders of the expertise.

Together with the Institute for Molecules and Materials (Nijmegen) and the Stratingh Institute for Chemistry (Groningen), ICMS has set up the Research Center for Functional Molecular Systems in 2012, which has initiated the Netherlands Award for Supramolecular Chemistry. This award will be granted annually.

TU/E TEAM

wins iGEM Best Innovation in Measurement

TU/e's iGEM team has won the Best Innovation in Measurement Special Prize at the Giant Jamboree in Boston, USA. The Eindhoven student team beat some two hundred other undergraduate teams. It was also nominated in the categories Best New Application and Best Education & Public Engagement. The team developed a biosensor based on proteins, which they inserted into the E. coli bacterium.

The International Genetically Engineered Machine (iGEM) Foundation runs the iGEM Competition - an international competition for students interested in the field of synthetic biology.

NETHERLANDS TOWARDS WORLD TOP IN 'ORGANS ON A CHIP'

with founding of new institute

TU/e and other universities in the Netherlands are working together with industry in the new hDMT foundation (Institute for human Organ and Disease Model Technology) for organ-on-a-chip-technology. hDMT was founded by nine partners, each with a specific area of expertise. The foundation will initially focus on three research lines: the heart, cancer, and blood vessels.

A number of TU/e groups from different departments will take part in the new institute, with contributions in the fields of materials, device integration, and modeling. The professors concerned are Jaap den Toonder, Kees Storm, Reinder Coehoorn, Bert Meijer, Albert Schenning, and Dick Broer.

BERT MEIJER

accepted Zernike Chair 2015

Prof.dr. Bert Meijer has accepted the prestigious 2015 Zernike Chair at the Zernike Institute for Advanced Materials at the University of Groningen. Bert Meijer spent several weeks in Groningen this past summer. During this time he gave a Masterclass on "Functional Molecular Materials" open to master's students, PhD candidates, and Postdocs. Furthermore, he gave the Zernike Chair lecture at the Zernike campus and a public lecture for a lay audience.

Polymers from molecular lego for

'GREEN' PAINT

ICMS and Chemical Engineering & Chemistry researchers dr.ir. Ilja Voets, prof.dr.ir. Remco Tuinier and prof.dr. Bert Meijer have received a grant of 700.000 euro from the NWO Fund New Chemical Innovations (NCI). They received the funding for the development of an environmentally friendly paint. The team will appoint two PhD students and two post-doctoral researchers. The research project will be executed in close collaboration with the companies SyMo-Chem and DSM Coatings Resins, who contribute together one third of the total project budget. The Fund NCI is a flexible instrument that promotes cooperation and knowledge transfer between academic institutes and companies. In this public-private partnership program at least two companies (TA) act as co-applicants.

NWO Vidi grant for

ILJA VOETS

Dr.ir. Ilja Voets has received a NWO (Netherlands Organisation for Scientific Research) Vidi Grant, of 800,000 euros. For this research project, Ilja Voets plans to make light sensitive molecular switches and incorporate them into colloidal materials aiming to control the mechanical and optical properties of composite supramolecular materials by light.

How to prepare for a career in research?

ICMS programs for master's and PhD students

The Institute for Complex Molecular Systems offers talented master's and PhD students a challenging interdisciplinary training program, aimed at those who plan to pursue a career in research. The program focuses on developing skills, both scientific and professional, to work successfully in a multidisciplinary research team.

By being part of the ICMS community participants are encouraged to exchange ideas with scientists from other disciplines. Participants will also follow lectures of distinguished ICMS visitors and our own staff. Together this will broaden scientific knowledge and sharpen critical thinking skills. Finally, ICMS organizes dedicated classes and workshops on skills such as writing, presenting, scientific integrity, teamwork, and cultural awareness.

Participants following the ICMS master's or PhD program always do this in combination with a degree program (MSc or PhD) in one of the TU/e departments. This ensures a strong focused background in combination with the skills and knowledge to work in an interdisciplinary research organization.

This fall, the ICMS has launched a renewed master's program to even better fit the profile and needs of participants. Students can apply for a certificate program that is done on top of their regular master's degree program. We offer a one year (12,5 cp) and a two year (20 cp) variant to students of Applied Physics, Biomedical Engineering, Chemical Engineering and Chemistry, Mechanical Engineering, and Mathematics & Computer Science.

Study program:

Two-year program	One-year program
Student starts with the ICMS program in the first year of their master	Student starts with the ICMS program in the second year of their master
2,5 cp Scientific skills (8I030)	2,5 cp Scientific skills (8I030)
2,5 cp ICMS Lectures 1 (8I040)	2,5 cp ICMS Lectures 1 (8I040)
10 cp Electives	5 cp Electives
2,5 cp ICMS Lectures 2 (8I050)	-
2,5 cp Master thesis Communication (8I060)	2,5 cp Master thesis Communication (8I060)
20 cp Total	12,5 cp Total

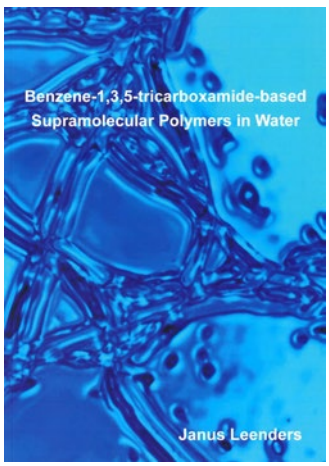
More about our programs for master and PhD students: **www.tue.nl/icms**

THESES ICMS

April 2015 – October 2015

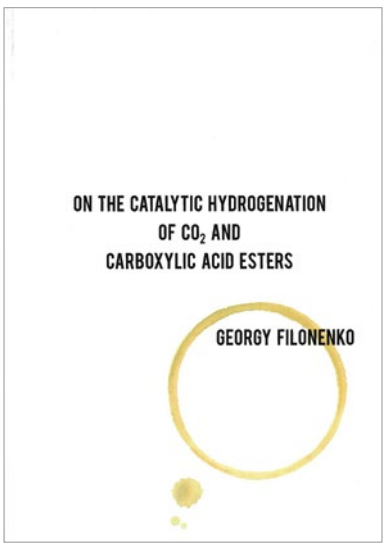
1 **Benzene-1,3,5-tricarboxamide-based supramolecular polymers in water**
Janus Leenders

April 14, 2015
PhD advisors:
prof.dr. E.W. Meijer
& dr.ir. A.R.A. Palmans



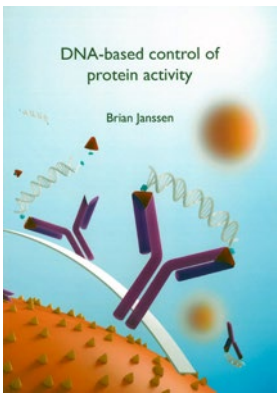
2 **On the catalytic hydrogenation of CO_2 and carboxylic acid esters**
Georgy Filonenko

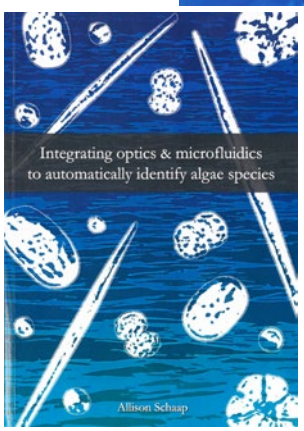
April 28, 2015
PhD advisors:
prof.dr.ir. E.J.M. Hensen
& dr. E.A. Pidko



3 **DNA-based control of protein activity**
Brian G.M. Janssen

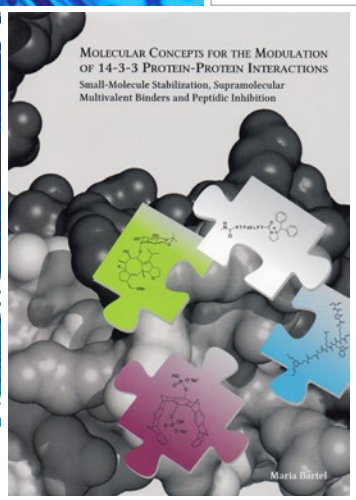
May 11, 2015
PhD advisors:
prof.dr. M. Merk
& prof.dr.ir. L. Brunsveld





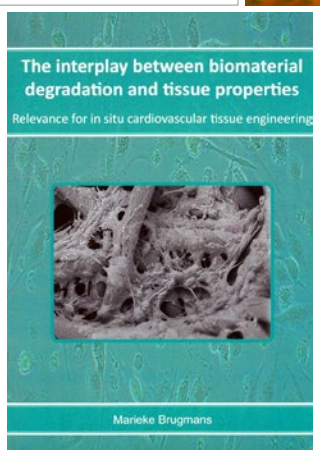
4 **Integrating optics & microfluidics to automatically identify algae species**
Allison Schaap

May 20, 2015
PhD advisors:
prof.dr.ir. J.M.J. den Toonder
& dr. Y. Bellouard



5 **Molecular concepts for the modulation of 14-3-3 protein-protein interactions: small-molecule stabilization, supramolecular multivalent binders and peptidic inhibition**
Maria Bartel

June 9, 2015
PhD advisors:
prof.dr.ir. L. Brunsveld
& dr. C. Ottmann

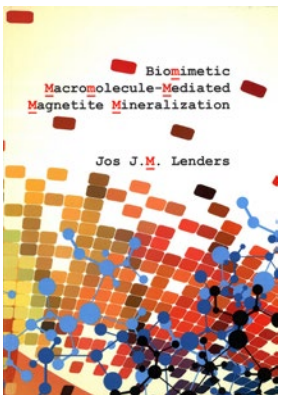


6 **The interplay between biomaterial degradation and tissue properties: relevance for in situ cardiovascular tissue engineering**
Marieke Brugmans

June 10, 2015
PhD advisors:
prof.dr.ir. F.P.T. Baaijens
& prof.dr. C.V.C. Bouten

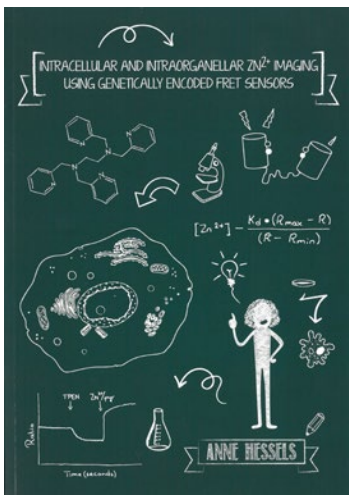
7 **Biomimetic macromolecule-mediated magnetite mineralization**
Jos Lenders

June 22, 2015
PhD advisors:
prof.dr. N.A.J.M. Sommerdijk
& prof.dr. G. de With



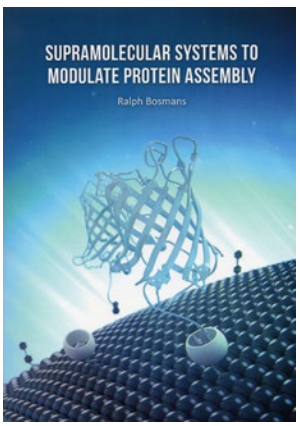
8 **Intracellular and intraorganellar Zn^{+2} imaging using genetically encoded FRET sensors**
Anne Hessels

June 23, 2015
PhD advisors:
prof.dr.ir. L. Brunsveld
& dr. M. Merkx



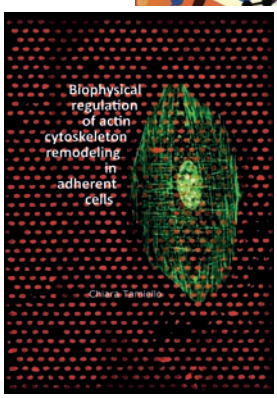
9 **Supramolecular systems to modulate protein assembly**
Ralph Bosmans

June 29, 2015
PhD advisors:
prof.dr.ir. L. Brunsveld
& prof.dr. M. Merkx



10 **Biophysical regulation of actin cytoskeleton remodeling in adherent cells**
Chiara Tamiello

September 3, 2015
PhD advisors:
prof.dr. C.V.C. Bouten
& prof.dr.ir. F.P.T. Baaijens



11 **Supramolecular biomaterials based on ureido-pyrimidinones and cucurbiturals**
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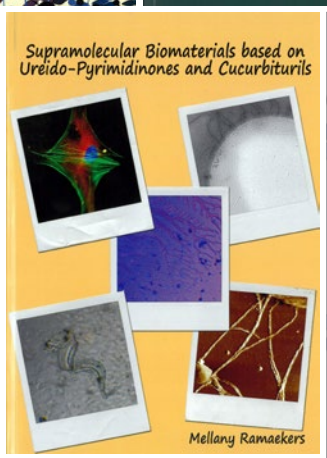
September 24, 2015
PhD advisors:
prof.dr. E.W. Meijer
& dr.dr. P.Y.W. Dankers



12 **Freeze tolerant soft matter**
Luuk Olijve

October 8, 2015
PhD advisors:
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& dr.ir. I.K. Voets

13 **Ureidopyrimidinone-based supramolecular networks for biomedical applications**
Bram Pape

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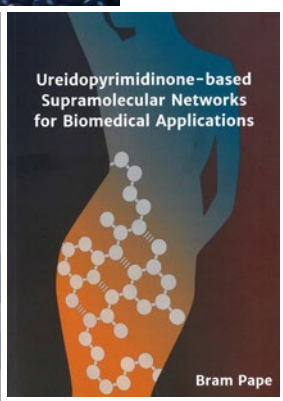

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New technologies by mastering complexity

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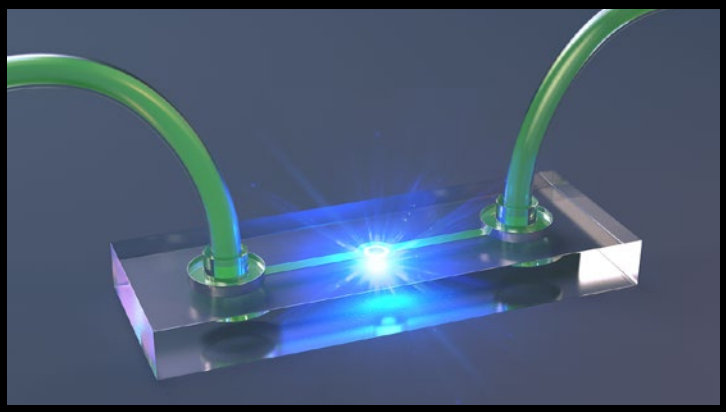

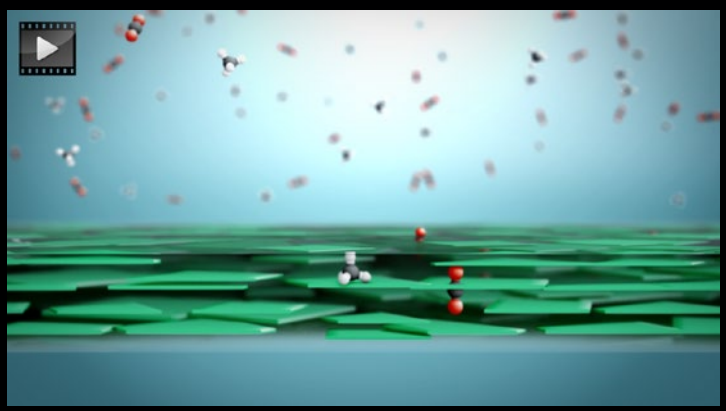
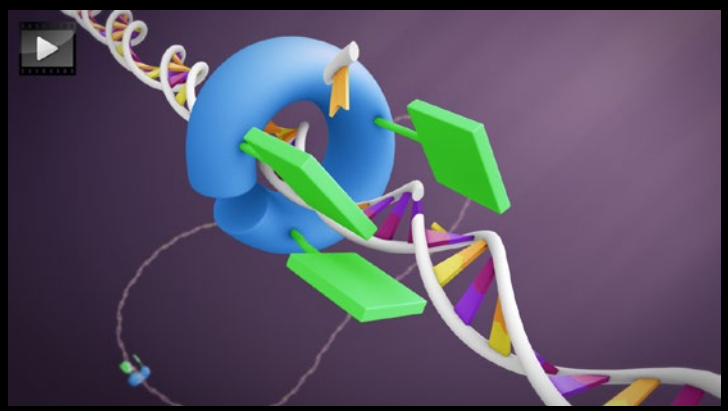
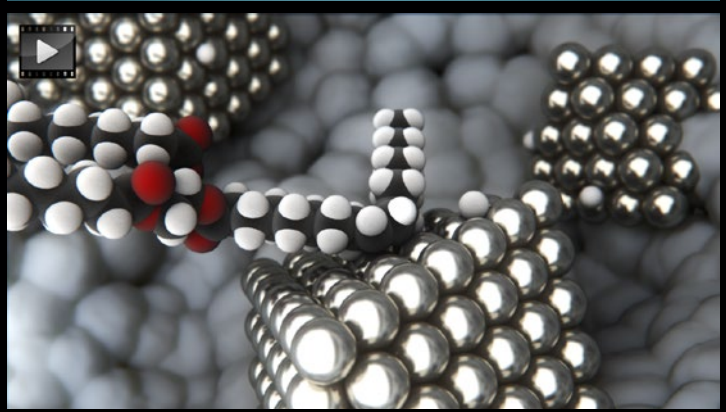
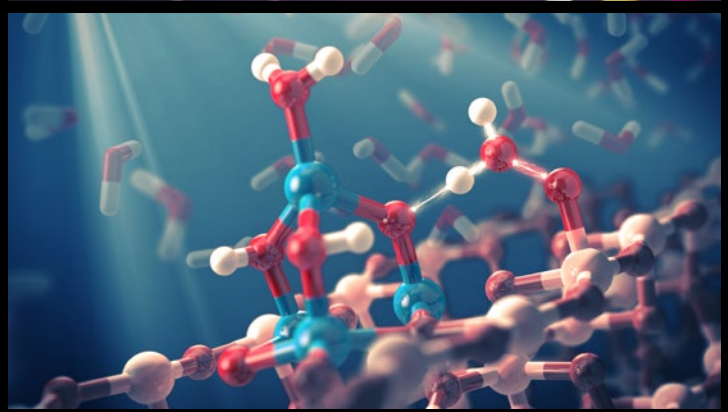
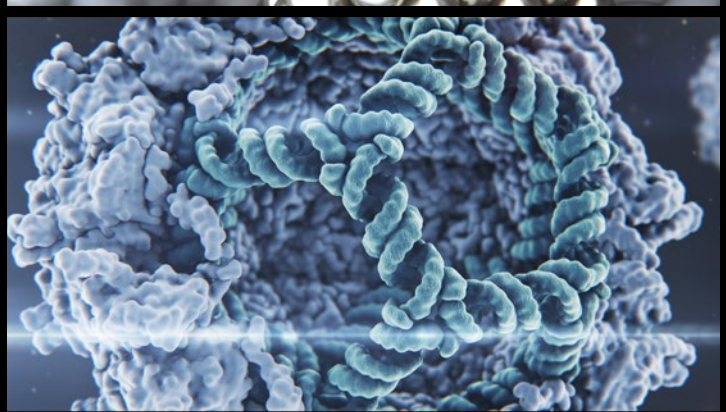
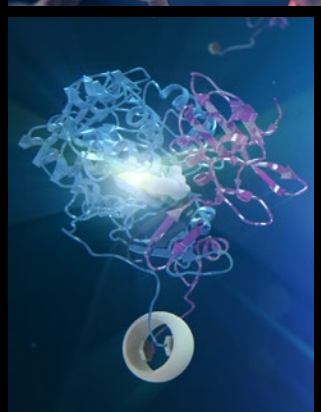

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