Charting a New Course

Annual Report 2013

DPI
Dutch Polymer Institute

Foreword
Towards a new format for DPI

Last year, in our Foreword to the 2012 Annual Report, we had expressed the hope that the Dutch government would take a long-term view and continue to support public-private partnerships like DPI as part of its policy to promote collaborative research and innovation and enhance the knowledge infrastructure in the Netherlands.

Over the past fifteen years, DPI has developed into an internationally acclaimed example of cost effectively addressing the needs of industry while at the same time building a strong academic base producing innovative solutions as well as competently trained polymer experts. DPI's success is also the success of the Dutch government, whose commitment and financial support have all along been of crucial importance in creating the strong knowledge infrastructure for polymers that the Netherlands boasts today.

This polymer knowledge infrastructure is likely to come under pressure now as a result of the changes in government policy announced recently. While we understand that a reappraisal of the funding schemes was necessary in light of the severe budget reductions required at the central government level, it is highly regrettable that with the introduction of the *generic* "Top Sectors and TKI" policy, all successful *specific* funding schemes addressing the needs of industry and the need to enhance the Dutch knowledge infrastructure have been discontinued. The Top Sector/TKI policy will certainly make some contribution to maintaining polymer expertise and employment in the Netherlands, but the accelerated reduction of government funding for DPI will have a significant negative impact on the field.

Serious consequences

Although we continue to have the financial commitment of our industrial partners, the reduction in government funding has severely affected DPI's financial position. It has necessitated some drastic cost-reduction measures, including suspension of vacancies and cancellation of equipment orders for DPI research projects. We are also not entering into any new project or programme commitments. While these measures were unavoidable in the given circumstances, they form a serious threat to the continuation of a proven collaborative platform that caters to the long-term needs of industry through a strategic research programme carried out by top-class research groups in the Netherlands and abroad.

Both our academic partners and our industrial partners recognize the importance of such a bridging role. In general, DPI research programmes have led to a greater academic effort in polymer science research than would have been possible without such a collaborative platform. And it has enabled a collaborative approach to challenges that extend beyond companies' individual innovation portfolios. To our partners, being a partner in DPI has meant participating in an active community of businesses and knowledge institutions which, thanks to a network-based virtual set-up with an international reach, offers its partners a variety of benefits: flexibility and responsiveness in project organisation and execution, a choice of the best available competences from across the world, high-quality research carried out in a programme-based framework assuring coherence and a long-term dimension. In addition, via the DPI Value Centre, we maintain a strong link with the downstream polymer industry. The Polymer Value Chain Projects launched by DPI and DPI Value Centre in 2012 are proving to be successful enablers of collaboration in innovation among players in the polymer value chain.

International partnerships

Our international dimension is one of our key strengths. With a substantial part of the world's polymer expertise being located in Western Europe, DPI has been able to fulfil a successful international role because of its well-established national and regional position. The international dimension is not only important to our partners; it also offers clear benefits for the knowledge infrastructure in the Netherlands. Over the past fifteen years, the revenues that DPI has been able to generate through its partnerships in other countries have had a positive impact on the volume and quality of academic research in the Netherlands. Moreover, bilateral partnerships between foreign

DPI TEAM – Top row: Thomas Manders, Peter Nossin, John van Haare, Christianne Bastiaens and Peter Kuppens. Second row: Renée Hoogers, Sherida Koenders, Miranda Heuvelmans, Jacques Joosten and Jeanne van Asperdt. Third row: Jan Stamhuis, Rosanne Peters, Denka Hristova-Bogaerds and Ronald Korstanje. Fourth row: Monique Bruining and Mercedes Crego Calama. Absent in this picture: Sybrand van der Zwaag and Angela Looymans.

companies and Dutch universities have sprouted from the fertile ground laid by the DPI network. Also, the presence of DPI and the active polymer network around it has encouraged a number of foreign companies to set up operations in the Netherlands. And just as important: our international dimension offers a wider platform for knowledge exchange and access to the talent pools of other countries.

In 2013, we made further progress in extending our international reach. At the European level, we took further steps towards establishing collaborations with Flanders (Flemish-speaking Belgium) and the German state of North-Rhine Westphalia. We have already signed a letter of intent with partners in Flanders and we expect to do the same in North-Rhine Westphalia soon. These collaborations across three European countries will not only strengthen our network in the Euregion, but will also enable us to link up better with the EU and its Horizon2020 programme.

In China, we entered into a partnership with a second university: Tsinghua University in Beijing, the country's No. 1 university. And our efforts in Brazil have resulted in the formation of a consortium in which DPI joined forces with the Eindhoven University of Technology and the National Council for Scientific and Technological Development of Brazil (CNPq).

Our partnerships with Chinese players are important for our partners in Europe, who are keen to tap into the growing pool of young Chinese scientists, as well as our partners in China, for whom such partnerships can be helpful in achieving their growing international ambitions. For businesses and universities in Brazil, working together with partners in Europe means an opportunity to acquire knowledge in the field of polymers and explore the possibilities for their attractive raw materials position in biomass in light of Europe's steadily depleting fossil-based resources.

Although our international activities remain of crucial importance, for the time being our financial situation will not leave us enough room to continue to expand our international base to the same extent as before. This also means that for the time being we are unable to follow up the successful pilot Networking Event we organised in Shanghai, China in November 2013 in cooperation with Teijin Aramid Asia, SABIC and International Top Talent (ITT).

Scientific quality

DPI continues to deliver a high volume of scientific output of a consistently high quality recognized by the international scientific community. In 2013, DPI projects resulted in 21 PhD theses and 170 scientific papers published by researchers working on DPI projects. At 4.70, our average Journal Impact Factor for 2013 remained at the high level sustained over the past several years.

DPI scientists and DPI projects are regularly honoured with international acclaim. Worthy of special mention here is SHINE, a EU Seventh Framework project that is being coordinated by DPI and in which a consortium of two universities, four research centres, four large industrial companies and two SMEs are working together to develop self-healing innovative elastomers. The EU has selected SHINE as one of the success stories in FP7.

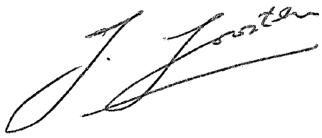
DPI research programmes offer PhD students the opportunity to work on industrially relevant topics and to gain experience in working to both academic and industry standards and requirements. This makes for a smooth transition of well-trained scientists to the labour market. In 2013, 45 new well-trained scientists became available for the polymer sector. Many of these entered into the employment of DPI's industrial and academic partners.

Under the leadership of Professor Martien Cohen Stuart, who retired as Scientific Director of DPI at the beginning of this year, DPI was able to boost the high scientific quality and reputation it has enjoyed worldwide. We would like to thank Professor Cohen Stuart for his strong commitment and dedicated efforts. Our thanks also go to Professor Claus Eisenbach, who retired as Scientific Chairman of our Coatings Technology research area, for the guidance and inspiration he gave to our research programme in this area.

The future of DPI

DPI has been successful so far thanks to the Dutch government's financial support and the commitment and contributions from our industrial and academic partners worldwide. We believe that the bridging role that DPI has played has made a major contribution to new developments in polymers and a dynamic knowledge infrastructure in the Netherlands. We are now in discussion with other parties to see if we can find additional funding at the national, regional and international level. Backed by the continued support of our partners, which we now need more than ever before, we hope to be able to safeguard this essential role for the benefit of the polymer sector.

Jacques Joosten – Managing Director



Sybrand van der Zwaag – Scientific Director

DPI VALUE CENTRE TEAM – Top row: Johan Tiesnitsch and Jos Lobée. Second row: Eelco Rietveld, Peter Nossin, Bart van den Berg, Arie Brouwer and Louis Jetten. Third row: Ineke Laeven, Judith Tesser, Martin van Dord, Peter Koppert, Gerrie Verhoeven and Coco Lenssen.

Contents

Organisation 2013

Supervisory Board
- **Dr. H.M.H. van Wechem**, *Chairman*
- **Dr. J.A. Roos**
- **Prof.dr. C.J. van Duijn**
- **Dr. F. Kuijpers**
- **Prof. K.C.A.M. Luyben**
- **Dr. M. Wubbolts**

Council of Participants
- **Prof.dr. G. ten Brinke**
  University of Groningen, *Chairman*

Scientific Reference Committee
- **Prof.dr. A.J. Schouten**
  University of Groningen, *Chairman*
- **Prof.dr. L. Leibler**
  Ecole Supérieure Physique et Chimie Industrielles, Paris
- **Prof.dr. H. Sirringhaus**
  University of Cambridge
- **Prof.dr. B. Voit**
  Institut für Polymerforschung, Dresden

Executive Board
- **Dr. J.G.H. Joosten**
  Managing Director, Chairman
- **Prof.dr. M.A. Cohen Stuart**
  Scientific Director (until 31-12- 2013)
- **Prof.dr. S. van der Zwaag**
  Scientific Director (from 01-01-2014)

Programme Area Coordinators
- **Dr. M.J. Bruining**
  Corporate Research
- **Dr. M. Crego Calama**
  High-Throughput Experimentation, Coatings Technology
- **Dr. J.A.E.H. van Haare**
  Functional Polymer Systems, Large-Area Thin-Film Electronics
- **R.J. Korstanje, MSc**
  Performance Polymers
- **Dr. P.M.M. Nossin**
  Bio-Inspired Polymers
- **Dr. J.E. Stamhuis**
  Polyolefins,Enhanced Oil Recovery, Emerging Technologies

Scientific Programme Chairmen
- **Prof.dr. V. Busico**
  Polyolefins
- **Prof.dr. C. Creton**
  Performance Polymers
- **Prof.dr. F. de Schryver**
  Functional Polymer Systems and Large-Area Thin-Film Electronics
- **Prof.dr. C.D. Eisenbach**
  Coatings Technology
- **Prof.dr. U.S. Schubert**
  High-Throughput Experimentation
- **Prof.dr. G. Eggink**
  Bio-Inspired Polymers
- **Prof.dr. M.A. Cohen Stuart**
  Corporate Research and Emerging Technologies

Organisation Staff
- **A.F.J. van Asperdt** - *Fin. Administration*
- **C.H.L.M. Bastiaens** - *Communications*
- **Dr. M.J. Bruining** - *General Affairs*
- **M.M.G. Heuvelmans** - *Fin. Administration*
- **R.P.F. Hoogers-Valken** - *Secretariat*
- **S.G. Koenders** - *Project Administration*
- **P.J.J. Kuppens, AA** - *Controlling*
- **A.C.M. Looymans** - *Project Administration*

Staff European projects
- **Dr. J.A.E.H. van Haare**
  Project Manager SEAFRONT
- **Dr. D.G. Hristova-Bogaerds**
  Project Manager COMPNANOCOMP
- **R.J. Korstanje, MSc**
  Project Manager SHINE
- **A.M.G. Steinmann**
  EU-SEAFRONT Project Office

PERSONNEL CHANGES AT DPI
DPI saw several changes in its personnel in 2013. A short overview is given below.

Jacques Joosten, whose tenure as Managing Director of DPI ended in April 2014, will continue to hold this position. His tenure has been extended for at least another two years.

As of 1 January 2014, Sybrand van der Zwaag took up the role of Scientific Director of DPI, succeeding Martien Cohen Stuart, who stepped down as Scientific Director having reached retirement age. See pages 11 and 21 for more information.

Professor Gerrit ten Brinke of the University of Groningen, who was Chair of DPI's Council of Participants, has stepped down from this position. DPI is currently looking for a successor.

Professor Claus Eisenbach, Scientific Chairman of the Coatings Technology research area, retired in 2013. DPI is currently looking for a successor.

Harold Gankema, Programme Area Coordinator for Coatings Technology and High-Throughput Experimentation and project leader of the European SHINE project, left DPI in February 2013. His role as Programme Area Coordinator has been taken over by Dr. Mercedes Crego Calama, who joined DPI in March 2013. The new coordinator for the SHINE project is Ronald Korstanje, who joined DPI in March 2013.

Jan Stamhuis has handed over his role as Programme Area Coordinator for Performance Polymers to Ronald Korstanje.

John van Haare, Ronald Korstanje and Denka Hristova-Bogaerds have each been given the responsibility to coordinate an EU project.

Shila de Vries, responsible for Legal and IP Affairs at DPI, left DPI in March 2013 to take up a new position elsewhere.

DPI: International Centre of Excellence in Polymers

In the last few years DPI has transformed itself into an International Centre of Excellence in Polymers. To achieve that goal, the institute has expanded its pre-competitive research programme with projects focussing on pre-commercial and societal themes.

PRE-COMPETITIVE PROGRAMME

DPI Rules & regulations apply to all projects

Polyolefins

30 projects

Industry

- Borealis
- Braskem
- Dow Benelux
- DSM
- ExxonMobil
- ITRI
- Lanxess Elastomers
- LyondellBasell
- Petrobras
- Sabic
- SCG Chemicals
- Sinopec
- Symyx
- Teijin Aramid
- Ticona
- Freeslate

Academia

- Consorzio Interuniversitario Nazionale per la Scienza e Technologia die Materiali (INSTM)
- Eindhoven University of Technology
- ESPCE-Lyon
- Fraunhofer Institute for Structural Durability and System Reliability LBF
- Japan Advanced Institute of Science and Technology
- Johann Kepler University Linz
- Karlsruhe Institute of Technology
- Loughborough University
- Martin-Luther University of Halle-Wittenberg
- National Council for Scientific and Technological Development (CNPq)
- Polymer Technology Group Eindhoven
- Queens University
- Radboud University Nijmegen
- UFRGS Universidade Federal do Rio Grande do Sul
- Universidade Federal do Rio de Janeiro
- University of Amsterdam
- University of Antwerp
- University of Erlangen
- University of Manitoba
- University of Naples Federico II
- University of Ottawa
- University of Perugia
- University of Salerno
- University of Turin
- University of Udine

Expenditure € 2.69 million
FTEs 29.8 (51 researchers)

Performance Polymers

29 projects

Industry

- AkzoNobel
- BASF
- Bayer
- Bekaert
- DSM
- Sabic
- SKF
- Teijin Aramid

Academia

- CNRS Strasbourg
- Delft University of Technology
- DWI an der RWTH Aachen
- Eindhoven University of Technology
- Fraunhofer Institute for Structural Durability and System Reliability LBF
- National Technical University of Athens
- University of Goningen
- University of Twente

Expenditure € 1.49 million
FTEs 13.9 (20 researchers)

Functional Polymer Systems

22 projects

Industry

- BASF
- DSM
- ECN
- Industrial Technology Research Institute Taiwan
- Philips
- Rolic Technologies
- Sabic
- Solvay
- TNO

Academia

- Delft University of Technology
- ECN
- Eindhoven University of Technology
- Imperial College London
- Nanoforce Technology
- University of Groningen

Expenditure € 1.40 million
FTEs 12.1 (27 researchers)

Coatings Technology

10 projects

Industry

- AkzoNobel
- Altana
- DSM
- Lawter
- Saint-Gobain

Academia

- Changchun Institute of Applied Chemistry
- Eindhoven University of Technology
- University of Haute-Alsace
- Wageningen University

Expenditure € 1.04 million
FTEs 13.5 (17 researchers)

Pre-competitive research programme

DPI's pre-competitive research programme currently embraces ten technology areas. Companies and knowledge institutes can participate in one or more of these areas, each of which encompasses a substantial number of projects. The participating companies jointly define the programmes for the specific technology areas in which they participate. PhD students and post-docs from our partner knowledge institutes perform their research in close collaboration with scientists from our industrial partners. Shaping that collaboration between industry and academia is the key to building a coherent community that delivers the research results to the envisaged high standard and prepares our scientists for their future careers, in industry or elsewhere.

The interaction between academic researchers and industrial scientists takes various forms. Each project team submits quarterly reports to DPI, while twice a year every researcher also gives a presentation for all of the partners in the specific technology area to highlight and explains its research results. This enables DPI to monitor, evaluate and steer the projects. The research results are shared within the technology area and all of the partners are free to use the knowledge that is acquired, with the exception of knowledge that is part of an invention. When an invention is reported and partners are interested in using that knowledge, DPI files a patent application and the industrial partners involved in that specific technology area have the first claim to it.

DPI Rules & regulations apply to all projects

High-Throughput Experimentation

6 projects

Industry

- Chemspeed
- Evonik
- Forschungsgesellschaft Kunststoffe
- Michelin
- Microdrop Technologies

Academia

- Fraunhofer Institute for Structural Durability and System Reliability LBF
- Friedrich-Schiller University, Jena
- Radboud University

Expenditure €0.72 million
FTEs 7.1 (13 researchers)

Bio-Inspired Polymers

8 projects

Industry

- Food and Biobased Research, Wageningen UR
- FrieslandCampina
- Petrobras
- Sabic
- Teijin Aramid

Academia

- Eindhoven University of Technology
- Food and Biobased Research, Wageningen UR
- Friedrich-Schiller-University Jena
- National Council for Scientific and Technological Development (CNPq)
- Tsinghua University
- Universidade Federal do Rio de Janeiro

Expenditure € 1.20 million
FTEs 8.8 (19 researchers)

Large-Area Thin-Film Electronics

9 projects

Industry

- DSM
- Philips
- Solvay
- TNO

Academia

- Eindhoven University of Technology
- Imperial College London
- Max Planck Institute für Polymerforschung
- University of Algarve
- University of Groningen
- University of Twente
- University of Wuppertal

Expenditure € 1.12 million
FTEs 12.1 (16 researchers)

Emerging Technologies

1 project

Industry

- DPI partners
- M2i partners

Academia

- Delft University of Technology

Enhanced Oil Recovery

3 projects

Industry

- Shell
- SNF

Academia

- Delft University of Technology
- University of Groningen

Expenditure € 0.30 million
FTEs 3.9 (5 researchers)

Corporate Research

25 projects

Industry

- All DPI partners take part in Corporate Research

Academia

- Delft University of Technology
- Eindhoven University of Technology
- ESRF, Grenoble
- Foundation for fundamental research on matter (FOM)
- Radboud University
- TI Food and Nutrition (TIFN)
- University of Groningen
- University of Twente
- Wageningen University

Expenditure € 1.40 million
FTEs 16.1 (17 researchers)

Industrial pre-commercial programme

The industrial pre-commercial programme consist of Value Chain projects and EU projects. The conditions for performing Value Chain projects are described below and those of EU projects are generally known and are available on the web.

The Value Chain projects offer companies and/or research institutes the opportunity to establish consortia for innovation projects, in which they collaborate within the value chain. Every partner plays an active role in the project, which must be aimed at further development of the innovation. The projects are intended to generate economic activity within the foreseeable future (i.e., no later than two to five years after completion of the project).

DPI's role is to actively assist in establishing the collaboration between the partners and to coordinate the project. DPI can also act as coordinator of a project. Particularly when SMEs are involved, DPI works together with the DPI Value Centre.

DPI provides a model framework for the collaboration, but the detailed rules are agreed between the members of the consortium. As regards intellectual property, the basic principle is that the knowledge created during the course of the project (foreground knowledge) is the property of the inventing partner, and any background knowledge contributed to the project remains the property of the partner that provided it. Other partners have free access to the knowledge contributed to and/or generated during the project, but only to the extent necessary for developments in the project. Specific agreements are made to enable access to another partner's IP for commercial application of the knowledge outside the project.

PRE-COMMERCIAL PROGRAMME

Model framework for collaboration

Rules and regulations set by involved partners	**Rules and regulations set by involved partners**	**Rules and regulations set by involved partners**	**Rules and regulations set by involved partners**
CompNanoComp (1-10-2011/ 30-9-2014)	**SHINE** (1-2-2013/31-7-2016)	**SEAFRONT** (1-1-2014/31-12-2017)	**Value Chain projects**
Partners • DPI • Rhodia • National Technical University of Athens • Eindhoven University of Technology • Centre National de la Recherche Scientifique - Laboratoire Polymères et Matériaux Avancés • General Electric • European Centre for Nanostructured Polymers • University of Ulm • Lomonosov Moscow State University • Institute of Macromolecular Compounds St. Petersburg • National Research Centre Kurchatov Institute • Phys Chem Ltd	**Partners** • DPI • Acciona Infraestructuras • Arkema • BIWI SA • Cidetec • Critical Materials • ESPCI ParisTech • Forschungszentrum Jülich • Fraunhofer UMSICHT • MTA-TTK • SKF Engineering & Research Centre • Teijin Aramid • Delft University of Technology	**Partners** • DPI • International Paint Ltd • Fraunhofer IFAM • I-Tech AB • University of Newcastle upon Tyne • Minesto AB • Solvay Specialty Polymers • Delft University of Technology • Eindhoven University of Technology • University of Bristol • Val FoU • Biotrend • BioLog • University of Gothenburg • Bio-On • Bluewater Energy Services • Smartcom Software • Solintel • Hapag Lloyd	**Projects** • Next Generation Valve • KeyKeg HD • Kunstof pallets uit gemengde reststromen • Closing the loop with biobased Carpet • De ontwikkeling van biobitumen op basis van hoogwaardig hergebruik van bio(afval)stromen • AM medical textiles • Hoogwaardig gegoten PMMA Plaat (HGPP) • Flame retardant glass-filled high heat PLA compounds for injection molding for application in household appliances • Antifogging additives for polymer films • Introductie van poedercoating-technologie op pilotschaal in toepassingen op ondergronden zoals kunststof en hout • Wicker 2.0 • Biofilm • Magneto-Rheological Elastomers technology and product development, stage 1: feasibility study
Budget €2.2 million (€1.5 million EU subsidy)	Budget €6.4 million (€4.0 million EU subsidy)	Budget €11.2 million (€8.0 million EU subsidy)	

Projects driven by societal themes

DPI is confronted with new demands from society in relation to scientific research into polymers. A major international issue is that of 'plastic soup', the vast volumes of plastic waste that accumulate in certain areas of the oceans and seas and harm the ecosystem. DPI has become increasingly aware in recent years that companies, knowledge institutions and the government are not its only stakeholders. Society at large can also benefit from the knowledge and expertise generated by the DPI community as a source of possible solutions for societal issues such as 'plastic soup'.

SOCIETAL PROGRAMME

Plastic Marine Litter
(to prevent plastic from ending up in the oceans)

Start date 1-9-2012

Partners

- DPI
- DPI Value Centre
- IMSA
- Stichting De Noordzee
- University Utrecht
- Kruidenier Foodservices
- SABIC
- Van Gansewinkel

DPI HIGHLIGHTS

DPI Invention Award

The DPI Invention Award 2013 was granted to Dr. Rob Duchateau in recognition of his scientific output in the last few years and for his application of fundamental knowledge as a catalyst for various polymer processes and properties. The award was presented to Dr. Duchateau at the European Polymer Congress 2013 in Pisa, Italy. The DPI Invention Award is granted every two years to a researcher from the DPI network who has made a significant contribution to the development of polymer research and technology in Europe and enabled scientific knowledge to be quickly converted into industrial applications. Previous winners of the award were Professor D.J. Broer and Dr. C.W.M. Bastiaansen (2007), Professor U.S. Schubert (2009) and Professor C.E. Koning (2011).

DPI Golden Thesis Award

The DPI Golden Thesis Award 2013 was granted to Nicole Franssen for her thesis entitled "Functional (Co)polymers from Carbenes – Scope, Mechanism and Polymer Properties". Nicole did her PhD work at the University of Amsterdam under the supervision of Prof. Bas de Bruin. The other two candidates were: Jeroen Cottaar ("Modeling of charge-transport processes for predictive simulation of OLEDs", Eindhoven University of Technology) and Danqing Liu ("Responsive Surface Topographies", Eindhoven University of Technology). The award was presented during the DPI Annual Meeting 2013 in Arnhem on 5 November.

New Scientific Director in 2014

As of 1 January 2014, Professor Sybrand van der Zwaag took up the role of Scientific Director of DPI. He succeeded Martien Cohen Stuart, who stepped down as Scientific Director having reached retirement age. In his capacity as Scientific Director, Sybrand Van der Zwaag is responsible for DPI's scientific quality and reputation.

Sybrand van der Zwaag (1955) holds an MSc degree in metallurgy from the Delft University of Technology (Netherlands) and a PhD in applied physics from Cambridge University (UK) for his research on supersonic impact on ceramics. After a post-doc position related to metallic glasses he joined Akzo Nobel Corporate Research in 1982 to work on the structure-property relationships for aramid and other high performance polymeric fibres. In 1987 he joined Akzo Fibre research to work on process innovations for aramid fibres. In 1992 he was appointed Professor of Microstructural Control in Metals at the Delft University of Technology, where he investigated fundamental aspects of solid state phase transformations in steel and aluminium for a more solid scientific basis to industrial process models. In 2003 he took up the Chair in Novel Aerospace Materials at the same university, working on the design of new materials for future aircraft and spacecraft. The NovAM research portfolio covers advanced polymers, self-healing materials, new metallic systems and polymer based sensorial composites.

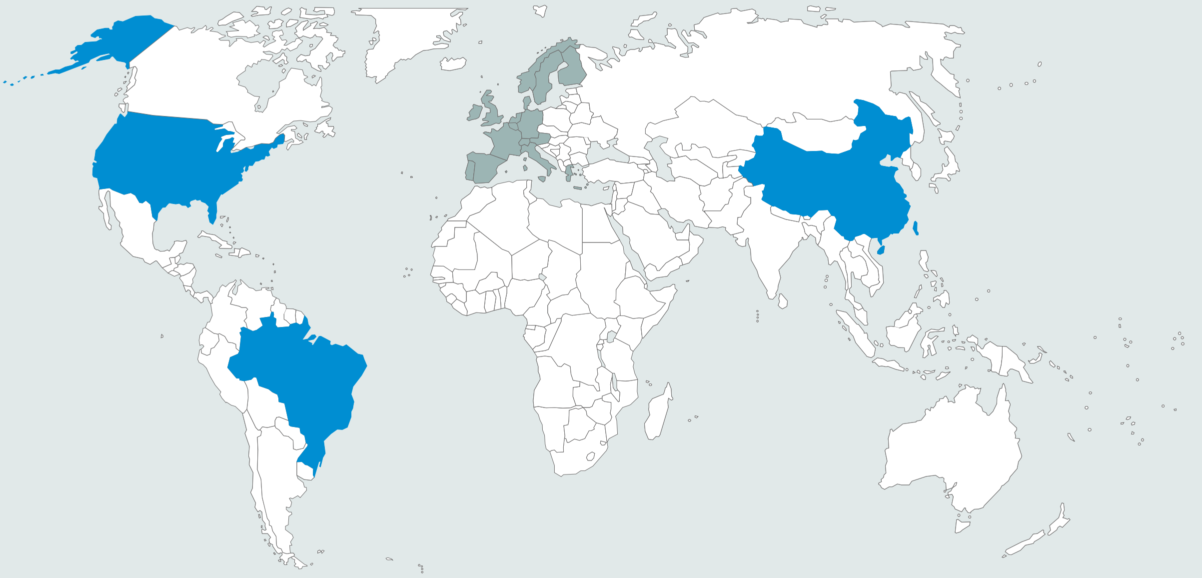
Professor van der Zwaag is a member of the Royal Holland Society of Sciences and Humanities and a fellow of the Institute of Materials, Minerals and Mining (IOM3). He is the scientific director of the Delft Centre for Materials, chairman of the national IOP research program on self-healing materials in the Netherlands and co-director of the German program in this field. He has published almost 400 journal publications and has supervised 38 PhD students.

In 2012 he was awarded the honorary title of 'Distinguished Professor" by the Board of the Delft University of Technology in recognition of his contribution to the interaction between academic research and industry in the field of materials in general and that of self-healing materials in particular. He remains deeply interested in the challenge of combining academic science with industrial needs and vice versa.

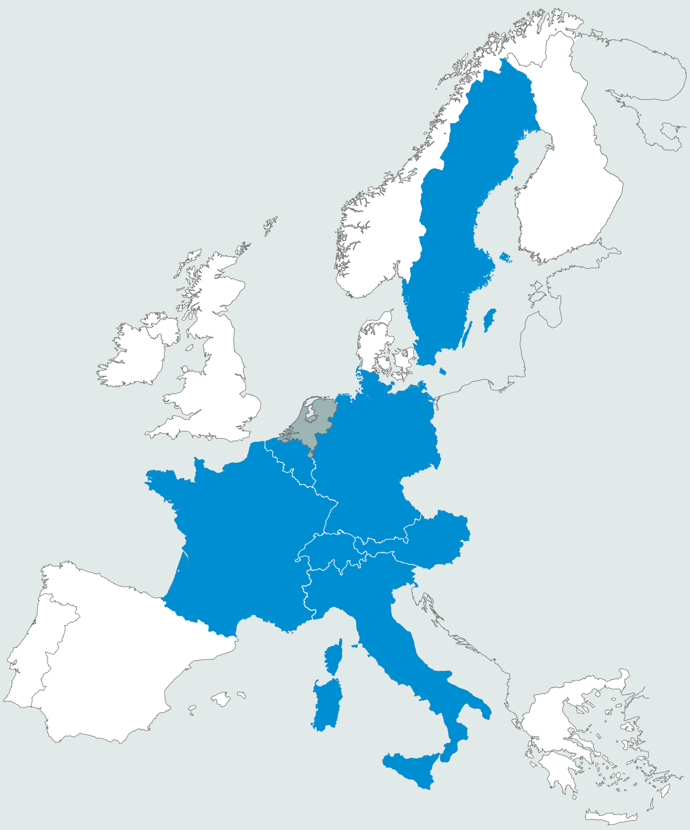
Martien Cohen Stuart wrote a personal note. See page 21.

Partners Industry 2013

North and South America, Asia



Europe



- Altana
- BASF
- Bayer
- Bekaert
- Borealis
- Celanese
- Chemspeed Technologies
- Evonik
- Forschungsgesellschaft Kunststoffe

- Accelrys
- Braskem
- ExxonMobil
- Freeslate
- Industrial Technology Research Institute Taiwan
- Petrobras
- SCG-Chemicals (new in 2013)
- Sinopec

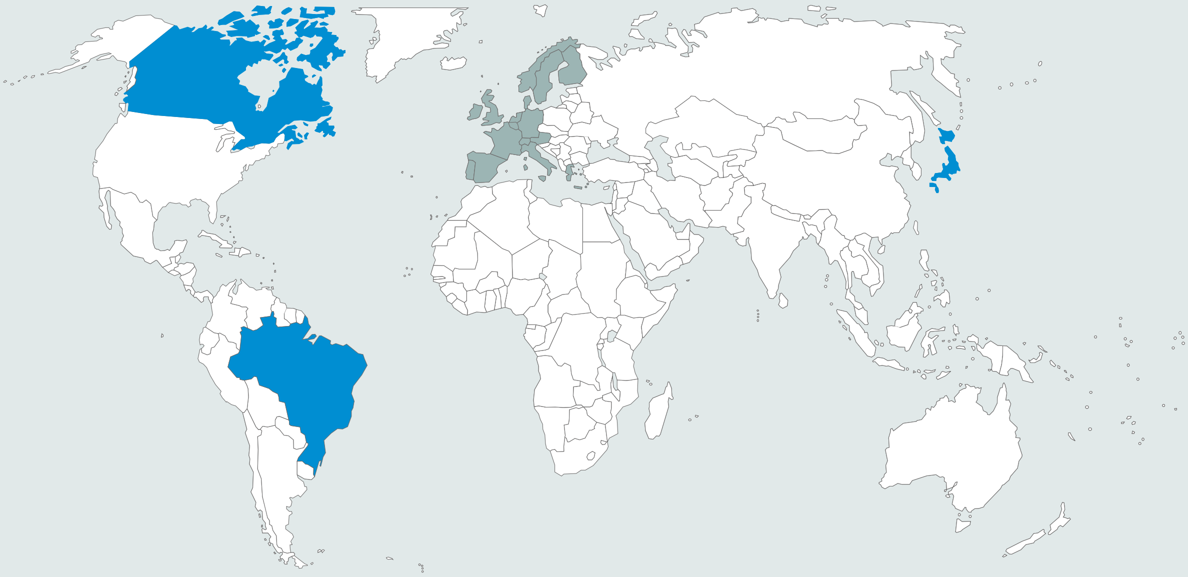
- LyondellBasell
- Michelin
- Microdrop Technologies
- Rolic Technologies
- Saint-Gobain
- SKF
- SNF Floerger
- Solvay

The Netherlands

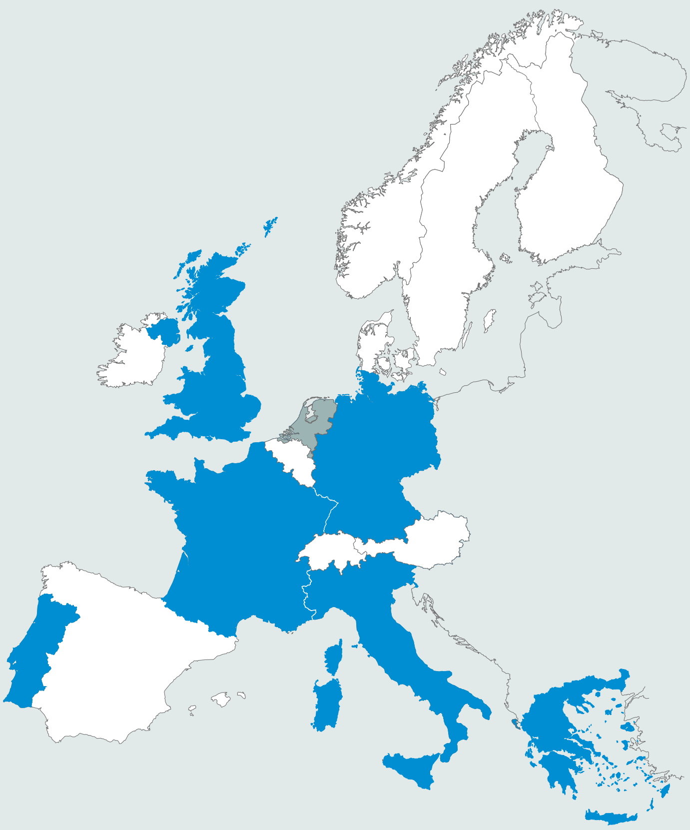
- AkzoNobel
- Dow Benelux
- DSM
- ECN
- Food and Biobased Research Wageningen UR
- FrieslandCampina
- Lanxess Elastomers
- Lawter
- Philips
- Sabic
- Shell
- Teijin Aramid
- TNO

Partners Knowledge institutes 2013

North and South America, Asia



Europe



- CNRS Strasbourg (new in 2013)
- INSTM (new in 2013)
- DWI an der RWTH Aachen
- ESCPE-Lyon
- ESRF, Grenoble
- Fraunhofer Institute for Structural Durability and System Reliability LBF
- Friedrich-Schiller-University, Jena
- Imperial College London
- Johann Kepler University Linz (new in 2013)
- Karlsruhe Institute of Technology (new in 2013)
- Leibniz-Institut für Polymerforschung Dresden (No research projects in 2013)
- Loughborough University
- Martin-Luther-University Halle-Wittenberg
- Max-Planck Institute für Polymer Forschung

- Changchun Institute of Applied Chemistry (new in 2013)
- Japan Advanced Institute of Science and Technology
- National Council for Scientific and Technological Development (new in 2013)
- Queens University
- Tsinghua University (new in 2013)
- UFRGS Universidade Federal do Rio Grande do Sul (new in 2013)
- Universidade Federal do Rio de Janeiro (new in 2013)
- University of Manitoba
- University of Ottawa

- Nanoforce Technology
- National Technical University of Athens
- Queen Mary & Westfield College, Uni. of London (No research projects in 2013)
- University of Algarve
- University of Antwerp
- University of Cologne (No research projects in 2013)
- University of Erlangen (new in 2013)
- University of Haute-Alsace
- University of Naples Federico II
- University of Perugia
- University of Salerno (No research projects in 2013)
- University of Turin (new in 2013)
- University of Udine
- University of Wuppertal

The Netherlands

- Delft University of Technology
- ECN
- Eindhoven University of Technology
- FOM
- Food and Biobased Research Wageningen UR
- NWO
- Polymer Technology Group Eindhoven
- Radboud University Nijmegen
- University of Amsterdam
- University of Groningen
- University of Twente
- Wageningen University

Summary of financial data 2013

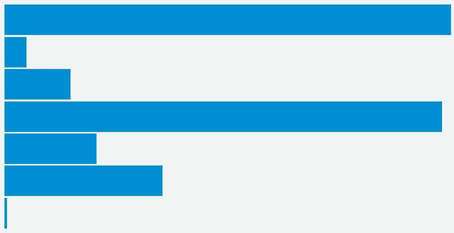
Income

Income	(x EUR million)	%
Contributions from industrial partners	3.92	11.6
In-kind contributions from industrial partners	11.54	34.1
Revenue Patents	0.03	0.1
Revenue DPI Value Centre	0.62	1.8
Contributions from knowledge institutes	3.16	9.3
Contributions from Ministry of EA	9.00	26.6
EU FP7 projects	2.37	7.0
Industrial pre-commercial research programme Value Chain	3.13	9.3
Solving societal themes and challenges	0.04	0.1
Total income	**33.81**	**100**

Expenditure

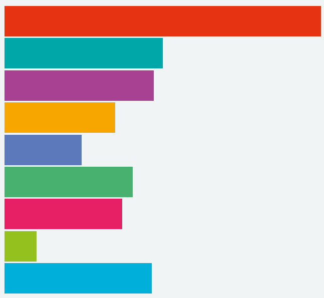
By nature

By nature	(x EUR million)	%
Personnel costs	11.95	36.5
Depreciation	0.58	1.8
Other costs	1.78	5.4
In-kind contribution	11.73	35.8
EU FP7 projects	2.45	7.5
Industrial pre-commercial research programme Value Chain	4.22	12.9
Solving societal themes and challenges	0.01	0.0
Total expenditure	**32.72**	**100**



By Technology Area

By Technology Area	(x EUR million)	%
Polyolefins	2.96	25.5
Performance Polymers	1.49	12.8
Functional Polymer Systems	1.40	12.0
Coatings Technology	1.04	8.9
High-Throughput Experimentation	0.72	6.2
Bio-Inspired Polymers	1.20	10.3
Large-Area Thin-Film Electronics	1.12	9.6
Enhance Oil Recovery	0.30	2.6
Corporate Research	1.40	12.0
Sub total	**11.63**	**100**
Knowledge Workers Scheme	0.11	
Knowledge Transfer	0.53	
Organisation and support	1.40	
Support to DPI Value Centre	0.47	
In-kind contribution	11.73	
EU FP7 projects	4.22	
Industrial pre-commercial research programme Value Chain	2.45	
Solving societal themes and challenges plus Geographical outreach	0.18	
Total expenditure	**32.72**	



Key Performance Indicators 2013

Number of industrial partners

2012	37
2013	38

European governmental funding (% of total funding)

2012	3%
2013	7%

Number of partner knowledge institutes
(universities, etc.)

2012	36
2013	45

Participation of foreign knowledge institutes
as % of total expenditure

2012	11%
2013	12%

Industrial contribution (cash and in-kind)
as % of total income

End 2012	50%
End 2013	46%

Overhead costs
as % of total expenditure

2012	4%
2013	4%

Contribution Ministry of Economic Affairs
as % of total income

End 2012	31%
End 2013	27%

Expenditure for knowledge transfer
x EUR million

2012	0.49
2013	0.53

Number of patents filed by DPI

2012	10
2013	8

Number of patents licensed or transferred to industrial partners and DPI Value Centre

2012	0
2013	0

Interest shown by industrial partners	5
Interest shown by university partners	2
Interest shown by DPI Value Centre	7

Number of patents to be transferred 0

Track record DPI researchers

Left in total	45
Employed by partner knowledge institute	18
Employed by non-partner knowledge institute	6
Employed by partner industrial company	10
Employed by non-partner industrial company or start-up	8
Unknown	3

Research output	2012	2013
Scientific publications	159	170
PhD theses	37	21

The added value of innovation in polymers

100th Start-up
For DPI Value Centre, 2013 was a year of many high points and many new exciting challenges going forward. In November we signed a contract with the 100th start-up: we will be supporting the innovation efforts of Nutripol, a new player in bio-degradable packaging. This collaboration is yet another example showing that new entrepreneurs recognise the added value of teaming up with DPI Value Centre. We are able to fullfill this role by combining our intimate knowledge of the polymer market with our strong connections in the polymer network and our entrepreneurial approach. The start-ups are happy to have a sparring partner who knows their business and with whom they can discuss their challenges and concerns. Our aim is to help companies realize their business ambitions in the field of polymers to innovate better and faster and thus enhance their chances to be successful in the market.

Active SME participation
Most of the companies participating in the Value Chain Projects launched recently were represented at the project meetings we organized in 2013. Once again, this shows that the SME community recognises the benefits of working with DPI Value Centre. Business people, especially in the SME segment, are busy and need to spend most of their time with their day-to-day production operations, which are the source of their income. The Value Chain Projects are enabling them to work together on challenging innovation projects. This, as the participants themselves put it, accelerates innovation: "Companies that did not know each other turn out to form a good match; they share the same priorities and contribute their specific expertise to achieve a common goal within the set period of time. Just the right partners, with just the right targets."

Expanding collaboration
2013 was also the year in which DPI Value Centre formalised its regional approach. With the support of the Dutch Ministry of Economic Affairs, DPI Value Centre has further expanded its activities in the Netherlands. We team up with three other specialised, independent organisations

POLYMER INNOVATION DAY 2013
Business market

active in the fields of Processing (ISPT), Bio-Based Economy (BBE) and New Chemical Innovations (NCI). Together we have formed one network to stimulate and support SME's and entrepreneurs with innovations in the chemical industry including materials. The formal launch of this network, called Top Chemie Δ, took place in April 2013. The network collaborates strongly with strategic regional partners such as Centres of Open Chemical Innovation (COCI). In Geleen, Bergen op Zoom and Zwolle, these collaborations will improve interaction with SME's across the chemical industry. Regional players such as academic innovation labs, business development companies and provincial governments have also been involved. All this is expected to result in the creation of a network of experts that can advise and support entrepreneurs. The added value of the Top Chemie Δ network, which will supplement the existing Syntens Innovatiecentra network now forming part of the Chamber of Commerce, is that it will bring in specific knowledge, expertise and valuable contacts from the sector.

Collaborating on sustainability

'From waste to raw material: closing the raw materials chain'. This is the title of a study commissioned by the Dutch Ministry of Infrastructure and the Environment into the possibility of setting up an innovation and education agenda for the rubber and plastics industry. Issues to be addressed include matters such as the improvement of recyclate quality in order to enable more realistic specifications for the manufacture of plastic products. How can we enable the reuse of rigid plastic products in high performance applications? How can we successfully recycle thermoplastic composites and rubbers? What viable business models are there for doing this profitably? And, finally, what will the recycling plant of the future be like? "This is only a preliminary study," says project leader Louis Jetten, "we are now preparing for the next phase to continue this research". A large number of plastics and rubber companies as well as knowledge institutes participated in the study.

100th START-UP
Nutripol

DPI Value Centre will continue to work along the lines that have proved successful so far. We are happy that our regional presence makes us even more accessible to SME's. This year, we will start collaborating with the Energy Top Sector network in the Netherlands, thus gaining access to the special expertise and knowledge of that sector. We will continue in our efforts to enhance our market profile. In this regard, our close cooperation with DPI, NRK (the Federation of the Rubber and Plastics Industry in the Netherlands) and Modint (Trade association of manufacturers, importers, agents and wholesalers of clothing, fashion accessories, carpet and (interior) textiles) is very important. We believe that materials play an essential role in product development in today's world. We want to enable ambitious entrepreneurs to take part in and benefit from the innovation dynamic that characterizes our network. And we know that once entrepreneurs have found their way to DPI Value Centre, they will come to us again – and again.

Arie Brouwer
Managing Director, DPI Value Centre

European project: **SEAFRONT**

The third European project coordinated by DPI within the Seventh Framework Programme of the European Commission started in January 2014. The goal of the SEAFRONT (Synergistic Fouling Control Technologies) project is to develop environmentally friendly coatings which prevent the undesirable accumulation of marine organisms on boats, ships, tidal power plants, fisheries and other aquatic installations. The coatings will be designed to improve operational efficiency, substantially reduce CO2 emissions and have no negative impact on the marine ecosystem. DPI and AkzoNobel are the main contractors of the EU project.

New coatings

The fouling control coatings to be developed within the project will not leach chemical or other harmful substances that are non-biodegradable in the marine environment. In addition, the coatings will reduce the hydrodynamic resistance of ships and boats, decreasing fuel consumption and thus substantially reducing CO2 emissions. Finally, the new coatings will lead to considerable savings in operational costs by improving the efficiency of tidal power installations and reducing the frequency of maintenance and cleaning in off-shore infrastructure and aquaculture applications.

Project team

The SEAFRONT project will be implemented within the Seventh Framework Programme (FP7) under the Ocean of Tomorrow call. Five multinationals, seven SMEs and seven research institutes spread across eight EU Member States will work together to achieve the goals within the four-year timeframe. DPI is the project coordinator and International Paint Ltd., a business unit of AkzoNobel and a world leader in the field of fouling control coatings, will bring any new coatings based on technology developed within the project to the market. In focusing on the delivery of sustainable products and solutions, the goals of this project perfectly match the strategic ambitions of AkzoNobel. The project budget amounts to 11.2 million Euros including 8 million Euros from the European Commission.

Scope

In addition to the development of environmentally friendly coatings, SEAFRONT aims to significantly enhance the fundamental understanding of fouling organisms and the mechanisms of settlement and adhesion. Particular attention will be paid to a better understanding of marine biofilm or so-called marine slime. This part of the research will be led by Professor Tony Clare of Newcastle University (UK), an internationally renowned marine biologist. The insights gained in these studies will enable SEAFRONT to develop concepts and technologies for enhanced performance, the ultimate goal being a completely non-fouling surface.

More information about this project can be found on the website:
www.seafront-project.eu

European project: **SHINE**

SHINE is a Seventh Framework Programme project which aims for the development of self-healing elastomers for dynamic seals and vibration and noise abatement systems. It will consider the concept on the basis of covalent and non-covalent bonding, which can provide a repeatable healing response as a result of reversible reactivity. SHINE will investigate both the healing mechanisms of pure elastomers and composites made of elastomers.
The methods for the design of these types of elastomer, tailor-made fillers and self-healing composites are given in a systematic manner. The SHINE project is intended to develop elastomers with mechanical properties comparable to conventional ones (with 60% recovery of the initial properties after healing), repeatable self-healing (preventive versus curative healing), operable at room temperature and without human intervention. If successful, the impact of the SHINE project will reduce transportation costs by reducing the maintenance burden of infrastructures.

The consortium consists of two universities, four research centres, five large companies and one SME. All the partners combine their expertise and competences to develop innovative self-healing elastomers.

The project has started on 1 February 2013 with a total budged of 6.4 M€, with 4 M€ contribution of the EU. The project will end 31 July 2016.

The first dissemination has taken place, in the form of a publication and posters on various conferences, related to the development of new poly-urethane materials with very efficient self-healing properties.

More information about this project can be found on the website:
www.selfhealingelastomers.eu

European project: **COMPNANOCOMP**

The European COMPNANOCOMP project started in October 2011. The aim of the project is to develop multiscale simulation methodology and software for predicting the morphology (spatial distribution and state of aggregation of nanoparticles), thermal (glass temperature), mechanical (viscoelastic storage and loss moduli, plasticity, fracture toughness and compression strength), electrical and optical properties of soft and hard polymer matrix nanocomposites from the atomic-level characteristics of their constituent nanoparticles and macromolecules and from the processing conditions used in their preparation.

The novel ground-breaking modelling methodology should significantly improve the reliable design and processability of nanocomposites contributing to the EU Grand Challenges for reduction of CO_2 emission, energy savings by light-weight high-strength nanocomposites, mobility and improved living environment. The successful outcome of the project will constitute an important advance in the state of the art and will have immediate industrial, economic and environmental impact.

The COMPNANOCOMP initiative consists of two collaborative projects being executed by an EU consortium (8 partners) under the Seventh Framework Programme and and a Russian consortium (4 partners) under the auspices of the Federal Russian government. DPI is acting as the coordinator of this project and Denka Hristova-Bogaerds is the Project Leader.

The project progresses successfully and is now in its final phase (with end date 30 September 2014). The results generated within the cooperative project are continuously presented at well-known in the field conferences and published in highly ranked journals:

Some recent publications from the project:

G.G. Vogiatzis and D.N. Theodorou, *"Local Segmental Dynamics and Stresses in Polystyrene–C60 Mixtures"*, Macromolecules, 2014, 47, 387–404

D.V. Guseva, P.V. Komarov and A. V. Lyulin, *"Molecular-dynamics simulations of thin polyisoprene films confined between amorphous silica substrates"*, J. Chem. Phys, 2014, 140, 114903

More information about COMPNANOCOMP project can be found on the website: **www.compnanocomp.eu**

SEVENTH FRAMEWORK PROGRAMME

Retirement Martien Cohen Stuart - Personal note

As of January 1st, 2014 I am no longer scientific director of DPI; Prof. Sybrand van der Zwaag is now in charge. Over the past five years, the world around DPI has changed quite a bit; the economy had pretty rough times. I joined in 2009, a few months after the fall of Lehman Brothers and the outbreak of the financial crisis. The market for scientific and technical jobs plunged and DPI saw a run on its vacant positions for PhD research. DPI also put out a helping hand to implement an emergency plan of the Dutch government to prevent massive lay-offs in the industry, the so-called 'kenniswerkersregeling'. Much to our delight, companies did not dump their DPI participations, and the tidal wave passed by without too much damage. It was also clear that DPI had to continuously revisit its working model to remain relevant for public-private collaboration. New ideas hatched within the DPI team; the strategy was revised and the international aspect was emphasized more. This led to agreements with China and Brazil, and to several successful proposals to EU programmes. The dynamic environment that DPI finds itself in calls for a competent and flexible team that can easily switch between various kinds of activities, and has the creativity to find solutions. The DPI as it developed over the past few years has those qualities, and it has been a great pleasure for me to be part of it. Even though saying farewell has a tinge of sadness, I am happy to see that DPI is alive, that new initiatives are taking shape all the time (such as the start-up of a new area on biomedical polymers), that the quality of science meets high standards, and that the polymer industry is very supportive. I therefore wish DPI a healthy future and a key role in the 'art of connecting'. It simply deserves it!

Martien Cohen Stuart

DPI and all DPI staff would like to thank Martien Cohen Stuart for his inspirational leadership as DPI's Scientific Director and for being such a pleasant colleague to work with. We wish him all the best for a long and healthy retirement!

DPI Annual Meeting 2013
embedded in successful three-day event

The DPI Annual Meeting 2013 was held as part of a three-day event that took place at the Papendal conference centre in Arnhem (Netherlands) on 4-6 November.

In a departure from the set-up of previous years, the organisers had opted for a combined programme including the Annual Meeting, the Young DPI Meeting, the Technology Area review meetings, the Programme Committee meetings, the meeting of the Council of Participants as well as the DPI Value Centre's Polymer Innovation Day.

The Young DPI meeting was attended by a record 45 scientists from different countries ranging from Germany to China and Brazil. Besides sharing some practical information with the participants, DPI wanted to give the young researchers an opportunity to get to know one another in a "fun and learning" setting. The young scientists thoroughly enjoyed the session, which focused on various aspects that play a role in working in an international environment, such as finding a common mode of communication in a culturally and linguistically diverse group, building mutual trust and making the most of networking opportunities.

Annual Meeting

The Annual Meeting was attended by some 240 people. Chaired by Martien Cohen Stuart, Scientific Director of DPI, the meeting featured lectures by renowned guest speakers Professor Ludwik Leibler of the ESPI ParisTech, who spoke on the subject of vitrimers, novel organic materials made of molecular networks with original properties; and Professor Han Meijer of Eindhoven University of Technology, who spoke about "One-step Creation of Hierarchical Fractal Structures with Thermoplastic Materials". The two lectures represented two very different ways of looking at materials: Professor Leibler from a highly imaginative and original perspective and Professor Meijer from a highly technical and almost formalistic approach.

During the Annual Meeting, Prof. Sybrand van der Zwaag, who succeeded Martien Cohen Stuart as Scientific Director of DPI as of 1 January 2014, introduced himself to the DPI community. Jacques Joosten gave a presentation highlighting DPI's progress and also touching on the challenges ahead. At the close of the Annual Meeting, the Golden Thesis Award was presented to Nicole Franssen for her thesis entitled "Functional (Co)polymers from Carbenes – Scope, Mechanism and Polymer Properties". Nicole, who did her PhD work at the University of Amsterdam under the supervision of Prof. Bas de Bruin, currently works at Shell Global Solutions in the Netherlands. The jury unanimously selected Nicole Franssen as the winner from among the three candidates nominated for the award. The other two candidates were: Jeroen Cottaar, of Eindhoven University of Technology, and Danquing Liu, of the same university.

The jury found the research work of all three nominees to be of an excellent quality, and their presentations too of a high professional level. In its report, the jury commended the first-prize winner for her excellent work and declared: "We unanimously congratulate Dr. Nicole Franssen for her innovative polymer chemistry, leading to polymers that cannot be made in any other way. The chemistry has been skilfully elaborated and the work also involves advanced structural characterisation."

GOLDEN THESIS AWARD 2013
Jeroen Cottaar, Danqing Liu, Scientific Director Martien Cohen Stuart, winner of the award Nicole Franssen and the jury: Katja Loos, Ilja Voets and Han Meijer.

CERTIFICATES OF INVENTION 2013
The winners of the Certificates of invention including Scientific Director Martien Cohen Stuart and Chairman of the Supervisory Board Herman van Wechem.

Poster Award

The Annual Meeting was followed by the conference dinner, a convivial gathering of some 280 people. During the dinner, Professor Martien Cohen Stuart announced the names of the winners of the Poster Award. The First Prize went to Laurens Polgar of the University of Groningen. The second prize was granted to Karel Wilsens of Eindhoven University of Technology and the third to Qingbao Guan of Delft University of Technology.

Polymer Innovation Day

The Polymer Innovation Day 2013, held under the auspices of DPI Value Centre and attracting over 300 people, centred on the theme "How Can Polymers Work for You?". The meeting targeted SMEs, start-ups and multinationals and aimed to promote collaboration among these players on innovation in the field of polymers.

YOUNG DPI 2013

Participants were offered an extensive, full-day programme of presentations and discussionson three very topical subjects: bio-based materials, the circular economy and so-called superior materials. Speakers from both established and new companies in each of these three clusters were invited to tell about their recent innovations and business.
For most of them DPI Value Centre had played a valuable role in supporting their innovation projects or their new business. In order to ensure that the focus througout the day remained on the content, cases or challenges were highlighted in short, to-the-point presentations and the audience were invited to help find solutions. To enable broader discussions and one-on-one exchanges with the speakers, a business market was set up where people could meet and build networks.

The day's programme included a keynote lecture entitled "Polymer Research in the European Context: Horizon 2020 – a chance or a challenge for the European plastics industry?" by Prof. Jan Diemert of the Fraunhofer Institute for Chemical Technology. In this lecture, Prof. Diemert gave an overview of European research in the polymer industry, covering some examples of successful projects in the past, the way they were established, how they have contributed to innovation and how pitfalls can be avoided. He also spoke about the so-called Horizon 2020 funding programme of the European Union and the chances and challenges it presents to the plastics industry.

It was clear from the animated discussions that took place during the breaks and the lively interactions at the business market that the Polymer Innovation Day was a great success. Arie Brouwer, director of DPI Value Centre: "Many participants told me enthusiastically how they were able to establish new, often unpredictable or even unimaginable, contacts. It is surprising to see again and again that there is always scope for making new valuable connections and that there are so many new initiatives by new players entering the field, often via niches they have discovered. That's exactly our aim: to offer our participants the opportunity to discover new possibilities for partnerships and to gain insights into new developments in science and innovation. We will continue to serve our lively community and make every effort to ensure that the Polymer Innovation Day remains a valuable happening."

Research for mass production

Workshop 'From Processing to Performance', 24 January 2013

Fifteen years ago, when DPI was launched, researchers were mainly involved in the chemistry of polymers. At that time, the most important issue was: How to make polymers with the desired properties? Now that more and more working lab prototypes of applications are being realized, attention also has to be paid to the processing of the polymers – preferably in a way that allows scaling up for mass production. This was the subject of DPI's annual cross technology area workshop in 2013.

Inkjet printing

The first speaker to address this subject was Professor Detlef Lohse of the Physics of Fluids group of the University of Twente, the Netherlands. His research group is trying to unravel how air bubbles in piëzo-driven inkjet printers disturb the printing behaviour and how these can be prevented from occurring. He showed how, with the help of the acoustical signal that the piëzo-electric device generates and a model of the acoustical channel, the size and the position of the bubbles can be determined. Apparently they arise at an active nozzle when a thin film of ink on the printer head interacts with the droplet, or in places where dust particles affect the surface tension of the fluid. Lohse: "A coating on the nozzle surface may prevent the formation of air bubbles." Another aspect that is being investigated is how to break up air bubbles once they have formed so that normal operation can resume and the printer does not have to be stopped and restarted. The answer is to apply an external acoustical signal. Finally, Lohse discussed the impact of the droplet on a surface; at some velocities it bounces back and does not wet the surface in the desired way. These results are of course very relevant when inkjet printers are used for printing polymer layers, for instance in OLEDS. Polymer solutions have properties that are not so well known as those of ink and are not easy to measure, so a method to prevent such problems from occurring is vital.

Coatings

The next speaker, Dr. Ulrich Nolte of the coatings company Altana, discussed two of his current research projects. Surface-active additives are used to improve coatings; they increase the pigment stability, avoid foam bubbles and improve the levelling of the coating. Polysiloxane modified with polyethylene oxide in the same proportion but in different architectures – linear chains, AB or ABA, or comb-like structures – results in changes in surface tension and in sliding force along the surface. The hypothesis is that the polysiloxane prefers the surface of the coating while the polyethylene is probably found in deeper layers. Nolte hopes to find – in cooperation with DPI – a method to test this hypothesis. The question Nolte would like answered is: "Which scientific measuring methods can help us to understand what happens at the surface during the curing process?" In the second project the effect of adding silica particles to a coatings system to improve the mechanical properties is being investigated. Measurements of the gloss, the scratch resistance, the indentation and the E-modulus dependent on the weight percentage of the added particles result in the hypothesis that the interaction between the particles in the matrix might play a role. DPI could perhaps help by suggesting methods to determine both the mechanical properties on a micro-scale close to the particles and the gradients in polymer density. "We have all kinds of methods to describe the macroscopic behaviour of our coating system, but simply lack the microscopic insight to make a good model that would help us to predict effects in coatings," is how Nolte summarizes the needs of his company.
In the discussion immediately after the presentation already a few useful suggestions (XPS, AFM) came up.

Spin coating

Next Dr. Jasper Michels from the Holst Centre discussed his research on the spin-coating process used to make solar cells on a lab scale in all its details in order to be able to translate this into real production processes such as roll-to-roll slot coating or inkjet printing. In solar cells the morphology is the key performance parameter – the size of the interface between the donor and acceptor domains determines the amount of charge carriers to be generated. It is therefore important to control that morphology and to be able to predict the device characteristics once you know which morphology you have made. In processing from solution, both crystallization and de-mixing of the two components – donor and acceptor material – play a role. Michels concludes: "There is not really a good method for monitoring what is happening in situ in the spin coating process, but I am glad to see that initiatives in that direction are being taken at DPI."

Overview

Prof. Anton Darhuber of the Physics Department of the Eindhoven University of Technology gave an interesting overview of solution processing of organic electronic materials. Spin coating is an inexpensive method resulting in layers of uniform thickness but unfortunately it is a slow batch process, incompatible with a roll-to-roll continuous process. Besides, it also involves a great deal of wastage of material. Possible alternatives are slot-die coating (roll width 4 m, speed 10 m/s), ink jet printing (roll width 5 m, speed 3.3 m/s), and dip-coating. In this latter method the surface is patterned with hydrophilic and hydrophobic materials and the liquid sticks to the hydrophilic parts. A problem that arises are satellite droplets. Darhuber: "These can be avoided by orienting the structures to be patterned in such a way that the last part of the object is taken out of the liquid at a sharp angle." In inkjet printing, striations in lines occur if the droplets are not close enough; line spacing has an optimum at about 200 μm, at smaller spacings, one begins to see overlap. Uniformity of the line over its width and the levelling time can be influenced by adding surfactants and by controlling the drying process actively (to avoid the coffee stain effect) by a non-contact and material-independent process with an infra-red laser and a multi-mirror device. Mirrors can be moved individually, so an IR pattern can be projected on the 2 by 2 cm sample to be dried.

Melt flows

In his lecture Professor Han Meijer of the Mechanical Engineering Department of the Eindhoven University of Technology explained how by splitting and combining polymer melt flows by simple mechanical means – valves, flow splitters, counter- and co-rotating elements – layered structures can be made. Layers can be made both parallel and perpendicular to a substrate surface, and even treelike structures with 'branches' and 'leaves' can be made. Films can be made as thin as 20 nm by stretching them after deposition. Applications that Meijer has in mind are photovoltaic cells and membranes for fuel cells. Meijer concludes: "Controlled organisation by mechanical means beats self-organisation by chemical means." In this setting with many chemically oriented researchers, this is a challenging thing to contend and it indeed gave rise to a discussion during which Meijer resolutely rejected all processes in which solvents were to be used.

Nucleation

Marcus Gahleither from Borealis, initially a producer of polyolefins, talked about how polypropylene is produced in his company. Polypropylene can, depending on the processing conditions, be produced in at least three different crystalline phases, called β, α and γ modifications, for high impact strength, high stiffness and good transparency, respectively. If these are produced from solutions, nuclei in a well-defined dispersion are needed. For different applications mixtures of these modifications can be produced by combining different reactors or by producing the polypropylene with distinct peaks in the molecular weight distribution, as a result of which crystallization takes place in these three phases. Temperature variations during processing and cooling-down have an influence on the end-result. Gahleither: "An important application is the replacement of old concrete sewage pipes by polypropylene ones. The latter can withstand earthquakes for instance and their stiffness – and other properties – can be adapted, also by changing the percentage of different modifications, to the needs of the soil in which they will be used. On top of that polypropylene pipes do not lose waste water; in concrete pipes sometimes up to 30% of the sewage water can escape." Another interesting application is the replacement of polycarbonate baby bottles containing toxic bisphenol A by bottles made from γ polypropylene.

Composites

Professor Theo Dingemans of the department Novel Aerospace Materials of Delft University of Technology studies composite materials. In aerospace materials research, the quest is always for lighter materials with good thermal and mechanical properties. Polymer resins with nanotube fillers are materials that are presently used in such applications. Commodity polymers have the disadvantage that their quality is difficult to control. Dingemans and his researchers therefore looked at high performance polymers, such as polyetherimides, combined with carbon nanotubes. They found that making the dispersions of the carbon nanotubes is precision work. These polymers are often initially amorphous but adding small amounts of carbon nanotubes can induce crystallinity and thus enormously improve the thermal and mechanical properties of the films. Surprisingly, even the form of the flask and the frequency of stirring when making the dispersion have an influence on the end result.

Vitrimers

The final speaker was Professor Ludwik Leibler of the Ecole Supérieure de Physique et Chimique Industrielle (ESPCI). He gave a presentation about a new class of polymers, which he and his co-workers call vitrimers, with properties in between those of thermoplastic and thermoset materials. Permanently cross-linked polymers have good mechanical properties and are insoluble once processed, but they cannot be reshaped. Non-cross linked polymers and polymers with reversible cross-links are processable but soluble. The new polymers, vitrimers, are both processable and insoluble and can be processed locally: complex shapes can be made by forging and welding, without the need for using moulds. The number of crosslinking bonds remains constant but the topology of the networks changes. Leibler: "The key is to design the chemistry so that at high temperature, exchange reactions enable stress relaxation and malleability, and upon cooling, the exchanges become so slow that the topology of the network is essentially fixed and the system behaves like a (stable) soft solid." Objects made of such polymers can be grinded, melted and reused for new products with the same quality, very much like ordinary silicate glass, but at much lower temperatures. In the discussion that followed vitrimers were seen as versatile materials because of these possibilities of recycling and reparability. Whether complete regeneration after fatigue damage is possible remains to be seen - an aspect that has not yet been studied.

In some of the methods discussed, solutions of polymers are used. The kind of solvent used, the deposition and the drying method all appear to have an influence on the ultimate function the polymer has to perform. In other methods, melts of polymers are used and here too the properties of the polymers depend on the way the devices are produced from the melts by mechanical means. The main conclusion: designing polymers with desired functionalities is not enough, the processing has to be taken into account as well. The 80 participants in the workshop learned from one another's experience in this field. At the end of the day, that is exactly why DPI organizes these workshops.

POLYOLEFINS

Polyolefins (PO) are the only class of synthetic macromolecules that can be produced catalytically with precise control of stereochemistry and, to a large extent, of (co)monomer sequence distribution. Therefore, as with the letters of the alphabet, the number of constituent elements which can be assembled into meaningfully organised structures is practically infinite and, accordingly, scope of application of polyolefins is continually growing.

OBJECTIVES

Polyolefin-based materials can be customised for a wide range of applications: from ultra-rigid thermoplastics to high-performance elastomers. This vast spectrum of performance is achieved by a variety of polyolefin molecular structures, whose common features are full atom economy in their synthesis, low cost, excellent properties, a long life cycle and ease of recycling. The research programme of the Polyolefins technology area encompasses the entire spectrum of the knowledge chain, the aim being to increase proficiency in the ever-expanding applications. Although polyolefins represent one of the oldest (if not the oldest) thermoplastic polymer families, they are still very much characterised by continuous innovation. Both gradual and step change technology renewal yield new applications and reduce the manufacturing- and user eco-footprint. The recent discovery of chain shuttling catalyst systems that enable the industrial production of polyolefin block (co)polymers with unprecedented structures, usable for a wide range of applications (from thermoplastic elastomers to optically active materials) is yet another illustration of this innovative capacity.

SUB-PROGRAMMES

Catalysis
Investigating, screening and developing (novel) homogeneous and heterogeneous catalyst systems, as well as new approaches for the immobilisation of molecular catalysts, new co-catalysts and activators.

Polymer structure, properties and processing
Understanding, modelling and predicting structure-processing property relationships in polyolefin-based polymer systems.

Polymer reactor engineering
Studying various reactor and technology unit operations to develop a quantitative description and acquire a thorough understanding of the crucial aspects of olefin polymerisation processes.

New methods and exploratory research
New polymerisation and polymer characterisation methods, high-throughput screening and experimentation, embryonic research and concept development.

Budget and organisation
Expenditure in 2013 totalled € 2.69 million (budget: € 3.00 million). A total of k€ 6 was spent on equipment. The total number of FTEs allocated at year-end 2013 was 29.8 (51 researchers). Prof.dr. Vincenzo Busico acted as Scientific Chairman and Dr. Jan Stamhuis as Programme Area Coordinator of the Polyolefins programme.

Publications and inventions
This technology area generated a total of 21 reviewed papers and four theses.

FACTS AND FIGURES

Partners from industry
- Borealis
- Braskem
- Dow Benelux
- DSM
- ExxonMobil
- ITRI
- Lanxess Elastomers
- LyondellBasell
- Petrobras
- Sabic
- SCG Chemicals
- Sinopec
- Symyx
- Teijin Aramid
- Ticona
- Freeslate

Partners from the research world
- Consorzio Interuniversitario Nazionale per la Scienza e Technologia die Materiali (INSTM)
- Eindhoven University of Technology
- ESPCE-Lyon
- Fraunhofer Institute for Structural Durability and System Reliability LBF
- Japan Advanced Institute of Science and Technology
- Johann Kepler University Linz
- Karlsruhe Institute of Technology
- Loughborough University
- Martin-Luther University of Halle-Wittenberg
- National Council for Scientific and Technological Development (CNPq)
- Polymer Technology Group Eindhoven
- Queens University
- Radboud University Nijmegen
- UFRGS Universidade Federal do Rio Grande do Sul
- Universidade Federal do Rio de Janeiro
- University of Amsterdam
- University of Antwerp
- University of Erlangen
- University of Manitoba
- University of Naples Federico II
- University of Ottawa
- University of Perugia
- University of Salerno
- University of Turin
- University of Udine

For details, see page 36.

PERFORMANCE POLYMERS

Performance Polymers (PP) have considerable potential to contribute to reducing energy use, environmental impact and the effects of climate change through component consolidation, weight reduction, lifetime extension, recyclability and utilisation of renewable feedstock and create new opportunities for the construction, transport, appliances and electronics industries.

OBJECTIVES

The Performance Polymers (PP) technology area combines Engineering Polymers and Rubber Technologies and is positioned between bulk plastics and specialty polymers such as functional polymer systems. Performance polymers possess improved chemical, mechanical and physical properties, especially beyond ambient conditions. They are applied as material systems under (cyclic or continuous) load-bearing conditions and frequently consist of multi-component mixtures with various polymers, reinforcements and additives.

The performance requirements of complex parts and assemblies in polymer materials necessitate close technological cooperation between polymer supplier, converter and end user. That in turn calls for a thorough understanding of polymerisation and polymer modification, as well as the processing, properties and design of polymer systems. Moreover, the wide variety of base polymers in this technology area demands a special effort to identify commonality in those themes along the value chain. This is reflected in the strategy and objectives of the Performance Polymers technology area, which include investigation of fundamental issues in the value chain using a 'chain of knowledge' approach in terms of energy saving, durability, ultimate performance and sustainability.

SUB-PROGRAMMES

Polymer and network chemistry and modification
Studies aimed at expanding the use of bio-based materials, by identifying their unique properties and reducing their eco-footprint. Further studies are designed to reduce the costs and energy use in polymerisation. Other objectives are network formation and the development of new concepts for monomer polymer molecular structure to achieve gradual changes in the balance of flow properties, static and dynamic mechanical behaviour and other functional properties.

Processing for properties, polymer physics and modelling
Understanding the relationship between the molecular structure, processing and properties of polymers. Studies of the processing effects of intermolecular interactions, e.g. hydrogen bonding. Processing, modification and vulcanisation studies of elastomer blends. Studies of complex flow behaviour, e.g. in particle reinforced visco-elastic materials.

Advanced reinforced thermoplastics and synthetic fibres
Studies of the interface effects in fibre-reinforced composite systems, the effects of nano-reinforcement on polymer material properties on macroscopic and microscopic scale with a focus on the effects at the matrix-filler interface, friction and wear studies of fibre-reinforced thermoplastics and elastomers.

Long term stability and performance
Investigation of the chemical and physical ageing mechanisms and their interaction, with the ultimate objective of predicting lifetime and attaining a fit-for-purpose design over the entire lifecycle. Studies of self-healing in polymeric materials as paradigm shift to realise improved fit-for purpose lifetimes.

FACTS AND FIGURES

Partners from industry
- AkzoNobel
- BASF
- Bayer
- Bekaert
- DSM
- Sabic
- SKF
- Teijin Aramid

Partners from the research world
- CNRS Strasbourg
- Delft University of Technology
- DWI an der RWTH Aachen
- Eindhoven University of Technology
- Fraunhofer Institute for Structural Durability and System Reliability LBF
- National Technical University of Athens
- University of Goningen
- University of Twente

Budget and organisation
Expenditure in 2013 totalled € 1.49 million (budget: € 2.03 million). A total of k€ 60 was spent on equipment. The total number of FTEs allocated at year-end 2013 was 13.9 (20 researchers). Prof.dr. Costantino Creton acted as Scientific Chairman and Ronald Korstanje acted as Programme Area Coordinator of the Performance Polymers programme.

Publications and inventions
This Technology Area generated a total of 28 reviewed papers and four theses; two inventions were reported and two patent applications were filed.

Detailed information on page 37.

FUNCTIONAL POLYMER SYSTEMS

The Functional Polymer Systems (FPS) Technology Area performs research on polymers, small organic molecules and their prototype devices that are capable of an electrical, optical, magnetic, ionic or photo-responsive function and that offer potential for industrial application.

OBJECTIVES

The FPS research programme is structured along application lines in the following sub-programmes: polymer lighting and field-effect transistors; polymers for information and communication technology; solar cells (photovoltaics); and responsive materials, (bio)sensors and actuators.

SUB-PROGRAMMES

Polymers for information and communication technology
The objective of this sub-programme is to develop scalable techniques for structuring polymers on a nano- and micro-scale by combining 'top-down' approaches with 'bottom-up' techniques based on self-assembly or supramolecular chemistry in order to produce new or greatly enhanced properties for optical, electrical, biomedical and sensor applications. Research projects are focusing on IR-reflective windows, membranes with controlled pore-size and responsive surfaces making use of the available patterning tools.

Photovoltaics (PV)
This area is dedicated to exploring new materials and gaining a fundamental understanding of all (photo-) physical processes occurring in polymer and small organic molecule bulk heterojunction PV. Organic PV is one of many promising PV technologies offering the prospect of large area cost-effective PV for sustainable energy production in the long term. The research focuses on novel low-bandgap materials, hybrid (inorganic-organic) blends, stable materials under ambient conditions, non-radiative decay processes, efficient charge separation, morphology control, tandem solar cells and a thorough understanding of materials behaviour under operational device conditions.

Responsive materials and functional membranes
The purpose of the research is to develop new materials and processes that result in a change of shape and/or large displacement upon an external electrical, magnetic, optical and/or chemical trigger. Research projects focus on new piezo-electronic materials, membranes with controlled nano-pores, switchable surfaces and antireflective coatings.

FACTS AND FIGURES

Partners from industry
- BASF
- DSM
- ECN
- Industrial Technology Research Institute Taiwan
- Philips
- Rolic Technologies
- Sabic
- Solvay
- TNO

Partners from the research world
- Delft University of Technology
- ECN
- Eindhoven University of Technology
- Imperial College London
- Nanoforce Technology
- University of Groningen

Budget and organisation
Expenditure in 2013 totalled € 1.40 million (budget: € 1.59 million). A total of k€ 5 was spent on equipment. The total number of FTEs allocated at year-end 2013 was 12.1 (27 researchers). Prof.dr. Frans de Schryver acted as Scientific Chairman and Dr. John van Haare as Programme Area Coordinator.

Publications and inventions
The research programme in this Technology Area generated a total of 18 reviewed papers and five theses. Three inventions were reported and one patent application was filed.

For details, see page 39.

COATINGS TECHNOLOGY

Within the Coatings Technology (CT) area frontier research in the general field of organic coatings is performed. The aim is to develop fundamental insights that will lead to innovative coatings technologies, The research is pre-competitive and is focussed at achieving sustainability, quality of life improvements, economic growth and preparing the coatings industry for future challenges.

OBJECTIVES

The research programme for Coatings Technology (CT) concentrates on exploring novel coating materials and technologies and acquiring fundamental insights into the structure-properties relationships of coatings to enable the coatings industry to meet future challenges. The research programme is based on three pillars: renewable raw materials and novel, environmentally friendly coating technologies; functional (smart) coatings; durability and testing of coatings.

SUB-PROGRAMMES

Renewable raw materials, formulation and powder coatings
There are currently three projects underway to study the feasibility of applying sustainable, renewable resources in coatings technology without compromising the properties of the final coating (film). The programme focuses on bio-based building blocks and raw materials as substitutes for materials derived from petrochemistry and their use in novel coating technologies. Systems being studied include polycarbonate powder coatings or waterborne polyurethane dispersions, as well as starch-based performance coating materials. The results are promising in that coatings have already been obtained which match and/or improve on the properties of purely synthetic coatings.

Functional (smart) coatings
'Smart coatings' are capable of responding to an external stimulus, such as light, temperature, pressure, pH, odours or gas. The stimulus causes a change in the coating's properties which may be permanent or reversible. Coatings with self-healing properties in response to mechanical damage or with light- or moisture-induced self-cleaning properties are of particular interest and have already been studied. Research on protective coatings that can adapt to their environment and/or conditions under which they are used is at the embryonic stage, but such systems, as well as tailored coatings for medical diagnostics (e.g. test strips) and implants, seem feasible in the future. The same applies for coatings with special optoelectronic and electronic properties that could be used in electronic devices and information technology.

Durability and testing of coatings
The aim is to gain a fundamental understanding of the degradation mechanisms of coatings used in outdoor exposure to enhance durability. Another objective of this sub-programme is to develop new testing methods for coatings, e.g. methods for testing adhesion, gloss or scratch resistance, which correlate to meaningful physical parameters. Last but not least, DPI collaborates intensively with the Materials Innovation Institute's 'Materials to Innovate' (M2i) programme in the study of anti-corrosion coatings.

FACTS AND FIGURES

Partners from industry
- AkzoNobel
- Altana
- DSM
- Lawter
- Saint-Gobain

Partners from the research world
- Changchun Institute of Applied Chemistry
- Eindhoven University of Technology
- University of Haute-Alsace
- Wageningen University

Budget and organisation
Expenditure in 2013 totalled € 1.04 million (budget: € 1.11 million). A total of € 128k was spent on equipment. The total number of FTEs allocated at year-end 2013 was 13.5 (17 researchers). Prof. Claus Eisenbach acted as Scientific Chairman and Dr. Mercedes Crego Calama as Programme Area Coordinator of the Coatings Technology programme.

Publications and inventions
The research programme in this Technology Area generated a total of five reviewed papers, one thesis and one invention was reported.

For details, see page 40.

HIGH-THROUGHPUT EXPERIMENTATION

High-Throughput Experimentation (HTE) and combinatorial materials research open the way to the rapid construction of libraries of polymers, blends and materials through systematic variation of composition. Detailed characterisation of such libraries will help to develop an in-depth understanding of structure property relationships.

OBJECTIVES

In the long term, it is envisioned that 'materials informatics' will facilitate the design and preparation of customised materials and devices with predetermined properties based on previously established structure-property relationships. DPI's unique combination of leading industrial and academic partners provides an excellent basis for successful output. It also guarantees early pre-competitive evaluation of the new (platform) technologies and their rapid transfer into the commercial R&D programmes of the industrial partners.

SUB-PROGRAMMES

Synthesis, catalysis & formulation
Besides fundamental research on the use of microwave irradiation, studies are conducted into the feasibility of scaling up microwave assisted polymerisation procedures. The synthesis efforts have been intensified in the direction of water-soluble polymers. In addition to fast synthesis and formulation platforms, other subjects being investigated include the incorporation of high-throughput screening techniques for molar mass, polymerisation kinetics and thermal and surface properties.

Thin-film library preparation & screening
This sub-programme focuses on gaining a detailed understanding of thin-film preparation technologies, the application of these technologies and the screening of thin-film material properties with automated atomic force microscopy and nano indentation technologies. Areas of application include the processing of light emitting materials, surface patterning, cell screening and the preparation of conductive tracks on polymeric substrates.

Combinatorial compounding
The objective is to develop a process to accelerate the preparation, characterisation and optimisation of plastic formulations. The combinatorial extrusion line used for this purpose has been equipped with in-line and on-line screening techniques (e.g. IR, UV/Vis, rheometry, ultrasonic spectroscopy) as well as systems for data acquisition, analysis and visualisation.

Materials informatics & modelling
This programme concerns data handling, database construction and the build-up of integrated knowledge capture systems for combinatorial materials and polymer research as well as experimental design, hard and soft modelling tools and tools for deriving quantitative structure-property relationships. A model is being developed for the screening of MALDI matrices to facilitate faster screening of molar mass.

Characterisation techniques
This sub-cluster is engaged in the development of detailed characterisation methods. An important aspect of the research is the combination of different measurement techniques to characterise multiphase or multi-component materials at macro, micro and nano scale. Another focal point is the analysis of branched polymers by means of two-dimensional liquid chromatography. Tools and models for nano scale characterisation of interfaces using AFM technology are also being developed.

FACTS AND FIGURES

Partners from industry
- Chemspeed
- Evonik
- Forschungsgesellschaft Kunststoffe
- Michelin
- Microdrop Technologies

Partners from the research world
- Fraunhofer Institute for Structural Durability and System Reliability LBF
- Friedrich-Schiller University, Jena
- Radboud University

Budget and organisation
Expenditure in 2013 totalled €0.72 million (budget: € 0.65 million). The total number of FTEs allocated at year-end 2013 was 7.1 (13 researchers). Prof.dr. Ulrich Schubert acted as Scientific Chairman and Dr. Mercedes Crego Calama as Programme Area Coordinator.

Publications and inventions
This Technology Area generated a total of 47 reviewed papers. Three inventions were reported and one patent application was filed.

For details, see page 41.

BIO-INSPIRED POLYMERS

Within the Bio-Inspired Polymers (BIP) programme, the main driver for the development of future materials is sustainability, with nature being regarded as an important source of inspiration for finding new leads and possibilities.

OBJECTIVES

The aim of the Bio-Inspired Polymers (BIP) programme is to develop advanced polymeric materials and methodologies for new and existing applications. The development of these materials is inspired by natural polymeric structures and principles of natural systems such as self-assembly and bio-catalysis.

Bio-Inspired Polymers can be produced from renewable or fossil resources through either chemocatalysis or enzymatic/microbial catalysis. The structure-property relationships of the novel materials are studied to elucidate why they exhibit unique properties. One important line of research is intended to develop a generic toolbox for new bio-based polymers with a view to creating new business opportunities. Aspects addressed by a bio-based polymer programme include the identification of new or improved (multi-)functionalities of bio-based building blocks and polymers and the assessment of relevant technologies in the bio-based value chain.

FACTS AND FIGURES

Partners from industry

- Food and Biobased Research, Wageningen UR
- FrieslandCampina
- Petrobras
- Sabic
- Teijin Aramid

Partners from the research world

- Eindhoven University of Technology
- Food and Biobased Research, Wageningen UR
- Friedrich-Schiller-University Jena
- National Council for Scientific and Technological Development (CNPq)
- Tsinghua University
- Universidade Federal do Rio de Janeiro

Budget and organisation

Expenditure in 2013 totalled € 1.20 million (budget: € 1.22 million). A total of € 41k was spent on equipment. The total number of FTEs allocated at year-end 2013 was 8.8 (19 researchers). Prof.dr. Gerrit Eggink acted as Scientific Chairman and Dr. Peter Nossin as Programme Area Coordinator of the Bio-Inspired Polymers Technology Area.

Publications and inventions

The research programme in this Technology Area generated a total of ten reviewed papers and two theses. Four inventions were reported and three patent applications were filed.

For details, see page 43.

LARGE-AREA THIN-FILM ELECTRONICS

Large-Area Thin-Film Electronics (LATFE) is the step in the value chain devoted to studying fundamental issues related to processing for large-area deposition and disruptive architectures for large-area organic electronic devices. Large-Area Thin-Film Electronics is an excellent example of a highly interdisciplinary research area, extending from chemistry and physics to engineering.

OBJECTIVES

Whereas Functional Polymer Systems (FPS) focuses on materials development and initial device performance, Large-Area Thin-Film Electronics (LATFE) is the obvious next step in the value chain. The fundamental knowledge generated should facilitate the reliable production and operation of organic electronic devices.

SUB-PROGRAMMES

Large-area material deposition using solution processing
The objective is to study fundamental issues of large-area polymer and small-molecule material deposition using roll-to-roll solution processing (gravure, flexo, screen, slot-die) to make the transition from lab scale to industrial scale for reliably processed devices. For patterning of structures inkjet printing is explored. Although lab-scale devices have superb performance, we lack the industrial processes and the fundamental knowledge about large-area material deposition from solution and patterning needed to choose the right deposition method per layer for mass production.

Disruptive device architectures
The purpose of this research is to develop disruptive device architectures for more reliable and easier production and to understand the failure mechanisms occurring in industrially produced devices. Current device architectures require very thin films (~ 100 nm) with less than 2% thickness deviation, which imposes very strict demands on the processing and production of devices. At the moment, this results in poor yields, high costs and many uncomprehended failures. There is an urgent need for new device architectures that allow more robust processing and production and improve yield without affecting device performance (efficacy, homogeneity of light output).

FACTS AND FIGURES

Partners from industry
- DSM
- Philips
- Solvay
- TNO

Partners from the research world
- Eindhoven University of Technology
- Imperial College London
- Max Planck Institute für Polymerforschung
- University of Algarve
- University of Groningen
- University of Twente
- University of Wuppertal

Budget and organisation
Expenditure in 2013 totalled € 1.12 million (budget: € 1.37 million). A total of € 10k was spent on equipment. The total number of FTEs allocated at year-end 2013 was 12.1 (16 researchers). Prof.dr. Frans de Schryver acted as Scientific Chairman and Dr. John van Haare as Programme Area Coordinator.

Publications and inventions
This Technology Area generated a total of six reviewed papers and one thesis. Three inventions were reported and one patent application was filed.

For details, see page 44.

POLYMERS FOR ENHANCED OIL RECOVERY

Polymers for Enhanced Oil Recovery represent an important application of water-soluble polymers. With the increasing complexity of oil recovery from existing and new reservoirs, this technology could contribute significantly to more efficient recovery of the world's energy resources. Originally a sub-programme in the Emerging Technologies (EMT) technology area, DPI has now created a new, separate technology area for polymers for enhanced oil recovery.

OBJECTIVES

Although the underlying mechanisms may be similar for a range of applications of water-soluble polymers, this specific application warrants the establishment of a specific programme focusing on the structure-property relationships of polymers in solutions and their behaviour in the reservoir.

SUB-PROGRAMMES

Structure–property relationships and the design of new model macromolecules
Controlled radical polymerisation techniques will be employed to investigate the effects of macromolecular topology, for example branching, on polymer solution properties and on viscosity and/or visco-elasticity. These novel structures are evaluated in core flow experiments to determine their injectivity and impact on the recovery of oil in porous media. The effects of polymeric surfactants, i.e. high molecular weight amphiphilic structures that have the potential to decrease the interfacial tension and enhance oil recovery compared with that obtained with the current polymer flooding applications, are also being investigated.

Relating polymer rheology to apparent viscosity in porous media
The objective of this sub-programme is to develop reliable models to predict the relationship of polymer-apparent viscosity in porous media to porous-medium properties, bulk rheological parameters and superficial velocity in the medium and establish the relationship with enhanced oil recovery.

FACTS AND FIGURES

Partners from industry
- Shell
- SNF

Partners from the research world
- Delft University of Technology
- University of Groningen

Budget and organisation
Expenditure in 2013 totalled € 0.30 million (budget: € 0.37 million). The total number of FTEs allocated at year-end 2013 was 3.9 (5 researchers). Prof.dr. Martien Cohen Stuart acted as Scientific Chairman and Dr. Jan Stamhuis as Programme Area Coordinator of the Polymer of the Enhanced Oil Recovery programme

Publications and inventions
This Technology Area generated a total of four reviewed papers and one thesis.

For details, see page 44.

EMERGING TECHNOLOGIES: ADVANCED COMPOSITES

The aim of the Emerging Technologies (EMT) Technology Area is to promote the exploration investigation of new ideas from industry concerning new technologies that do not fit into any of the existing technology areas. When a company approaches DPI with a proposal for a project on a new topic, DPI will find an academic partner to carry out the research.

OBJECTIVES

Projects in the Emerging Technologies technology area are handled like any other DPI projects. However, after two years a decision is made on whether the project will be extended for another two years, by which time at least one other industrial party, in addition to the industrial party that initiated the project, must be willing to participate. The project can then be absorbed into another technology area. As in the case of projects in the Corporate Research technology area, the intellectual property (IP) generated in the first two years is owned by all of DPI's partners. If a project is continued after two years, the IP is treated in the same way as in other technology areas. In 2012, Water-Soluble Polymers, Smart Packaging and Advanced Composites were selected as the focus areas for Emerging Technologies. Potential projects in these areas are currently being discussed with industry. However, other opportunities are emerging that would promote DPI's mission of studying and developing new sustainable polymer technologies in cooperation with industry and academia.

SUB-PROGRAMMES

In 2012, on-going projects involving water-soluble polymers to be used for enhanced oil recovery (EOR) were transferred to a new technology area, Polymers for EOR (page 65). A new project to investigate High Performance Matrices for Advanced Composites was launched in 2012. This project, which is being carried out in association with Delft University of Technology, is part of a new collaboration with the Dutch materials programme, M2i. In this joint programme, DPI is studying base materials, for example matrix and fibres, whilst M2i is investigating the design and properties of composites. Interface studies and processing/composite manufacturing are a joint focus area.

FACTS AND FIGURES

Partners from industry
- DPI partners
- M2i partners

Partners from the research world
- Delft University of Technology

Organisation
Prof.dr. Martien Cohen Stuart acted as Scientific Chairman and Dr. Jan Stamhuis as Programme Area Coordinator of the Emerging Technologies programme.

Publications and inventions
This Technology Area has generated no output in 2013.

For details, see page 44.

CORPORATE RESEARCH

The role of the Corporate Research programme is to initiate and support enabling science and conceptual new science that is of interest to all of the partners in DPI because of its long-term potential impact.

OBJECTIVES

This programme is primarily science-driven, based on a vision of future industrial needs and opportunities. It operates at the forefront of scientific knowledge and capabilities in the field of polymer science. The programme activities are arranged in several sub-clusters.

SUB-PROGRAMMES

Enabling science

- Polymer characterisation (surfaces and interfaces (applying mainly microscopic techniques), molecular characterisation (SEC techniques on cross-linked architectures and networks, for example, and analysis of molar mass distribution)).
- Structure vs. performance: multiscale modelling, fluid dynamics (rheology) and solid-state properties (bulk materials and surface properties).

New science

Development of new concepts in polymer chemistry and polymer physics with a view to meeting long-term requirements in terms of sustainability, durability and bio-related polymer systems.

Infrastructure

Corporate Research also strengthens the research infrastructure by investing in equipment for the benefit of the entire DPI community.

DPI fellowship programme

Under this programme, talented young researchers with a tenured or tenure-track position at a Dutch university can be appointed as a 'DPI fellow'. The aim of the programme is to secure their commitment to the Dutch polymer science community and give them the opportunity to attain scientific leadership qualities in an area matching DPI's current or future strategy.

Bio-Related Materials (BRM) programme

In association with FOM and TIFN, DPI has established an Industrial Partnership Programme on biomaterials and bio-related materials. The aim of the programme is to understand how to move from the scale of complexes and aggregates to the mesoscopic scale, taking account of both the time dependent interactions and structures in their chemical detail and the resulting dynamic and spatially varying mesoscale physical properties.

Understanding the visco-elasticity of elastomer-based nanocomposites (VEC) programme

Filled rubbers are widely used in industry. Adding silica particles to a polymer matrix increases the mechanical properties of the material but causes various non-linear effects, notably a dramatic decline in elasticity under high strain (the Payne effect). This effect is still not understood very well. During this project systematic experiments will be conducted with rubbers of varying compositions. On the macroscopic scale, we are performing rheological measurements and combining them with microscopic characterisations in order to link behaviour on a macroscopic scale with the microstructure of the sample.

FACTS AND FIGURES

Partners from industry

- All DPI partners take part in Corporate Research

Partners from Academia

- Delft University of Technology
- Eindhoven University of Technology
- ESRF, Grenoble
- Foundation for fundamental research on matter (FOM)
- Radboud University
- TI Food and Nutrition (TIFN)
- University of Groningen
- University of Twente
- Wageningen University

Budget and organisation

Expenditure in 2013 totalled € 1.40 million (budget: € 1.40 million). The total number of FTEs allocated at year-end 2013 was 16.1 (17 researchers). Prof.dr. Martien Cohen Stuart acted as Scientific Chairman and Dr. Monique Bruining as Programme Area Coordinator of the Corporate Research programme.

Publications and inventions

This research programme generated a total of 37 reviewed papers, four theses and one invention was reported.

For details, see page 44.

Output 2013

POLYOLEFINS

Projects

#632: Experimental and computational study of dense gas-fluidised beds with liquid injection

#633: Understanding structure/performance relationships for non-metallocene olefin polymerization catalysts

#635: Measuring active site concentration of olefin polymerization catalysts

#636: The study of the role of the support, support preparation and initial conditions on olefin polymerisation

#637: Role of entanglements on the flow behavior of polyolefins

#638: Thermally stable olefin polymerization catalysts by reversible intramolecular alkyl shuttling

#641: High-Troughput Computational Pre-Screening of Catalysts

#642: Development of High-Temperature 2-Dimensional Liquid Chromatography for the Characterization of Polyolefins

#646: New Functionalized Materials by Rh and Pd Mediated Carbene Homo-Polymerization and Olefin/Carbene Co-Polymerization

#674: Rheology Control by Branching Modeling

#706: Intrinsic effect of catalyst immobilization techniques on catalyst activity and selectivity

#708: Structure-property relations of olefinic block copolymers

#709: Integrated Models for PolyOlefin Reactors

#710: Linking chemically specific structure information to physical properties of polyolefins.

#711: Mass transfer & kinetics in heterophasic copolymerization of propylene

#712: Elucidation and control of the active surface structure and chemistry in MgCl2-supported Ziegler-Natta catalysis: an integrated experimental and computational approach

#714: Putting values to a model for Flow Induced Crystallization

#728: Structural investigations on MAO and design of alternative well-defined cocatalysts and single-component catalysts

#731: Main group metal-alkyl cocatalysts and scavengers in molecular olefin polymerization catalysis: a mechanistic investigation

#732: Strategies for stabilizing trivalent vanadium and chromium propylene polymerization catalysts

#750: Optimisation and Calibration of High-Temperarure Liquid Chromatographic Separation of Polypropylene and Propylene based Copolymers

#751: Predictive Modelling of Polyolefin Reactors

#753: Impact of the geometric parameters of catalyst supports on the kinetics and morphology of polyolefins

#754: Direct insight into elusive active Ti species of high-yield Ziegler-Natte Catalysts

#757: Influence of entanglement on rheological response of Ultra High Molecular Weight Polyethylene from linear to nonlinear viscoelastic behaviour

#785: High Impact Polypropylene: Structure Evolution and impact on Reaction

#787: In situ X-ray measurements

#791: A comprehensive integrated HTC&HTE workflow for the mechanistic study of (novel) olefin polymerization catalysts

#793: Novel Quadrupolar Nuclear Magnetic Resonance Methodology for the Study of MgCl2-Supported Ziegler-Natta Catalysts

#795: The molecular and morphological origin of large improvement of stress-strain properties of polyethylenes

Theses

Camille Descour
Olefin block copolymers: synthesis and dissection

Ajin Verghese Cheruvathur
Surface chemistry of flat-model Ziegler-Natta catalysts

Nicole Franssen
Functional (co)polymers from carbenes

Anton Ginzburg
Development of high temperature two dimensional liquid chromatography of polyolefins

Scientific publications

G. Portale, D. Cavallo, G.C. Alfonso, D. Hermida-Merino, M. van Drongelen, L. Balzano, G.W.M. Peters, J.G.P. Goossens and W. Bras
Polymer crystallization studies under processing-relevant conditions at the SAXS/WAXS DUBBLE beamline at the ESRF
Journal of Applied Crystallography 46 1681-1689

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An Equation of State-Based Modeling Approach for Estimating the Partial Molar Volume of Penetrants and Polymers in Binary Mixtures

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Journal of Applied Polymer Science 129 (4) 1897-1906

A. Ginzburg, T. Macko, F. Malz, M. Schroers, I. Troetsch-Schaller, J. Strittmatter and R. Brull
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E. Tioni, V. Monteil and T. McKenna
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Macromolecules 46 (2) 335-343

Z. Ma, L. Fernandez-Ballester, D. Cavallo, T. Gough and G.W.M. Peters
High-Stress Shear-Induced Crystallization in Isotactic Polypropylene and Propylene/Ethylene Random Copolymers
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N.M.G. Franssen, J.N.H. Reek and B. de Bruin
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Dalton Transactions 42 (25) 9058-9068

N.M.G. Franssen, J.N.H. Reek and B. de Bruin
Synthesis of functional 'polyolefins': state of the art and remaining challenges
Chemical Society Reviews 42 (13) 5809-5832

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On the "Tertiary Structure" of Poly-Carbenes; Self-Assembly of sp(3)-Carbon-Based Polymers into Liquid-Crystalline Aggregates
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Propagation and termination steps in Rh-mediated carbene polymerisation using diazomethane
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PERFORMANCE POLYMERS

Projects

#623: Fundamental aspects of Nano-composites

#647: New Functionalized Materials by Rh and Pd Mediated Carbene Homo-Polymerization and Olefin/Carbene Co-Polymerization

#648: Graphene-based nanocomposites- A study on the potential of grapheme, nanosheets as an alternative low-cost filler for multi-functional polymeric materials

#649: Thermoplastic elastomers via living radical graft polymerzation from functional elastomers

#650: Molecular Modelling of Cavitation in Polymer Melts and Rubbers

#651: Smart Surface Modifiers for Engineering Plastics

#652: Rubber/silica nano-composites via reactive extrusion

#653: Biodegradable Thermoplastic Polyurethanes from Renewable Resources

#654: Effects of the nano-scale structure of polymer surfaces on their adhesion and friction

#656: Green Rigid blocks for Engineering plastics with ENhanced pERformance

#664: Sustainable elastomers and Thermoplastics by short fibre reinforcement

#671: Optimized plastication in extruders for better economy and product properties

#696: Self-healing thermoplastic polymers based on in-situ solvent deployment

#697: Creating multiple distributed healing in fibre composites using compartmented fibres liquid filled fibres

#742: Membranes with Adjustable Interior in their Nanopores

#743: Curable Semi-aromatic or aliphatic Semi-crystalline Thermoplastics

#744: Molecular Simulations of Polymer Networks: Stress-Strain Relations, Cavitation, and Dynamics in Confinement

#745: Microstructure-based Modeling of the Intrinsic Kinectics of Aging and Deformation of Polymer Glasses

#746: Particles at Fluid-Fluid Interfaces

#747: Polyamide/silica nanocomposites: a systematical investigation

#749: The chemistry of rubber modification and crosslinking: New approaches towards an old problem

#755: MONodisperse OLIGOamide building blocks for thermoplastic elastomers (TPEs) revisited

#756: Do contacts in electrically conductive particulate composites really exist?

#782: How short-cut fibers influence friction, wear and noise generation of polymers

#783: COntact mechaNics, FrictIon and coNtact fatiguE on polymeric SURFACES

#784: Reactive Polymer Colloids for Design of Interfaces in Fiber/matrix Composite Materials

#786: Processing for Enhanced Product Performance

#788: Predicting the Fountain Flow Instability from Material Properties and Processing conditions

#789: Functional Polymeric Additives for Engineering Plastics

Theses

Elena Miloskovska
Structure-property relationships of rubber/silica nanocomposites via sol-gel reaction

Athanasios Morozinis
Molecular Modelling of Cavitation in Polymer Melts and Rubbers

Nicole Franssen
Functional (co)polymers from carbenes

Christian Hintze
Influence of processing induced morphology on mechanical properties of short aramid fibre filled elastomer composites

Scientific publications

N.M.G. Franssen, J.N.H. Reek and B. de Bruin
A different route to functional polyolefins: olefin-carbene copolymerisation
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E. Tkalya, M. Ghislandi, W. Thielemans, P. van der Schoot, G. de With and C. Koning
Cellulose Nanowhiskers Templating in Conductive Polymer Nanocomposites Reduces Electrical Percolation Threshold 5-Fold
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M. Ghislandi, E. Tkalya, B. Marinho, C.E. Koning and G. de With
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M. Ghislandi, E. Tkalya, S. Schillinger, C.E. Koning and G. de With
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S.S. Sarkawi, W.K. Dierkes and J.W.M. Noordermeer
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A contact model for orthotropic-viscoelastic materials
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M. Shirazi, M.B. de Rooij, A.G. Talma and J.W.M. Noordermeer
Adhesion of RFL-coated aramid fibres to elastomers: The role of elastomer-latex compatibility
Journal of Adhesion Science and Technology 27 (17) 1886-1898

M. Shirazi, A.G. Talma and J.W.M. Noordermeer
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Journal of Applied Polymer Science 128 (4) 2255-2261

C. Hintze, R. Boldt, S. Wiessner and G. Heinrich
Influence of processing on morphology in short aramid fiber reinforced elastomer compounds
Journal of Applied Polymer Science 130 (3) 1682-1690

A. Jeyakumar, H. Goossens, B. Noordover, M. Prusty, M. Scheibitz and C. Koning
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S.S. Sarkawi, W.K. Dierkes and J.W.M. Noordermeer
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Kgk-Kautschuk Gummi Kunststoffe 66 (3) 27-33

S. Saiwari, W.K. Dierkes and J.W.M. Noordermeer
Devulcanization of Whole Passenger Car Tire Material
Kgk-Kautschuk Gummi Kunststoffe 66 (7-8) 20-25

W. Kaewsakul, K. Sahakaro, W.K. Dierkes and J.W.M. Noordermeer
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D. Hudzinskyy, M.A.J. Michels and A.V. Lyulin
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M.P.F. Pepels, M.R. Hansen, H. Goossens and R. Duchateau
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V.S.D. Voet, M. Tichelaar, S. Tanase, M.C. Mittelmeijer-Hazeleger, G. ten Brinke and K. Loos
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Polymer Chemistry 4 (18) 4955-4965

A.K. Morozinis, C. Tzoumanekas, S.D. Anogiannakis and D.N. Theodorou
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N.V. Rodriguez, M.A. Masen and D.J. Schipper
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G. ten Brinke and K. Loos
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W. Kaewsakul, K. Sahakaro, W.K. Dierkes and J.W.M. Noordermeer
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Rubber Chemistry and Technology 86 (2)
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N.M.G. Franssen, J.N.H. Reek and B. de Bruin
Synthesis of functional 'polyolefins': state of the art and remaining challenges
Chemical Society Reviews 42 (13) 5809-5832

N.M.G. Franssen, B. Ensing, M. Hegde, T.J. Dingemans, B. Norder, S.J. Picken, G.O.R.A. van Ekenstein, E.R.H. van Eck, J.A.A.W. Elemans, M. Vis, J.N.H. Reek and B. de Bruin
On the "Tertiary Structure" of Poly-Carbenes; Self-Assembly of sp(3)-Carbon-Based Polymers into Liquid-Crystalline Aggregates
Chemistry-a European Journal 19 (35)
11577-11589

N.M.G. Franssen, M. Finger, J.N.H. Reek and B. de Bruin
Propagation and termination steps in Rh-mediated carbene polymerisation using diazomethane
Dalton Transactions 42 (12) 4139-4152

Filed patent applications

#742: H.P.C. van Kuringen, A.P.H.J. Schenning, D.J. Boer
Novel nanoporous membranes for removing species from an aqueous solution

#747: Y. Zhao, X. Zhu, M. Möller
Silica spheres as nanocapsule carriers

Reported inventions

#742: H.P.C. van Kuringen, A.P.H.J. Schenning, D.J. Boer
Novel nanoporous membranes for removing species from an aqueous solution

#747: Y. Zhao, X. Zhu, M. Möller
Silica spheres as nanocapsule carriers

Projects

#626: Hardening of elastomers (and gels) in response to magnetic fields

#627: Air-stable n-type field-effect transistors

#630: Functional polymer based nano- and micro-optics for solid state lighting management

#631: Triplet recombination in polymer solar cells

#660: Bulk heterojunction polymer:zinc oxide solar cells from novel organozinc precursors

#661: Structurally defined conjugated dendrimers and hyperbrached polymers in solar cells

#677: Understanding interactions between polymer surfaces and proteins: towards a ideal polymer biosensor substrate material

#678: Air stable organic photovoltaics

#679: Smart textiles

#680: Charge carrier transport and recombination in advanced OLEDs

#681: Hybrid solar cells based on Si nanoparticles and conjugated polymers

#682: Creation of functional nanostructures in solution/dispersion

#762: Solution-Processed Small-Molecule Tandem OPV

#763: Design of novel donor-acceptor systems with optimized morphology and transport

#764: Responsive IR reflectors based on polymeric cholesteric liquid crystals

#765: New supramolecular architectures exhibiting piezoelectric properties

#766: Responsive and self-healing membranes with well-defined nanopores using block copolymers

#767: Towards solution processable near-IR and IR-reflective coatings and mirrors with high transparency in the UV-visible regime

#775: Switchable topologies using responsive polymers for controlled wetting and self-cleaning surfaces

#776: Membranes with adjustable interior in their nanopores

#777: Tuning the optical properties of thin film coatings by using self-assembled protein particles

#792: Particle Stability and Mobility in Silicones

Theses

Andreas Ringk
Organic electronics by self-assembly

Mian Dai
Optically and environmentally responsive fibres

Veronique Gevaerts
Morphology control and device optimization for efficient organic solar cells

Marijn Kemper
Non-specific protein-surface interactions in the context of particle-based biosensors

Stela Andrea Muntean
Molecular-dynamics simulations of polymeric surfaces for biomolecular applications

Scientific publications

M. Dai, O.T. Picot, J.M.N. Verjans, L.T. de Haan, A.P.H.J. Schenning, T. Peijs and C.W.M. Bastiaansen
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D. Di Nuzzo, G.J.A.H. Wetzelaer, R.K.M. Bouwer, V.S. Gevaerts, S.C.J. Meskers, J.C. Hummelen, P.W.M. Blom and R.A.J. Janssen
Simultaneous Open-Circuit Voltage Enhancement and Short-Circuit Current Loss in Polymer: Fullerene Solar Cells Correlated by Reduced Quantum Efficiency for Photoinduced Electron Transfer
Advanced Energy Materials 3 (1) 85-94

G.A.H. Wetzelaer, N.J. Van der Kaap, L.J.A. Koster and P.W.M. Blom
Quantifying Bimolecular Recombination in Organic Solar Cells in Steady State
Advanced Energy Materials 3 (9) 1130-1134

A. Ringk, X.R. Li, F. Gholamrezaie, E.C.P. Smits, A. Neuhold, A. Moser, C. Van der Marel, G.H. Gelinck, R. Resel, D.M. de Leeuw and P. Strohriegl
N-Type Self-Assembled Monolayer Field-Effect Transistors and Complementary Inverters
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D.H.K. Murthy, A. Melianas, Z. Tang, G. Juska, K. Arlauskas, F.L. Zhang, L.D.A. Siebbeles, O. Inganas and T.J. Savenije
Origin of Reduced Bimolecular Recombination in Blends of Conjugated Polymers and Fullerenes
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R.A.J. Janssen and J. Nelson
Factors Limiting Device Efficiency in Organic Photovoltaics
Advanced Materials 25 (13) 1847-1858

G.A.H. Wetzelaer, A. Najafi, R.J.P. Kist, M. Kuik and P.W.M. Blom
Efficient electron injection from solution-processed cesium stearate interlayers in organic light-emitting diodes
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D. Escudero, E. Heuser, R.J. Meier, M. Schaferling, W. Thiel and E. Holder
Unveiling Photodeactivation Pathways for a New Iridium(III) Cyclometalated Complex
Chemistry-a European Journal 19 (46) 15639-15644

L.J. Liu, S. van Bavel, S.P. Wen, X.N. Yang and J. Loos
Morphology and Performance of Poly (2-methoxy-5-(20-ethyl-hexyloxy)-p-phenylenevinylene) (MEH-PPV):(6,6)-phenyl-C61-butyric Acid Methyl Ester (PCBM) Based Polymer Solar Cells
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R.J. de Vries, A. Badinski, R.A.J. Janssen and R. Coehoorn
Extraction of the materials parameters that determine the mobility in disordered organic semiconductors from the current-voltage characteristics: Accuracy and limitations
Journal of Applied Physics 113 (11)

L. Gulikers, J. Evers, A. Muntean and A. Lyulin
The effect of perception anisotropy on particle systems describing pedestrian flows in corridors
Journal of Statistical Mechanics-Theory and Experiment

M. Mesta, M. Carvelli, R.J. de Vries, H. van Eersel, J.J.M. van der Holst, M. Schober, M. Furno, B. Lussem, K. Leo, P. Loebl, R. Coehoorn and P.A. Bobbert
Molecular-scale simulation of electro-luminescence in a multilayer white organic light-emitting diode
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A. Ringk, W.S.C. Roelofs, E.C.P. Smits, C. van der Marel, I. Salzmann, A. Neuhold, G.H. Gelinck, R. Resel, D.M. de Leeuw and P. Strohriegl
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Organic Electronics 14 (5) 1297-1304

D. Di Nuzzo, S. van Reenen, R.A.J. Janssen, M. Kemerink and S.C.J. Meskers
Evidence for space-charge-limited conduction in organic photovoltaic cells at open-circuit conditions
Physical Review B 87 (8)

P. de Bruyn, A.H.P. van Rest, G.A.H. Wetzelaer, D.M. de Leeuw and P.W.M. Blom
Diffusion-Limited Current in Organic Metal-Insulator-Metal Diodes
Physical Review Letters 111 (18)

O.T. Picot, R. Alcala, C. Sanchez, M.A. Dai, N.F. Hughes-Brittain, D.J. Broer, T. Peijs and C.W.M. Bastiaansen
Manufacturing of Surface Relief Structures in Moving Substrates Using Photoembossing and Pulsed-Interference Holography
Macromolecular Materials and Engineering 298 (1) 33-37

O.T. Picot, M. Dai, E. Billoti, D.J. Broer, T. Peijs and C.W.M. Bastiaansen
A real time optical strain sensor based on a cholesteric liquid crystal network
Rsc Advances 3 (41) 18794-18798

Filed patent application

#775: D. Liu, D.J. Broer
Manipulating surface structures by a liquid crystal network

Reported inventions

#775: D. Liu, Dirk J. Broer
Fresnel lens with adaptive light intensity response

#775: D. Liu, D.J. Broer
Manipulating surface structures by a liquid crystal network

#775: D. Liu, D.J. Broer
Surfaces with adjustable friction and grip

COATINGS TECHNOLOGY

Projects

#658: Waterborne polyurethane dispersions based on renewable resources

#675: Drying of a waterborne coating: spontaneous phase inversion in jammed systems

#676: UV to daylight curing of organic coatings

#713: Physical aspects and modeling of weathering of polyester-urethane coatings

#758: Self-replenishing hydrophobic coatings with intrinsic hardness cured by LED's

#759: Novel Isocyanate-free, Chain-Extended Polyurethane Dispersions Containing Alternative Internal Dispersing Agents

#760: Microstructure control in polyurethane (PU) ionomers

#779: Preparation and Characterization of Model Waterborne Clearcoats

#780: Self-replenishing high-surface-energy coatings

#781: Film Formation in Complex Colloidal Coatings

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H.J. Zhu, H.P. Huinink, P.C.M.M. Magusin, O.C.G. Adan and K. Kopinga
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Journal of Magnetic Resonance 235 109-114

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Temperature-triggered release of a liquid cross-linker micro-encapsulated in a glassy polymer for low temperature curing
Polymer 54 (1) 75-83

H.H. Feng, N.A.L. Verstappen, A.J.C. Kuehne and J. Sprakel
Well-defined temperature-sensitive surfactants for controlled emulsion coalescence
Polymer Chemistry 4 (6) 1842-1847

H.H. Feng, J. Sprakel, D. Ershov, T. Krebs, M.A.C. Stuart and J. van der Gucht
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Soft Matter 9 (10) 2810-2815

Thesis

Huanhuan Feng
Understanding and manipulating coalescence in dense emulsions

Reported invention

#758: Y. Zhang, C. Rocco, A. C. C. Esteves, L. G. J. van der Ven, R. A. T. M. van Benthem, C. Croutxe-Barghorn, X. Allonas, G. de With
New self-replenishing coatings

HIGH-THROUGHPUT EXPERIMENTATION

Projects

#620: Rapid-prototyping and inkjet printing using polyurethane precursons

#666: 3D Printing of Hydrogels Based on Liquid Free-Form Fabrication of Modified Polysaccharides

#668: Microwave-assisted synthesis of polyamides from amines and carboxylic acids

#690: Libraries of poly (ethylene oxide)via parallel living anionic polymerization

#729: High-throughput screening technologies applied to compatibility maps

#730: Cellular pharmacokinetics of polymers for drug delivery - A high-throughput approach to polymers with optimum targeting characteristics

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A. Teichler, S. Holzer, J. Nowotny, F. Kretschmer, C. Bader, J. Perelaer, M.D. Hager, S. Hoeppener and U.S. Schubert
Combinatorial Screening of Inkjet Printed Ternary Blends for Organic Photovoltaics: Absorption Behavior and Morphology
Acs Combinatorial Science 15 (8) 410-418

A.C. Rinkenauer, A. Vollrath, A. Schallon, L. Tauhardt, K. Kempe, S. Schubert, D. Fischer and U.S. Schubert
Parallel High-Throughput Screening of Polymer Vectors for Nonviral Gene Delivery: Evaluation of Structure-Property Relationships of Transfection
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Self-Healing Materials via Reversible Crosslinking of Poly(ethylene oxide)-Block-Poly(furfuryl glycidyl ether) (PEO-b-PFGE) Block Copolymer Films
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Self-Healing Polymer Coatings Based on Crosslinked Metallosupramolecular Copolymers
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U. Mansfeld, S. Hoeppener and U.S. Schubert
Investigating the Motion of Diblock Copolymer Assemblies in Ionic Liquids by In Situ Electron Microscopy
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B.L. Farrugia, K. Kempe, U.S. Schubert, R. Hoogenboom and T.R. Dargaville
Poly(2-oxazoline) Hydrogels for Controlled Fibroblast Attachment
Biomacromolecules 14 (8) 2724-2732

A.M. Breul, M.D. Hager and U.S. Schubert
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A.M. Breul, J. Schafer, E. Altuntas, M.D. Hager, A. Winter, B. Dietzek, J. Popp and U.S. Schubert
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A. Vollrath, D. Pretzel, C. Pietsch, I. Perevyazko, R. Menzel, S. Schubert, G.M. Pavlov, D. Weiss, R. Beckert and U.S. Schubert
Preparation, Cellular Internalization, and Biocompatibility of Highly Fluorescent PMMA Nanoparticles (vol 33, pg 1791, 2012)
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G.M. Pavlov, K. Knop, O.V. Okatova and U.S. Schubert
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Polymer Chemistry 4 (1) 113-123

U. Mansfeld, A. Winter, M.D. Hager, G. Festag, S. Hoeppener and U.S. Schubert
Amphiphilic supramolecular A(B)(2)A quasi-triblock copolymers
Polymer Chemistry 4 (11) 3177-3181

K. Kempe, S. Onbulak, U.S. Schubert, A. Sanyal and R. Hoogenboom
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T. Rudolph, K. Kempe, S. Crotty, R.M. Paulus, U.S. Schubert, I. Krossing and F.H. Schacher
A strong cationic Bronsted acid, [H(OEt2)(2)]-[Al{OC(CF3)(3)}(4)], as an efficient initiator for the cationic ring-opening polymerization of 2-alkyl-2-oxazolines
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E. Altuntas, C. Weber and U.S. Schubert
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Soft Matter 9 (1) 99-108

M.J. Barthel, U. Mansfeld, S. Hoeppener, J.A. Czaplewska, F.H. Schacher and U.S. Schubert
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Soft Matter 9 (13) 3509-3520

U. Mansfeld, S. Hoeppener, K. Kempe, J.M. Schumers, J.F. Gohy and U.S. Schubert
Tuning the morphology of triblock terpoly (2-oxazoline)s containing a 2-phenyl-2-oxazoline block with varying fluorine content
Soft Matter 9 (25) 5966-5974

K. Knop, G.M. Pavlov, T. Rudolph, K. Martin, D. Pretzel, B.O. Jahn, D.H. Scharf, A.A. Brakhage, V. Makarov, U. Mollmann, F.H. Schacher and U.S. Schubert
Amphiphilic star-shaped block copolymers as unimolecular drug delivery systems: investigations using a novel fungicide
Soft Matter 9 (3) 715-726

Filed patent application

#620: S. Wünscher, J. Perelaer, A. Teichler, U.S. Schubert
Induction Flash Sintering by Microwave Radiation

Reported inventions

#668: F. Kretschmer, S. Hoeppener, U.S. Schubert
High speed, microwave-induced metal nano-particle formation in low melting materials

#729: B. Steinhoff, U.S. Schubert
Multiple analysis by a flexible wellplate

#730: A. Schallon, A.C. Rinkenauer, L. Tauhardt, K. Kempe, U.S. Schubert
Effective transfection by novel drug carrier polymers

BIO-INSPIRED POLYMERS

Projects

#686: Thermal Catch and Release

#687: Functionality of novel amphiphilic biomaterials synthesized by enzymatic linking of food polysaccharides, food proteins and fatty acids

#688: Lessons from biomineralization: Self-Organizing and Mineralization-Directing Block Copolymers

#689: Bio-inspired hairy surfaces for actuation or sensing, produced with roll-to-roll technology

#737: Exploring novel biobased polymers comprising furandicarboxylic acids, 2,2,4,4-tetramethyl 1,3-cyclobutanediol (CDBO) derivatives and substituted hydroxy benzoic acids as biobased rigid monomers

#738: Tailored water-based materials assembled from sponge-like building blocks

#739: Melt processable Bio-based Aromatic Polymers

#740: Enzymatic catalysis for the production of biobased monomers and polymers based upon them

Theses

Silvia van Kempen
Molecular assembly, interfacial rheology and foaming properties of oligofructose fatty acid esters

Yogesh Deshmukh
Influence on hydrogen bonding efficiency of structural modification

Scientific publications

C. von der Ehe, J.A. Czaplewska, M. Gottschaldt and U.S. Schubert
Synthesis of thermoresponsive glycopolymers via ATRP of N-isopropylacrylamide and N-allylacrylamide and subsequent thiol-ene reaction
European Polymer Journal 49 (9) 2660-2669

S.E.H.J. van Kempen, C.G. Boeriu, H.A. Schols, P. de Waard, E. van der Linden and L.M.C. Sagis
Novel surface-active oligofructose fatty acid mono-esters by enzymatic esterification
Food Chemistry 138 (2-3) 1884-1891

S.E.H.J. van Kempen, K. Maas, H.A. Schols, E. van der Linden and L.M.C. Sagis
Interfacial properties of air/water interfaces stabilized by oligofructose palmitic acid esters in the presence of whey protein isolate
Food Hydrocolloids 32 (1) 162-171

S.E.H.J. van Kempen, H.A. Schols, E. van der Linden and L.M.C. Sagis
The Effect of Diesters and Lauric Acid on Rheological Properties of Air/Water Interfaces Stabilized by Oligofructose Lauric Acid Monoesters
Journal of Agricultural and Food Chemistry 61 (32) 7829-7837

C. Allolio, N. Salas-Illanes, Y.S. Desmukh, M.R. Hansen and D. Sebastiani
H-Bonding Competition and Clustering in Aqueous LiI
Journal of Physical Chemistry B 117 (34) 9939-9946

B. Yeniad, N.O. Koklukaya, H. Naik, M.W.M. Fijten, C.E. Koning and A. Heise
Synthesis of enantiopure homo and copolymers by raft polymerization and investigation of their enantioselective lipase-catalyzed esterification
Journal of Polymer Science Part a-Polymer Chemistry 51 (1) 84-93

Y. Wang, Y. Gao, H. Wyss, P. Anderson and J. den Toonder
Out of the cleanroom, self-assembled magnetic artificial cilia
Lab on a Chip 13 (17) 3360-3366

B. Yeniad, H. Naik, C.E. Koning and A. Heise
Enantioselective Enzymatic Modification of Chiral Block Copolymers
Macromolecular Chemistry and Physics 214 (5) 556-562

S.E.H.J. van Kempen, H.A. Schols, E. van der Linden and L.M.C. Sagis
Non-linear surface dilatational rheology as a tool for understanding microstructures of air/water interfaces stabilized by oligofructose fatty acid esters
Soft Matter 9 (40) 9579-9592

Y.S. Deshmukh, R. Graf, M.R. Hansen and S. Rastogi
Dissolution and Crystallization of Polyamides in Superheated Water and Concentrated Ionic Solutions
Macromolecules 46 (17) 7086-7096

Filed patent applications

#737: S. Thiyagarajan, R. Knoop, D. van Es
Biobased semi-crystalline polyesters (I)

#737: S. Thiyagarajan, R. Knoop, D. van Es
Biobased semi-crystalline polyesters (II)

#739: C.H.R.M. Wilsens, B.A.J. Noordover, S. Rastogi
Bio-based liquid crystal polyesters

Reported inventions

#737: S. Thiyagarajan, R. Knoop, D. van Es
Biobased semi-crystalline polyesters (I)

#737: S. Thiyagarajan, R. Knoop, D. van Es
Biobased semi-crystalline polyesters (II)

#737: S. Thiyagarajan, R. Knoop, D. van Es
Biobased semi-crystalline polyesters (III)

#739: C.H.R.M. Wilsens, B.A.J. Noordover, S. Rastogi
Bio-based liquid crystal polyesters

LARGE-AREA THIN-FILM ELECTRONICS

Projects

#640: Engineering the morphology of organic (semi)-conductor layers

#659: Crosslinkable Semiconductors for Robust Polymer Electronics

#704: Forming processes in metal oxide organic light-emitting diodes

#733: Solution processed multilayer polymeric light-emitting diodes

#734: Predictive processing of polymer: fullerene solar cells

#735: Solution-processable low-temperature oxide semiconductors for large-area electronics

#741: Inkjet Printing of Suspensions

#748: Organic semiconductors blended into a crosslinkable insulator: Separating processability from optoelectronic functionality

#752: Looking down the rabbit hole: impact of porosity in the (in)organic layers on the performance of moisture permeation multi-layer barriers

Thesis

Mingtao Lu
Polymer Light-Emitting Diodes with Doped Charge Transport Layers

Scientific publications

Y.H. Lin, H. Faber, K. Zhao, Q.X. Wang, A. Amassian, M. McLachlan and T.D. Anthopoulos
High-Performance ZnO Transistors Processed Via an Aqueous Carbon-Free Metal Oxide Precursor Route at Temperatures Between 80-180 degrees C
Advanced Materials 25 (34) 4689-4689

Q. Chen, H.L. Gomes, P.R.F. Rocha, D.M. de Leeuw and S.C.J. Meskers
Reversible post-breakdown conduction in aluminum oxide-polymer capacitors
Applied Physics Letters 102 (15)

P.R.F. Rocha, A. Kiazadeh, D.M. De Leeuw, S.C.J. Meskers, F. Verbakel, D.M. Taylor and H.L. Gomes
The role of internal structure in the anomalous switching dynamics of metal-oxide/polymer resistive random access memories
Journal of Applied Physics 113 (13)

S. Kouijzer, J.J. Michels, M. van den Berg, V.S. Gevaerts, M. Turbiez, M.M. Wienk and R.A.J. Janssen
Predicting Morphologies of Solution Processed Polymer: Fullerene Blends
Journal of the American Chemical Society 135 (32) 12057-12067

B.J. Brasjen, H. Gu and A.A. Darhuber
Dewetting of thin liquid films on chemically patterned substrates: front propagation along narrow lyophobic stripes and stripe arrays
Microfluidics and Nanofluidics 14 (3-4) 669-682

J.J. van Franeker, W.P. Voorthuijzen, H. Gorter, K.H. Hendriks, R.A.J. Janssen, A. Hadipour, R. Andriessen and Y. Galagan
All-solution-processed organic solar cells with conventional architecture
Solar Energy Materials and Solar Cells 117 267-272

Filed patent application

#734: J.J. van Franeker, X. Lou, M.M. Wienk, R.A.J. Janssen
Process for preparing novel polymeric solar cells

Reported inventions

#704: B.F. Bory; S.C.J. Meskers
Novel LED's: Light Emitting Alkali Halides

#734: J.J. van Franeker, X. Lou, M.M. Wienk, R.A.J. Janssen
Process for preparing novel polymeric solar cells

#735: Y-H. Lin, T. Anthopoulos
Reliable and reproducible low temperature processing of multilayer inorganic oxide TFT's

ENHANCED OIL RECOVERY

Projects

#716: Design of new chemical products (polymers and amphiphilics) for EOR

#736: Relating Polymer Rheology to Apparent Viscosity in Poreus Media

#778: Strategies towards industrial production of new (branched) polyacrylamide structures for EOR

Thesis

Diego Wever
Synthesis and evaluation of novel linear and branched polyacrylamides for enhanced oil recovery

Scientific publications

D.A.Z. Wever, F. Picchioni and A.A. Broekhuis
Branched polyacrylamides: Synthesis and effect of molecular architecture on solution rheology
European Polymer Journal 49 (10) 3289-3301

D.A.Z. Wever, F. Picchioni and A.A. Broekhuis
Comblike Polyacrylamides as Flooding Agent in Enhanced Oil Recovery
Industrial & Engineering Chemistry Research 52 (46) 16352-16363

D.A.Z. Wever, L.M. Polgar, M.C.A. Stuart, F. Picchioni and A.A. Broekhuis
Polymer Molecular Architecture As a Tool for Controlling the Rheological Properties of Aqueous Polyacrylamide Solutions for Enhanced Oil Recovery
Industrial & Engineering Chemistry Research 52 (47) 16993-17005

D.A.Z. Weyer, E. Riemsma, F. Picchioni and A.A. Broekhuis
Comb-like thermoresponsive polymeric materials: Synthesis and effect of macromolecular structure on solution properties
Polymer 54 (21) 5456-5466

EMERGING TECHNOLOGIES

Project

#761: Reactive Liquid Crystal Oligomers as Precursors Towards Composite Resins

CORPORATE RESEARCH

Projects

#598: Application of time resolved X-ray diffraction techniques for study on structural and morphological changes during polymerization and processing

#615: 3-D tomographic reconstruction of local morphology and properties of polymer systems with nanometric resolutions by means of TEM and AFM

#693: Elastin-Functionalized Silica Particles

#694: Modelling of draw resonance and related instabilities in polymer processes

#695: Optical microscopy for nanoscale imaging

#698: Designer Polypeptides for Self-Assembled Delivery Vehicles

#699: Artificial flagella: Nature-inspired micro-object manipulation using responsive polymers

#700: The Ultimate Stabilizer-Free Emulsion Polymerization

#701: Understanding the visco-elasticy of elastomer-based nanocomposites

#715: Novel Polyimide Architectures: Towards Membranes with Tunable Transport Properties

#717: All-aromatic heterocyclic liquid crystal polymers for photovoltaic applications

#727a: Improved characterization techniques for branched polymers

#727b: (Oligo)cellulose by enzymatic polymerisation

#727c: Polymers go even greener

BRM
Multi-scale structure and mechanics of collagenous materials

Structure and evolution of high-density protein systems

Unraveling the lipid-amylose inclusion complex formation

Multiple protein glass transitions at low water content

Hybrid networks

Cross-linked food proteins as hierarchical biopolymers

VEC
Electron microscopy

Mesoscale deformation

Non-linear rheology I

Non-linear rheology II

Theory-modelling

Theses

Carina van der Walt
Fiber spinning under filament pull-out conditions

Chrysostomos Batistakis
Molecular simulations of confined ultrathin polymer films: structure, dynamics and mechanical behavior

Marta Dobrowolska
The Stabilizer-Free Emulsion Polymerization

Danqing Liu
Responsive surface topographies

Scientific publications

J. Ciric and K. Loos
Synthesis of branched polysaccharides with tunable degree of branching
Carbohydrate Polymers 93 (1) 31-37

L.Y. Yu, X.R. Li, E. Pavlica, F.P.V. Koch, G. Portale, I. da Silva, M.A. Loth, J.E. Anthony, P. Smith, G. Bratina, B.K.C. Kjellander, C.W.M. Bastiaansen, D.J. Broer, G.H. Gelinck and N. Stingelin
Influence of Solid-State Microstructure on the Electronic Performance of 5,11-Bis(triethylsilylethynyl) Anthradithiophene
Chemistry of Materials 25 (9) 1823-1828

J.E. Stumpel, D.Q. Liu, D.J. Broer and A.P.H.J. Schenning
Photoswitchable Hydrogel Surface Topographies by Polymerisation-Induced Diffusion
Chemistry-a European Journal 19 (33) 10922-10927

E.G. Dere, H. Sharma, R.M. Huizenga, G. Portale, W. Bras, V. Bliznuk, J. Sietsma and S.E. Offerman
Formation of (Fe,Cr) carbides and dislocation structures in low-chromium steel studied in situ using synchrotron radiation
Journal of Applied Crystallography 46 (1) 181-192

S. Naderi and P. van der Schoot
Size and boundary effects on the diffusive behavior of elongated colloidal particles in a strongly confined dense dispersion
Journal of Chemical Physics 139 (13)

C. Batistakis, M.A.J. Michels and A.V. Lyulin
Glassy boundary layers vs enhanced mobility in capped polymer films
Journal of Chemical Physics 139 (2)

D. Dasgupta, I.K. Shishmanova, A. Ruiz-Carretero, K.B. Lu, M. Verhoeven, H.P.C. van Kuringen, G. Portale, P. Leclere, C.W.M. Bastiaansen, D.J. Broer and A.P.H.J. Schenning
Patterned Silver Nanoparticles embedded in a Nanoporous Smectic Liquid Crystalline Polymer Network
Journal of the American Chemical Society 135 (30) 10922-10925

D.Q. Liu, C.W.M. Bastiaansen, J.M.J. den Toonder and D.J. Broer
(Photo-)Thermally Induced Formation of Dynamic Surface Topographies in Polymer Hydrogel Networks
Langmuir 29 (18) 5622-5629

I. Vukovic, H. Friedrich, D.H. Merino, G. Portale, G. ten Brinke and K. Loos
Shear-Induced Orientation of Gyroid PS-b-P4VP(PDP) Supramolecules
Macromolecular Rapid Communications 34 (15) 1208-1212

B. McCulloch, G. Portale, W. Bras, J.A. Pople, A. Hexemer and R.A. Segalman
Dynamics of Magnetic Alignment in Rod-Coil Block Copolymers
Macromolecules 46 (11) 4462-4471

S. Naderi and P. van der Schoot
Collective stringlike motion of semiflexible filamentous particles in columnar liquid crystalline phases
Physical Review E 88 (3)

S. Naderi, E. Pouget, P. Ballesta, P. van der Schoot, M.P. Lettinga and E. Grelet
Fractional Hoppinglike Motion in Columnar Mesophases of Semiflexible Rodlike Particles
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M.L. Petrus, R.K.M. Bouwer, U. Lafont, D.H.K. Murthy, R.J.P. Kist, M.L. Bohm, Y. Olivier, T.J. Savenije, L.D.A. Siebbeles, N.C. Greenham and T.J. Dingemans
Conjugated poly(azomethine)s via simple one-step polycondensation chemistry: synthesis, thermal and optoelectronic properties
Polymer Chemistry 4 (15) 4182-4191

D.Q. Liu, C.W.M. Bastiaansen, J.M.J. den Toonder and D.J. Broer
Single-composition three-dimensionally morphing hydrogels
Soft Matter 9 (2) 588-596

G. Portale, D. Cavallo, G.C. Alfonso, D. Hermida-Merino, M. van Drongelen, L. Balzano, G.W.M. Peters, J.G.P. Goossens and W. Bras
Polymer crystallization studies under processing-relevant conditions at the SAXS/WAXS DUBBLE beamline at the ESRF
Journal of Applied Crystallography 46 1681-1689

M. van Drongelen, T. Meijer-Vissers, D. Cavallo, G. Portale, G. Vanden Poel and R. Androsch
Microfocus wide-angle X-ray scattering of polymers crystallized in a fast scanning chip calorimeter
Thermochimica Acta 563 33-37

D.M. Petrovic, K. Leenhouts,
M.L. van Roosmalen and J. Broos
An expression system for the efficient incorporation of an expanded set of tryptophan analogues
Amino Acids 44 (5) 1329-1336

M.B. van Eldijk, I. van Leeuwen,
V.A. Mikhailov, L. Neijenhuis, H.R. Harhangi,
J.C.M. van Hest, M.S.M. Jetten, H.J.M.O.
den Camp, C.V. Robinson and J. Mecinovic
Evidence that the catenane form of CS2 hydrolase is not an artefact
Chemical Communications 49 (71) 7770-7772

A. Cumurcu, J. Duvigneau, I.D. Lindsay,
P.M. Schon and G.J. Vancso
Multimodal imaging of heterogeneous polymers at the nanoscale by AFM and scanning near-field ellipsometric microscopy
European Polymer Journal 49 (8) 1935-1942

C. van der Walt, L. Malan, A.S. Uys and
N.T. Malan
Low Grade Inflammation and ECG Left Ventricular Hypertrophy in Urban African Males: The SABPA Study
Heart Lung and Circulation 22 (11) 924-929

M.E. Dobrowolska, J.H. van Esch and
G.J.M. Koper
Direct Visualization of "Coagulative Nucleation" in Surfactant-Free Emulsion Polymerization
Langmuir 29 (37) 11724-11729

R.P. Temming, L. Eggermont, M.B. van Eldijk,
J.C.M. van Hest and F.L. van Delft
N-terminal dual protein functionalization by strain-promoted alkyne-nitrone cycloaddition
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#769: High performance Stereocomplex of Poly(lactic acid) SC-PLA

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#771: Silica nanoparticles - a Catalysts Approach for Polyolefin Reactor Intermixed Compounds with Controlled intermixing of polyOlefins

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DPI is a foundation funded by Dutch industry, universities and the government which was set up to perform exploratory research in the area of polymer materials.

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