Facing the challenges ahead

Annual Report 2019

DPI
The Polymer Research Platform

Foreword

Facing the challenges ahead

As we write this, the world continues to be in the grip of the COVID-19 pandemic. This is a major crisis in the history of mankind, impacting all areas of our lives. It is still too early to say what the consequences will be for the polymer sector in general and for DPI in particular, but we have complete faith in the value of polymeric materials and in the DPI collaboration platform as an enabler of research-based innovation in polymers.

New Managing Director

The last quarter of 2019 was marked by the announcement of a major change in DPI's management. After serving DPI for 14 years, Jacques Joosten decided to step down as Managing Director and to hand over the baton to his successor as soon as a new Managing Director would be available. He has meanwhile been succeeded by Ernst Jan van Klinken, who took up the position as of 1 February 2020.

Under Jacques' leadership, DPI underwent a major transformation: from a public-private partnership jointly funded by industry, universities and the Dutch government to a primarily industry-funded collaboration platform. After handing over his duties to his successor in a short and smooth transition process, Jacques took up his new role as a member of the DPI Supervisory Board.

Jacques' official farewell from DPI took place at our Annual Meeting in November, which – as part of our ongoing efforts to focus attention on sustainability and circularity of plastics – was centred around the theme "The Role of Plastics in the Circular Economy, Today and Tomorrow". It featured a panel discussion among representatives of various sectors on the management of flexible plastic packaging waste.

Circular Plastics Initiative

In 2019, DPI teamed up with the Institute for Sustainable Process Technology (ISPT, which – like DPI – is a Netherlands-based public private partnership platform) to launch the Circular Plastics Initiative. The mission is to create a unique international circular plastics value chain involving players from the plastics, food and recycling/waste-processing sectors. Various major companies from different sectors have already signed up. A project was started in October 2019 to analyse post-consumer waste streams from five different regions in Europe, identify their waste components (e.g. polymers, additives and contaminants) and evaluate suitable processing technologies. It is expected that more projects will be rolled out composing a broad portfolio of projects addressing current and future needs around plastics in a fully circular economy.

New industrial partners

The strength of the DPI platform lies in its international partner base. Three major companies joined DPI in 2019: Russia's largest integrated petrochemicals company SIBUR, the multinational petroleum and natural gas company Saudi Aramco and the Chinese advanced materials company Kingfa. SIBUR is participating in the Polyolefins research

programme, while Saudi Aramco and Kingfa have signed up for the Performance Polymers programme. With their broad business portfolios and strong scientific expertise, the three companies are a welcome addition to the DPI platform. Their participation reaffirms DPI's reputation as a leading international platform for collaborative research and brings our industrial partner base to a total of 18 partners.

As a virtual network-based collaboration platform, DPI works together with polymer research groups worldwide. This enables us to engage the best possible experts to work on the research topics defined. In 2019, a total of 27 knowledge institutions from across the world were involved in DPI projects.

Working on and for the future

DPI's research programmes are closely linked to the needs of our industrial partners. Exploratory initiatives play an important role in delineating these needs. Taken in conjunction with new developments in science and technology, which we track on an ongoing basis, such initiatives help us to work with our industrial partners to unlock new routes for achieving their common innovation goals.

While value-chain projects are directed at specific innovations, our core research programmes are focused on pre-competitive areas in which companies can work together without compromising their individual competitive interests. Participation in DPI research projects is therefore subject to companies' strategic priorities. At the same time, developments in the wider world, including societal concerns, also inspire new research topics that may interest our industrial partners. For example, CEFIC's roadmap for the years 2030-2050, "European chemistry for growth: Unlocking a competitive, low carbon and energy efficient future", will no doubt spawn a variety of research projects that are of relevance to industry. These will not only relate to traditional polymer research, but also address increasingly important topics such as low-carbon raw materials for the chemical industry as a whole and material technologies supporting the energy transition. Another topic gaining scientific and industrial attention is the use of electrochemistry in organic synthesis. As always, subsidy schemes will be instrumental in promoting exploratory research in new areas.

New strategy

The DPI team is currently working on formulating a new strategy, which will be first communicated at our 2020 Annual Meeting in October. While industry remains in the driver's seat in defining DPI's research programmes, we will continue to act proactively in creating and enhancing awareness of new developments and identifying research topics that may be of interest to our industrial partners. Today's world urgently needs solutions in the area of circular plastics and collaborative polymer research will play a key role in enabling such solutions. We therefore expect that there will be growing attention for circularity in DPI's existing programme areas and that new programme areas will emerge around societal themes. Research areas expected to grow in importance to DPI and DPI's partners are biodegradability, biomedical materials and possibly also biobased materials. We believe the world will continue to need new, lighter, more effective and environmentally sound polymeric materials to meet its changing needs and to sustain a higher quality of life for an ever-growing world population. As we have shown over the past two decades, DPI has the resilience to continually adapt to changing circumstances, to proactively connect to societal missions and to drive the much-needed advances in research and innovation.

Jacques Joosten,
Former Managing Director

Ernst Jan van Klinken,
Managing Director

Contents

Organisation 2019

Supervisory Board until June 2019

- **Dr. H.M.H. van Wechem**, *Chair*
- **J. de Jeu, MA MSc**
- **Dr. F. Kuijpers**
- **Prof. K.C.A.M. Luyben**
- **Dr. J.A. Roos**

Supervisory Board per July 2019

- **Dr. Yvonne Engelen**, *Chair*
- **Prof. Frank Baaijens**
- **Bernie van Leeuwen, MSc**
- **Dr. Erik Van Praet**

Executive Board

- **Dr. J.G.H. Joosten**
  Managing Director, Chair
- **Vacancy**
  Scientific Director

Programme Area Coordinators

- **Dr. C.L.Bostoen**
  Polyolefins
- **Dr. D.G. Hristova-Bogaerds**
  Performance Polymers
- **R.J. Korstanje, MSc**
  Functional Polymers and Surfaces
  Polymers for Oil and Gas
- **Dr. J. Smook** (left in 2019)
  Polyolefins
- **Dr. J.E. Stamhuis** (left in 2019)
  Polyolefins
  Polymers for Oil and Gas

Scientific Programme Chairs

- **Prof.dr. V. Busico**
  Polyolefins
- **Prof.dr. C. Creton**
  Performance Polymers
- **Prof.dr. D.J. Broer**
  Coatings Technology

Organisation Staff

- **A.F.J. van Asperdt**
  Financial Administration
- **L.A.W. Damen**
  Project Administration
  Financial Administration
- **R.P.F. Hoogers-Valken**
  Secretariat
- **P.J.J. Kuppens AA**
  Controlling
- **Dr. C.H. Lai**
  Business Developer
- **Rosanne Peters**
  HR&O Manager
- **C.H.L.M. Scharff-Bastiaens**
  Communications
- **L. de Wit**
  Project Administration

Staff European projects

- **A. Brouwer, MSc**
  Programme Manager Seafront
- **Dr. D.G. Hristova-Bogaerds**
  Project Manager EMMC-CSA
- **L. de Wit**
  EU Project Office

Jan Stamhuis takes leave of DPI

Having served DPI for 15 years, Dr. Jan Stamhuis, Programme Area Coordinator, took his leave of our organisation in 2019.

Jan, a Polymer Scientist with a PhD from Groningen University, joined DPI in 2004 following 25 years at Shell in a variety of positions. At DPI, Jan took up the position of Programme Area Coordinator with responsibility for the research areas of Polyolefins, Engineering Plastics and Rubber Technology.

In 2007, under Jan's coordination, the Engineering Plastics and Rubber Technology areas were merged to form the Performance Polymers programme area. Jan's portfolio was expanded in 2009 to include the newly created Emerging Technologies programme area, which in 2012 formed the basis for the creation of a new research area: Polymers for Enhanced Oil Recovery. In 2016, following the restructuring of DPI's programme areas, Jan became Programme Area Coordinator for the new area Polymers for Oil and Gas, while retaining Polyolefins in his portfolio for most of the time until 2018.

During the period 2013-2019, Jan was also in charge of IP and Legal matters at DPI.

DPI is very grateful to Jan for his dedicated efforts over the years as Programme Area Coordinator. Jan is a real connector, whose close interaction with DPI's industrial and academic partners worldwide helped build a strong DPI community. With his broad experience and scientific expertise, he played a key role in optimising DPI's research programme and enhancing DPI's offering as a unique collaboration platform.

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 focusing on pre-commercial application themes.

Pre-competitive research programme

DPI's pre-competitive research programme currently embraces five programme 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 programme content for the programme 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 research results to the envisaged high standard and prepares our scientists for their future careers, in industry or elsewhere.

PRE-COMPETITIVE PROGRAMME

DPI Rules & regulations apply to all projects

Polyolefins		Performance Polymers	
18 projects		**11 projects**	
Industry	**Academia**	**Industry**	**Academia**
• Borealis • Braskem • Dow Benelux • ExxonMobil • Reliance • SABIC • SIBUR • SCG Chemicals • Sinopec	• Eindhoven University of Technology • ESCPI-Lyon • ETH Zurich • Fraunhofer Institute for Structural Durability and System Reliability LBF • Japan Advanced Institute of Science and Technology • Leibniz-Institut für Polymerforschung Dresden • Lomonosov Moscow State University • The University of Texas at Austin • University of Chemistry and Technology Prague • University of Groningen • University of Naples Federico II • University of Perugia • University of Turin • Utrecht University	• Saudi Aramco • DSM • Hutchinson • Kingfa • Nouryon • SABIC • Shell • SKF • Tejin Aramid	• Eindhoven University of Technology • CNRS Strasbourg • Delft University of Technology • Ghent University • KU Leuven • Polymer Competence Center Leoben • Radboud University • The University of Manchester • University of Nottingham • University of Oxford • University of Twente
Expenditure € 1.88 million FTEs 17.4 (27 researchers)		Expenditure € 0.85 million FTEs 11.7 (21 researchers)	

Industrial pre-commercial programme

The industrial pre-commercial programme consists of Value Chain projects and EU projects. The conditions for performing Value Chain projects are described below and those for EU projects are in accordance with published EU rules that are available on the relevant websites.

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 an 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 and to coordinate the project. DPI's role can also be limited to acting as coordinator of a project.

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 for research purposes and 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-COMPETITIVE PROGRAMME

DPI Rules & regulations apply to all projects	
Coatings Technology	**Polymers for Oil and Gas**
2 projects	**4 projects**
Industry • Wageningen University & Research	**Industry** • Shell • SNF Floerger
	Academia • Clausthal University of Technology • Université de Bordeaux • University of Groningen • University of Twente
Expenditure € 0.05 million FTEs 0.4 (1 researcher)	Expenditure € 0.31 million FTEs 3.5 (4 researchers)

EMMC-CSA

DPI is a partner in the project EMMC-CSA (European Materials Modelling Council – Coordination and Support Action), which comes under the EU's Horizon 2020 framework programme.

Modelling is a key pillar underpinning the development of new materials and products responding to societal needs and challenges and for ensuring competitiveness of European industry in the 21st century.

Scope

The aim of the project is to allow European Industry to reap the benefits of materials modelling more effectively and vigorously by helping to bridge the gap between academic innovation and industrial application.

The project, which was launched in September 2016 and has a duration of three years, is being carried out by a consortium of 15 partners from 10 countries and involves 5 companies and 10 Research and Technology Organisations (RTOs).

DPI's role

The tasks of DPI are related to the translation of industrial challenges into modelling solutions and the development of strategies for a wider adoption of materials modelling by industry. DPI is also represented in the EMMC Operational Management Board.

More information about the European Materials modelling council EMMC and this project can be found at:

https://emmc.info/about-emmc-csa/

Co-funded by the Horizon 2020 programme of the European Union

INDUSTRIAL PRE-COMMERCIAL PROGRAMME

Model framework for collaboration

Rules and regulations set by involved partners

EMMC-CSA
(1-9-2016/31-8-2019)

Partners

- Access e.V.
- Dow Benelux
- DPI
- Ecole Polytechnique Federale de Lausanne
- Fraunhofer IWM
- Goldbeck Consulting
- Granta Design
- Helmholtz-Zentrum Geesthacht
- Materials Design (MDS)
- Politecnico di Torino
- QuantumWise
- SINTEF
- TU Wien
- University of York
- Uppsala University

Budget €3.77 million
(€3.77 million EU subsidy)

NEWPOL (New Polymer Materials) programme

DPI is working together with NWO, the Netherlands Organisation for Scientific Research, on the NEWPOL (New Polymer Materials) programme. NEWPOL is a public-private initiative focusing on developing new polymeric materials by encouraging cross-pollination between different research fields and disciplines.

DPI has organised the NEWPOL activities as a separate programme area. The programme offers DPI a good opportunity to explore the possibilities of this model of cooperation.

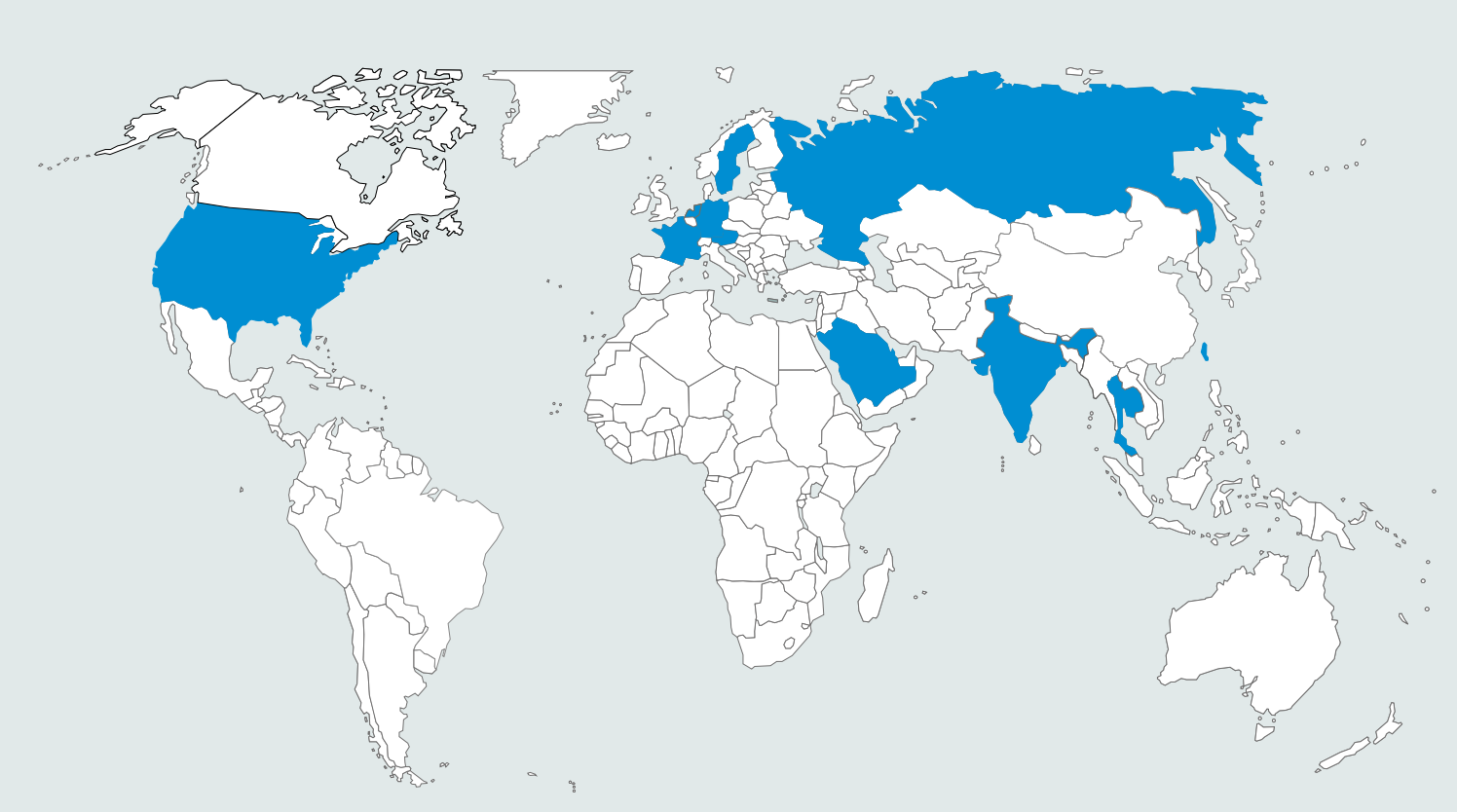
All of DPI's industrial partners are participating in this programme, which encompasses six projects on topics such as:

- Colouring paint without pigments
- Commodity polymers with self-organising smart coatings that respond to environmental changes by changing color and/or shape
- Supramolecular biomaterials for stem cell expansion
- Self-synthesizing gels
- Development of a SuperActive synthetic biomaterial to repair damaged tissues in the body
- Flexible memories made from coordination polymers.

Universities involved:

- AMC Amsterdam
- Delft University of Technology
- Eindhoven University of Technology
- University of Groningen
- Wageningen University & Research

Partners Industry 2019



Europe

BOREALIS Keep Discovering	Borealis
HUTCHINSON	Hutchinson
SIBUR	SIBUR (new in 2019)
SKF	SKF
SNF FLOERGER	SNF Floerger

North and South America

Braskem	Braskem
ExxonMobil	ExxonMobil

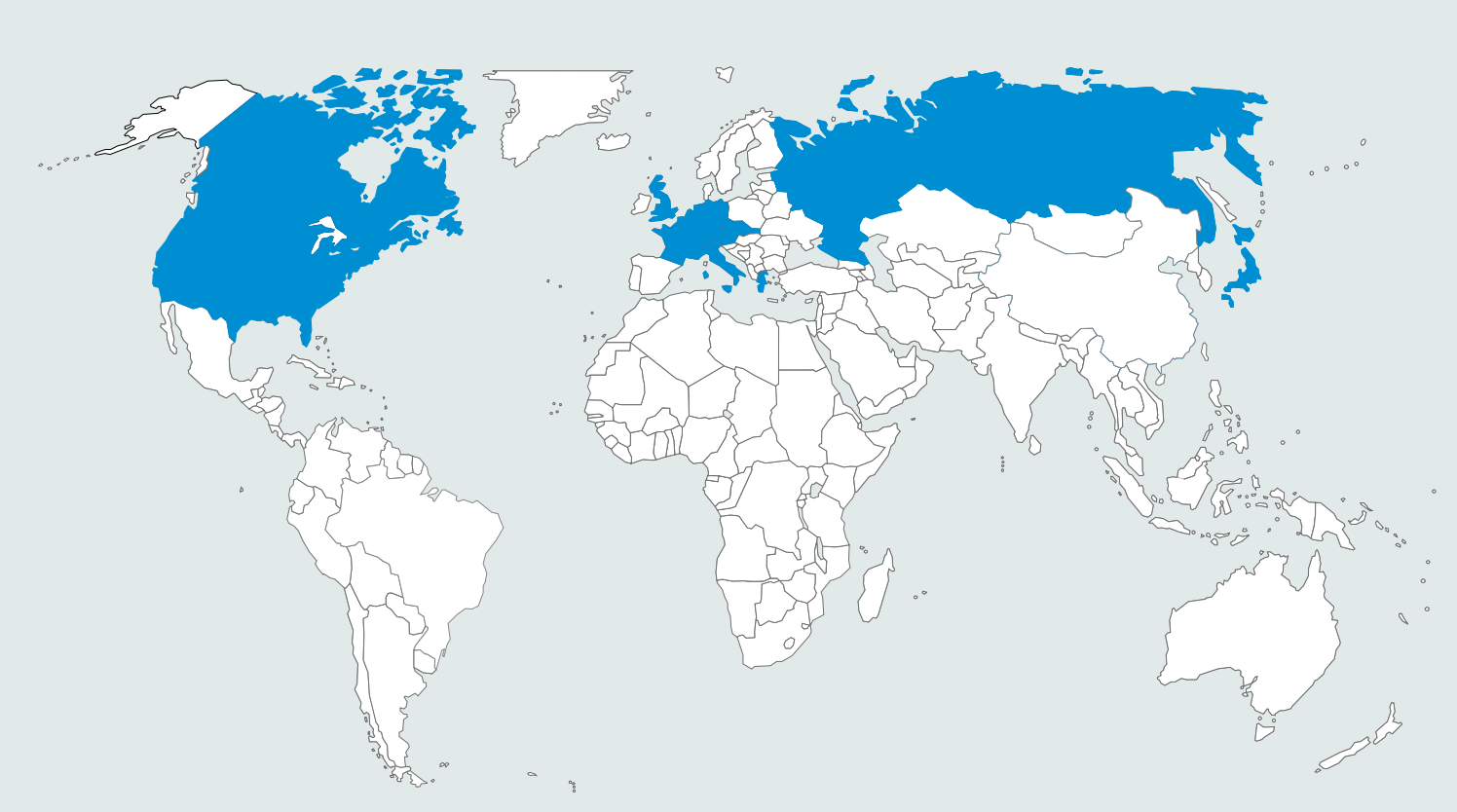
Asia

Kingfa (new in 2019)
Reliance
Saudi Aramco (new in 2019)
SCG-Chemicals
Sinopec

The Netherlands

AkzoNobel
Dow Benelux
DSM
Nouryon (left in 2019)
SABIC
Shell
Tejin Aramid

Partners Knowledge institutes 2019



Europe

Clausthal University of Technology (new in 2019)	Polymer Competence Center Leoben (new in 2019)
CNRS Strasbourg	The University of Manchester
ESCPI-Lyon	Université de Bordeaux
ETH Zurich	University of Chemistry and Technology Prague
Fraunhofer Institute for Structural Durability and System Reliability LBF	University of Naples Federico II
Ghent University	University of Nottingham (new in 2019)
KU Leuven	University of Oxford (new in 2019)
Leibniz-Institut für Polymerforschung Dresden	University of Perugia
Lomonosov Moscow State University	University of Turin

North and South America, Asia

JAIST	Japan Advanced Institute of Science and Technology
TEXAS The University of Texas at Austin	The University of Texas at Austin
University of Manitoba	University of Manitoba (no research projects in 2019)

The Netherlands

TU Delft	Delft University of Technology
TU/e Eindhoven University of Technology	Eindhoven University of Technology
	Radboud University
university of groningen	University of Groningen
UNIVERSITY OF TWENTE	University of Twente
Universiteit Utrecht	Utrecht University
WAGENINGEN UNIVERSITY & RESEARCH	Wageningen University & Research

Summary of financial data 2019

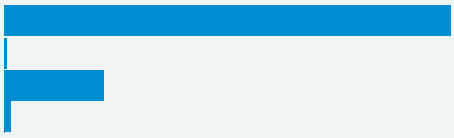
Income

	(x EUR million)	%
Contributions from industrial partners	2.96	63.8%
Revenue Patents	0.06	1.3%
Contributions from knowledge institutes	0.24	5.2%
Subsidy of TKI Toeslag	1.31	28.2%
EU projects	0.07	1.5%
Total income	**4.64**	**100.0**

Expenditure

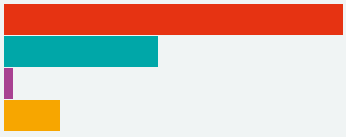
By nature

	(x EUR million)	%
Personnel costs	3.49	80.6%
Depreciation	0.01	0.2%
Other costs	0.78	18.0%
EU projects	0.05	1.2%
Total expenditure	**4.33**	**100**



By Programme Area

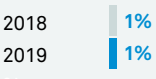
Polyolefins	1.88	60.8%
Performance Polymers	0.85	27.5%
Coatings Technology	0.05	1.6%
Polymers for Oil and Gas	0.31	10.0%
Sub total	**3.09**	**100**
Knowledge Transfer	0.16	
Organisation and support	0.92	
EU projects	0.05	
Business Development	0.11	
Total expenditure	**4.33**	



Key Performance Indicators 2019

Number of industrial partners

European governmental funding (% of total funding)



Number of partner knowledge institutes
(universities, etc.)

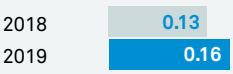
Participation of foreign knowledge institutes
as % of total expenditure

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

Overhead costs
as % of total expenditure

Subsidy (TKI Toeslag)
as % of total income

Expenditure for knowledge transfer
x EUR million



Track record DPI researchers

Left in total	20
Employed by partner knowledge institute	11
Employed by non-partner knowledge institute	5
Employed by partner industrial company	1
Employed by non-partner industrial company or start-up	1
Unknown	2

Research output	2018	2019
Scientific publications	40	33
PhD theses	7	4
Average journal impact factor	3.85	3.83

DPI Annual Meeting 2019
Farewell to Managing Director Jacques Joosten

This year's Annual Meeting centred around the farewell of outgoing Managing Director Jacques Joosten. Although the meeting marked his official farewell, Jacques will continue to hold the office until a successor is appointed. Around 275 people from across the world attended the event, held at the Van der Valk Hotel Conference Centre in Eindhoven on 12 and 13 November.

The morning of the first day was devoted to a "Get to Know DPI" session, providing guests the opportunity to learn about DPI in general and about DPI's research programmes in particular. DPI Programme Area Coordinators were present to explain about the activities in their respective areas: Polyolefins, Performance Polymers, Polymers for Oil & Gas and Functional Polymers and Surfaces. Various projects being carried out under the auspices of European Union programmes were also highlighted.

The afternoon programme on the first day included a retrospective talk by Dr. Thijs Michels, former Scientific Director of DPI, highlighting developments in polymer science and technology during the past twenty-five years. Speaking about the role that DPI had played for over 20 years in bridging industrial and academic research, Dr. Michels emphasised how Jacques Joosten's extensive network in the polymers in the Netherlands and abroad as well as his dedicated efforts had helped to bolster the value of the DPI collaboration platform.

On behalf of the outgoing Supervisory Board members (DPI recently installed a new Supervisory Board), Dr. Herman van Wechem praised Jacques Joosten for the way he had managed DPI for fourteen years and thanked him for the part he had played in assuring the continuation of DPI in an uncertain setting.

Panel discussion

In continuation of the efforts DPI has been making for the past few years to encourage debate on the subject of sustainability and the need for circularity of plastics, the overall theme of this year's Annual Meeting was "The Role of Plastics in the Circular Economy, Today and Tomorrow". In this context, a special programme item was a Panel Discussion – moderated by Joris Luyendijk, well-known journalist, author and anthropologist – on a very topical subject: the management of plastic waste, in particular flexible plastic packaging waste. Panel members had been chosen to represent different segments of the plastics value chain:

- Dr. Ben Alpern, Senior Expert, SIBUR (Russia)
- Dr. Ellen de Brabander, Senior Vice President R&D, PepsiCo (USA)
- Prof. Vincenzo Busico, Full Professor of General and Inorganic Chemistry at the Department of Chemical Sciences of the Federico II University (Italy)
- Fionn Ferreira, Chemistry student at University of Groningen and winner of several international science awards (Netherlands)
- Prof. John Grin, Programme leader Transnational Configurations, Conflict and Governance, University of Amsterdam (Netherlands)
- Dr. Shahab Jahromi, Managing Director, Knowfort Technologies (Netherlands)

A lively exchange of ideas and views took place under the experienced moderatorship of Joris Luyendijk. The panel members were all agreed that pursuing sustainability and circularity of plastics was a common priority. A variety of opinions were put forward about the nature and magnitude of the challenges and possible approaches to them. Here's a summary of members' views: there is no single and no simple solution; a comprehensive approach is desirable; although a big leap is what everyone wants, in practice a step-change is more realistic; the problem of plastic packaging waste or the circularity of plastics should not be seen in isolation: it should be seen in conjunction with the broader, bigger

DPI ANNUAL MEETING 2019
Jacques Joosten

DPI POSTER AWARD 2019

The first prize was awarded to Georgios Vogiatzis and the second prize to Gaia Urciuoli and Antonio Vittoria.

issues such as climate and energy; recyclability is only one of the many aspects to be considered; the diverse interests of the players involved leads to a silo mentality: what is needed is a more direct connection between stakeholders from the different value chain segments; the explosive growth of some world economies increases and aggravates the problems; while public buy-in and awareness are important in order to realise changes, there is still insufficient public knowledge (e.g. about plastics) and awareness about environmental consequences; proper education of the public is therefore a key priority.

It was clear that – given the diverse interests and roles of the sectors involved and the economic and technological complexity of the matter – there is still a long way to go before any concrete steps can be taken in a concerted manner. About one thing, however, there was general consensus: business as usual is not an option. Asked for suggestions and ideas for breaking the current impasse, the panel members advocated identifying what each one of us can do to tackle the problem; working together and more proactively; establishing mission-driven partnerships among all players involved; a smart and prudent use of resources; and a good dose of realism.

Poster Award

Every year at the DPI Annual Meeting, scientists working on DPI projects are given the opportunity to present their research by means of posters and compete for the DPI Poster Award. In keeping with the practice a few years ago, the prizes are awarded on the basis of a public vote: this year, too, all attendees of the annual meeting were invited to rate the posters and cast their votes for the three best posters.

The first prize was awarded to Georgios Vogiatzis of Eindhoven University of Technology for his poster entitled "Physical Aging of Glassy Polymers: Climbing up the Time-scales"; Georgias is working on a research project in the field of Performance Polymers. The second prize went to Gaia Urciuoli and Antonio Vittoria of the University of Naples, whose work is in the field of Polyolefins (poster title: "Investigating Microstructural and Structural Reproducibility of HTE Synthesized Olefin Block Copolymers"). The third prize was awarded to Yuanshuai Liu of Utrecht University, working in the field of Polyolefins (poster title: "Structure-Activity-Polymer Property Studies on a Novel Ziegler-Natta Olefin Polymerization Model System").

Conference dinner

In keeping with tradition, a Conference Dinner was held on the evening of the first day. Some 200 people from a variety of companies and universities from across the world attended the dinner, which offered an excellent opportunity to get to know one another in an informal setting. Since this annual meeting was also a farewell event, several relatives and close friends of Jacques Joosten were also present. Among the latter were two long-standing scientific friends from China and Russia. They both made short dinner speeches. Prof. Jiasong He, of the Institute of Chemistry of the Chinese Academy of Sciences, spoke about his interactions with the polymer community in the Netherlands during the past thirty-three years. Dr. Liuba Myasnikova, leading scientist at Joffe Physico-Technical Institute of the Russian Academy of Sciences, also spoke about her longstanding collaboration with Dutch scientists.

As in previous years, the programme of the Annual Meeting included Review Meetings of the various Programme Areas of DPI.

Farewell present Jacques Joosten

Three years ago, Jacques became involved in a socio-economic project in Muleba, a district located in the Kagera region in northwest Tanzania. The project is a collaborative initiative of Mali, a farmer's organisation in Tanzania, and Mali Muleba, a non-profit organisation based in Belgium. Mali Juice is an enterprise that buys fruit from local farmers and uses it to produce healthy fruit juice exclusively for sale on the local market. Mali Muleba contributes technical expertise and management experience to the enterprise and also provides financial support. The two partners work together to assure a better and sustainable future for the generations to come: Umoja ni nguvu! (Swahili for: Collaboration pays!)

Instead of farewell presents, Jacques would very much appreciate donations to the Mali project. You can send your donation directly to the bank account of Mali Muleba vzw: BE18 0016 5913 3365, specifying "Farewell Jacques Joosten".

For more information on the Mali project, please visit: www.malimuleba.com

POLYOLEFINS

The Polyolefins research programme encompasses the entire spectrum of the knowledge chain. The aim is to create the knowledge base needed to support the ever-expanding range of applications.

Polyolefin-based materials can be customised for many different applications: from ultra-rigid thermoplastics to high-performance elastomers. This wide performance scope is achieved through a variety of polyolefin molecular structures, whose common features are high atom economy in their synthesis, low cost, excellent properties, a long life cycle and ease of recycling.

The programme focuses on deepening of understanding of polyolefin catalysis, reaction engineering, processing and material properties and the development of new methods and methodologies to support the ongoing transition from empirical to fundamental understanding.

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.

FACTS AND FIGURES

Partners from industry
- Borealis
- Braskem
- Dow Benelux
- ExxonMobil
- Reliance
- SABIC
- SIBUR
- SCG Chemicals
- Sinopec

Partners from the research world
- Eindhoven University of Technology
- ESCPI-Lyon
- ETH Zurich
- Fraunhofer Institute for Structural Durability and System Reliability LBF
- Japan Advanced Institute of Science and Technology
- Leibniz-Institut für Polymerforschung Dresden
- Lomonosov Moscow State University
- The University of Texas at Austin
- University of Chemistry and Technology Prague
- University of Groningen
- University of Naples Federico II
- University of Perugia
- University of Turin
- Utrecht University

Budget and organisation
Expenditure in 2019 totalled € 1.88 million. The total number of FTEs allocated at year-end 2019 was 17.4 (27 researchers). Prof.dr. Vincenzo Busico was Scientific Chair and Dr. Jan Smook and Dr. Claude Bostoen were Programme Area Coordinators of the Polyolefins programme.

Publications and inventions
This programme area generated a total of six reviewed papers.

For details, see page 22

PERFORMANCE POLYMERS

Performance Polymers possess superior chemical, mechanical and physical properties, especially beyond ambient conditions. They are usually used as multi-component polymeric systems consisting of various polymers, reinforcements and additives.

The research focus of the Programme Area Performance Polymers is to enhance the performance of different polymeric systems by combining chemistry, physics and engineering science. This leads to a better understanding of the "structure versus performance" relationship on all length scales – from molecular to macroscopic. Via the generated knowledge, the Performance Polymers programme provides opportunities for responding to the new sustainability challenges posed to the industrial sectors of automotive, aerospace, electronics, oil & gas transport and construction.

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 effect of ageing and use conditions on the performance of thermoplastic composites with the ultimate goal of predicting lifetime and attaining a fit-for-purpose design over the entire lifecycle.

FACTS AND FIGURES

Partners from industry
- Saudi Aramco
- DSM
- Hutchinson
- Kingfa
- Nouryon
- SABIC
- Shell
- SKF
- Tejin Aramid

Partners from the research world
- Eindhoven University of Technology
- CNRS Strasbourg
- Delft University of Technology
- Ghent University
- KU Leuven
- Polymer Competence Center Leoben
- Radboud University
- The University of Manchester
- University of Nottingham
- University of Oxford
- University of Twente

Budget and organisation
Expenditure in 2019 totalled € 0.85 million. The total number of FTEs allocated at year-end 2019 was 11.7 (21 researchers). Prof.dr. Costantino Creton was Scientific Chair and Dr. Denka Hristova-Bogaerds was Programme Area Coordinator of the Performance Polymers programme.

Publications and inventions
This programme area generated a total of seventeen reviewed papers and four theses.

For details, see page 23

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 the research world
- Wageningen University & Research

Budget and organisation
Expenditure in 2019 totalled € 0.05 million. The total number of FTEs allocated at year-end 2019 was 0.4 (1 researcher). Ronald Korstanje acted as Programme Area Coordinator of this programme area.

Publications and inventions
The research programme in this programme area generated a total of eight reviewed papers.

For details, see page 24

POLYMERS FOR OIL AND GAS

Polymers find broad application in the recovery, transport and utilisation of oil and gas, e.g. as oil field chemicals or as light-weight materials with superior durability properties. The aim of the Polymers for Oil and Gas programme is to generate tools and new insights into existing and new polymers for utilisation in the exploration, production and transport of oil and gas.

Two main areas of study are distinguished: firstly, the use of polymers in fluids for enhanced oil recovery (EOR) and other sub surface drilling/recovery applications. Secondly, the behaviour of polymers in functional materials used under extreme/adverse conditions (in close collaboration with the Performance Polymers programme area).

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 Floerger

Partners from the research world
- Clausthal University of Technology
- Université de Bordeaux
- University of Groningen
- University of Twente

Budget and organisation
Expenditure in 2019 totalled € 0.31 million. The total number of FTEs allocated at year-end 2019 was 3.5 (4 researchers). Dr. Jan Stamhuis and Ronald Korstanje acted as Programme Area Coordinator of the Polymers for Oil and Gas programme.

For details see page 24

Output 2019

POLYOLEFINS

Projects

#919: Structure-Activity-Polymer Property Studies on a Novel Ziegler-Natta Olefin Polymerization Model System

#800: Quantitative Structure-Activity Relationships (QSAR) in Metallocene-Based Olefin Polymerization Catalysis

#801: Predictive modelling of mechanical anisotropy in oriented semi-crystalline polymers directly from morphological characteristics

#802: Structure determination at the nanoscale and atomic dynamics of MgCl2 primary particles in Ziegler-Natta catalysts

#803: HEat Management in Polymerization Reactors (HEMPR)

#804: From homogeneous to "colloidal" olefin polymerization catalysts: effects of mass transport limitations on reaction kinetics and polymer microstructure

#810: Online Polyolefin structuring during Cast Film Extrusion

#813: Multi-scale investigation of silica-supported ethylene polymerization catalysts during the early stages of the reaction

#814: Control of crystallisation, chain entanglement and rheology via process conditions

#815: Augment the macroscopic PROperties of i-PP composites by controlling the microscopic Fiber-matrix Interactions via Transcrystallization

#816: Correlation between process-induced crystallization and mechanical properties in injection molded isotactic polypropylene (iPP)

#817: An inter-disciplinary high-throughput approach to olefin block copolymers

#830: Electrostatic charging of polyolefin powders on the level of particles

#831: Molecular modelling of stretch-induced crystallization in polyethylene and polypropylene layers

#832: Quality model for COntaminated Recycled Polyolefins

#834: RHEOlogical determination of POLyolefin ARchitectures

#835: Quantitative Structure-Activity Relationships (QSAR) in Post-Metallocene-Based Olefin Polymerizations Using Chemically Meaningful Computational Descriptors

#836: Practical, High Throughput Quench Labeling Techniques for Information-Rich Analysis of Alkene Polymerization Catalysts

Scientific publications

G. Takasao, T. Wada, A. Thakur, P. Chammingkwan, M. Terano and T. Taniike
Machine Learning-Aided Structure Determination for TiCl4-Capped MgCl2 Nanoplate of Heterogeneous Ziegler-Natta Catalyst
Acs Catalysis 9 (3) 2599-2609

E.N.T. Cuthbert, V. Busico, D.E. Herbert and P.H.M. Budzelaar
Formation and Activation of Zr/Hf Bis(phenolate-ether) Precatalysts
European Journal of Inorganic Chemistry 2019 (29) 3396-3410

D. Kot, T. Macko, J.H. Arndt and R. Brull
Porous graphite as platform for the separation and characterization of synthetic polymers - an overview
Journal of Chromatography A 1606

F. Di Sacco, A. Pucci and P. Raffa
Versatile Multi-Functional Block Copolymers Made by Atom Transfer Radical Polymerization and Post-Synthetic Modification: Switching from Volatile Organic Compound Sensors to Polymeric Surfactants for Water Rheology Control via Hydrolysis
Nanomaterials 9 (3)

M. Banaei, R. Dellaert, N.G. Deen, J.A.M. Kuipers and M.V. Annaland
Borescopic particle image velocimetry in bubbling gas-solid fluidized beds
Particuology 43 66-75

E. Milacic, M.W. Baltussen and J.A.M. Kuipers
Direct numerical simulation study of droplet spreading on spherical particles
Powder Technology 354 11-18

Projects

#805: Probing interfacial damage in composites with mechanofluorescence

#806: 2D Material Coatings for Fibres

#811: Reliable Prediction of Residual Structural Integrity and Damage- Evolution During Long-Term Fatigue in Thermoplastic Composites

#812: Physics-based fatigue design tool for matrix cracking and delamination in unidirectional and sandwich composites under multi-axial fatigue loads with arbitrary R-ratio : development, validation and finite element implementation

#819: Controlling electrical percolation in hybrid thermoplastic composites through informed selection of fillers

#822: Processing for enhandced product performance

#823: Modular, designer polydopomine adhesives for facile and versatile surface conjugation of function of polyethylenes

#824: Micromechanical modelling of complex composite systems for improved failure prediction and product design

#826: Multi-layered wEar-Resistant Coatings with additional fUnctionality – new stRategies for enhancIng the tribologicAl performance of poLymers in demanding environments

#827: Impact Modelling of Polymers: high-Rate Experiments for Solid-state Simulations

#828: Elastomer DEgradation under ME-chanical Loading: investigation of coupling effect

Theses

Kalouda Grigoriadi
Molecular origin of physical ageing and rejuvenation in glassy polystyrene

Mohammad Khafidh
Friction, wear and noise of short-cut aramid fibre reinforced elastomers in sliding contacts

Leonid Pastukhov
Long-term performance of fibre-reinforced thermoplastics

Wouter Vogel
All-aromatic Hyperbranched Polyaryletherk-etone Networks

Scientific publications

K. Grigoriadi, M. Wubbenhorst, L. van Breemen, P.D. Anderson and M. Hutter
Thermal vs. mechanical rejuvenation of a-PS: molecular dynamics reveal different microscopic scenarios
Abstracts of Papers of the American Chemical Society 257

J.W. Chu, A.J. Marsden, R.J. Young and M.A. Bissett
Graphene-Based Materials as Strain Sensors in Glass Fiber/Epoxy Model Composites
Acs Applied Materials & Interfaces 11 (34) 31338-31345

T.D. Dinh, D. Garoz, M. Hajikazemi and W. Van Paepegem
Mesoscale analysis of ply-cracked composite laminates under in-plane and flexural thermo-mechanical loading
Composites Science and Technology 175 111-121

M. Hajikazemi, D. Garoz and W. Van Paepegem
Model to accurately predict out-of-plane shear stiffness reduction in general cracked laminates
Composites Science and Technology 179 88-96

M. Khafidh, D.J. Schipper, M.A. Masen, N. Vleugels, W.K. Dierkes and J.W.M. Noordermeer
Validity of Amontons' law for run-in short-cut aramid fiber reinforced elastomers: The effect of epoxy coated fibers
Friction

K. Grigoriadi, T. Putzeys, M. Wubbenhorst, L.C.A. van Breemen, P.D. Anderson and M. Hutter
Effect of low-temperature physical aging on the dynamic transitions of atactic polystyrene in the glassy state
Journal of Polymer Science Part B-Polymer Physics 57 (20) 1394-1401

M. Li
Study on melting and polymorphic behavior of poly(decamethylene terephthalamide)
Journal of Polymer Science Part B-Polymer Physics 57 (8) 465-472

G.G. Vogiatzis, L.C.A. van Breemen and M. Hutter
Network Topology of the States Probed by a Glassy Polymer during Physical Aging
Macromolecular Theory and Simulations 28 (6)

K. Grigoriadi, J.B.H.M. Westrik, G.G. Vogiatzis, L.C.A. van Breemen, P.D. Anderson and M. Hutter
Physical Ageing of Polystyrene: Does Tacticity Play a Role?
Macromolecules 52 (15) 5948-5954

A. Amiri-Rad, L.V. Pastukhov, L.E. Govaert and J.A.W. van Dommelen
An anisotropic viscoelastic-viscoplastic model for short-fiber composites
Mechanics of Materials 137

N. Vleugels, W.K. Dierkes, A. Beume, L.A.E.M. Reuvekamp and J.W.M. Noordermeer
Main Governing Factors Influencing Mechanical Properties of Short-Cut Aramid Fiber-Reinforced Elastomers
Rubber Chemistry and Technology 92 (3) 445-466

M. Khafidh, D.J. Schipper and M.A. Masen
The Formation of a Modified Surface Layer on Elastomeric Materials
Tribology Letters 67 (1)

M. Khafidh, D.J. Schipper, M.A. Masen, N. Vleugels, W.K. Dierkes and J.W.M. Noordermeer
Friction and wear mechanism of short-cut aramid fiber and silica reinforced elastomers
Wear 428 481-487

T. Kershah, S.F.S.P. Looijmans, P.D. Anderson and L.C.A. van Breemen
Temperature dependent two-body abrasive wear of polycarbonate surfaces
Wear 440

Z.P. Madzarevic, S. Shahid, K. Nijmeijer and T.J. Dingemans
The role of ortho-, meta- and para-substitutions in the main-chain structure of poly(etherimide)s and the effects on CO2/CH4 gas separation performance
Separation and Purification Technology 210 242-250

W.M. Pazin, N. Vilanova, I.K. Voets, A.E.E. Soares and A.S. Ito
Effects of artepillin C on model membranes displaying liquid immiscibility
Brazilian Journal of Medical and Biological Research 52 (3)

C.L. Li, T. Veldhuis, B. Reuvers, R.J. Sablong and C.E. Koning
Fully renewable limonene-derived polycarbonate as a high-performance alkyd resin
Polymer International

COATINGS TECHNOLOGY

Projects

#911: Tuning the interactions between silica fillers and polymer binders towards hard and crack resistant water-based coatings

#781: Film Formation in Complex Colloidal Coatings

Scientific publication

A. Vagias, Q. Chen, G.H. ten Brink, D. Hermida-Merino, J. Scheerder and G. Portale
Investigation of the Nanoscale Morphology in Industrially Relevant Clearcoats of Waterborne Polymer Colloids by Means of Variable-Angle-Grazing Incidence Small-Angle X-ray Scattering
Acs Applied Polymer Materials 1 (9) 2482-2494

P.T.M. Albers, S.P.W. Govers, J. Laven, L.G.J. van der Ven, R.A.T.M. van Benthem, G. de With and A.C.C. Esteves
Design of dual hydrophobic-hydrophilic polymer networks for highly lubricious polyether-urethane coatings
European Polymer Journal 111 82-94

J. Konieczny and K. Loos
Bio-based polyurethane films using white dextrins
Journal of Applied Polymer Science 136 (20)

J. Konieczny and K. Loos
Polyurethane Coatings Based on Renewable White Dextrins and Isocyanate Trimers
Macromolecular Rapid Communications 40 (10)

H.M. van der Kooij, S.A. Semerdzhiev, J. Buijs, D.J. Broer, D.Q. Liu and J. Sprakel
Morphing of liquid crystal surfaces by emergent collectivity
Nature Communications 10

J. Konieczny and K. Loos
Green Polyurethanes from Renewable Isocyanates and Biobased White Dextrins
Polymers 11 (2)

R. Neffati and J.M.C. Brokken-Zijp
Electric conductivity in silicone-carbon black nanocomposites: percolation and variable range hopping on a fractal
Materials Research Express 6 (12)

V. Shchetnikava, J. Slot and E. Ruymbeke
Comparative Analysis of Different Tube Models for Linear Rheology of Monodisperse Linear Entangled Polymers
Polymers 11 (5)

POLYMERS FOR OIL AND GAS

Projects

#807: Smart brines for minimal surface adsorption in polymer EOR

#808: Adsorption/retention of Polymer in Porous Media

#818: Experimental and Numerical Evaluation of Polymer Viscoelasticity Effects during EOR Applications

#821: New Polymeric Surfactants for Enhanced Oil Recovery

NEWPOL

Projects

#731.015.502: Responsive Commodity Polymers

#731.015.504: Self-Synthesizing Hydrogels

#731.015.505: Supramolecular Biomaterials with Antimicrobial and Regenerative Activity

#731.015.506: Towards flexible memories with coordination polymers with polar rotors

Scientific publications

M. Simenas, S. Balciunas, A. Gonzalez-Nelson, M. Kinka, M. Ptak, M.A. van der Veen, M. Maczka and J. Banys
Preparation and Dielectric Characterization of P(VDF-TrFE) Copolymer-Based Composites Containing Metal-Formate Frameworks
Journal of Physical Chemistry C 123 (26) 16380-16387

A. Gonzalez-Nelson, F.X. Coudert and M.A. van der Veen
Rotational Dynamics of Linkers in Metal-Organic Frameworks
Nanomaterials 9 (3)

Reported invention

731: L. Maric, S. Otto and C. Pappas
SelfSynthGels

DPI ...

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.

DPI operates at the interface of universities and industry, linking the scientific skills of university research groups to the industrial need for innovation.

DPI carries out pre-competitive research projects to add value to the scientific community through scientific publications and to the industrial community through the creation of intellectual property.

DPI provides a unique platform for generating awareness of new technology, in which participating industrial companies, competitors in the market place, communicate on a pre-competitive basis to trigger innovation.

DPI integrates the scientific disciplines and know-how of universities into the 'chain of knowledge' needed to optimise the conditions for making breakthrough inventions and triggering industrial innovation.

DPI aims to combine scientific excellence with a genuinely innovative impact in industry, thereby creating a new mindset in both industrial and academic research.

DPI aims to fill the innovation gap between industry and universities and so resolve the Dutch Paradox of scientific excellence and lack of innovation.

Some 60 researchers (PhDs and Post-Docs) are currently involved in DPI projects at knowledge institutes throughout the world.

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