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December 2017

NORNER NEWS 07

European Polymer Exploration Centre

Circular Economy Development

Sustainable buildings

Advanced materials for Oil & Gas

norner™
The Polymer Explorers

Leader

3@Norner

Espen Ommundsen

Hi, I am working with composites and is manager for research projects. I like the exitement of being involved in developing new material solutions.

Heidi Houghton

Hi, I am a member of our Perfornamce Laboratory. My responsibility is high quality material testing and analysis towards the oil and gas industry.

Jorunn Nilsen

Hi, as a researcher and a polymer expert, I am working in projects with green packaging and sustainable solutions.

I would like to highlight the fact that we sold our first license on own developed technology in the field of polymer production. You can read more about NTT technology and how it will give our customers better performance products in a cost-effective manner.

Dear reader

We celebrate 10 years birthday - yippee

We are approaching the end of a fantastic year boosting our business platform and taking new prosperous steps to meet our future dreams while celebrating our 10 years anniversary.

We have celebrated through the year with successful seminars both with customers, with all our employees and with our owners and key stakeholders.

We started off the year by announcing our plans to invest in a brand new, world leading **Polymer Exploration center.**
This is an exciting combination of a top notch advanced competence and test facility for polymers together with offices and analytic labs in the world's first **Powerhouse which also will include labs**.

The Powerhouse was selected due to its unique concept of taking responsibility for the total emission where also the bound energy from materials plays a significant role.

This fits our vision to design sustainable material for the future – for us this is to Walk the talk.

We will spend the next year planning the facility and will invite key partners to join us in this new journey and shape the center to cover their needs for future success.

Included in our plan is considerable investments in brand new technology and assets. You can enjoy reading about both the Polymer Exploration center and the sustainable Powerhouse concept in this edition.

Along with our ambiguous plans to go green with new facilities, we have really strengthened the team and secured future competence with many new talents to cover your needs. Our people are our most important asset and we are very proud of our Norn's – both the new ones and those that have been part of our company for a long time – up to 40 years!

I would also like to highlight the fact that we sold our first license on own developed technology in the field of polymer production. You can read more about NTT technology and how it will give our customers better performance products in a cost-effective manner.

Thus, 2017 has really been a year to step up and bring Norner to the next level to realize our business vision:
The global market leader of Industrial R&D services in Polymers by exploring opportunities and discover Sustainable solutions.

Enjoy the reading!
-Tine

Highlights

Royal advice

Norwegian Crown Prince Håkon and Crown Princess Mette-Marit have a genuine interest for clean oceans and expressed their intentions to make a difference by inviting key stakeholders to discuss "Plastics waste in the oceans" at a networking lunch.
Norner was one of 12 experts invited at Skaugum Estate, the residence of the Crown Prince and Crown Princess, on Monday October 16th. As the most comprehensive polymer technology centre in Norway with more than 40 years' experience with plastics and the whole value chain, Norner's unique competence is a very important contributor to find solutions.

Tine at Royal celebration

When our HRH King Harald and HRH Queen Sonja celebrated their 80th birthdays this year, our CEO, Tine Rørvik was very honoured to be invited by the prime minister to the gala dinner, which was arranged in the Norwegian Opera house. She was invited as the representative of the business life in Telemark county.

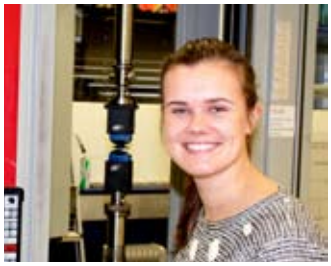
Investing in consumables

During the last two years we have invested for packaging and pharma.

- New GPC with IR sensor for polymer analyses.
- New dynamic rheology instrument with state of the art capabilities.
- New advanced FTIR
- Drop testing equipment for rigid packaging
- US (USP) and EU Pharmacopeia analysis of plastic packaging materials
- NIAS screening methods for plastic packaging and EU 10/2011
- Materials testing and analysis for PET, PS, PP and PE
- Autoclave testing for food packaging
- Honestmeter for antistatic performance

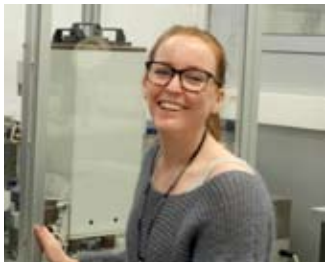
New employees

We are happy to welcome more new employees in our technology centre.

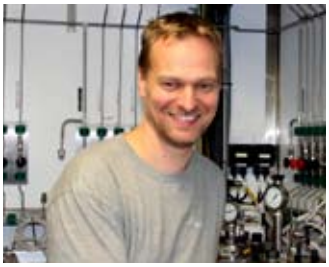


Henriette Skarpeid, MSc in Material Technology from NTNU, has started in Performance Laboratory. She will be working in the coating team and material laboratory.

Muhammad Ahsan Bashir, MSc from Aato University in Finland and a PhD from Lyon, France has started as a researcher in R&D. Bashir will strengthen us within polyolefin technology.



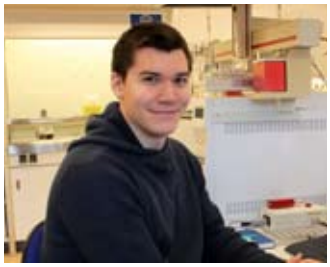
Iselin Grauer Moen has started in Performance Laboratory. She has a BSc in Gass & Energy Technology. She will work in Jolnir team and material laboratory.



Geir Åge Wickmann has started in Performance Laboratory. Geir will be working in Jolnir Test House. He has industry mechanic education with experience from technical and mechanical industry systems.

Ingeborg Paus Wik has started in Scientific Lababoratory. Ingeborg is educated Chemical engineer. She will be working in analytical laboratory with rheology and thermal analyses.

Heidi Tinderholt has started in Business Support. She holds a Bsc of Management (economy). Heidi has long working expierience from accounting and purchasing.



Steffen Annfinsen, MSc from NTNU in Trondheim Norway. Steffen is hired as an Analytical chemist in the Science lab group. He will start working in Norner from January 2nd 2018.

Norner 10 year

Anniversary and Industry Seminar

Ole Jan Myhre
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Norner was established, as an independent supplier of innovation services, in 2007 and we have been celebrating our 10-year anniversary. We have done so together with the most important people; our clients and our colleagues.

During these 10 years we have served more than 600 customers in more than 60 countries. We have managed to keep and maintain our competence and develop our capabilities. It was therefore natural to invite a selection of the largest and most important customers and contacts to our own plastics industry seminar at midsummer in June.

The plastics industry is standing in front of an increasing pressure from the public and authorities - to deliver more sustainable innovations. We wanted to create an exciting industry seminar with focus on innovation, future trends and circular economy in the polymer value chain. It seems like we managed just that when judging from the feedback.

We enjoyed numerous good presentations and several of our international customers and partners kindly accepted our invitation to present their view on how we can and need to change the way we design and use plastic materials and manage the transition into a circular economy.

Frederic Dreux, who is packaging capability leader in Unilever, made an impression with his presentation "Unlocking Polymer Circularity. Here he presented their ambitious plan to reduce Unilever's environmental footprint and practical examples of their actions including plastic packaging.

Roy Vardheim, the MD of Technology Centre Mongstad, gave an inspiring presentation on how they contribute to development of CO2 capturing technologies and how their broad academic cooperation is turned into new working industrial solutions.

It was a highlight when Siw Fredriksen, advisor in green technology at Norner, gave us several successful examples of bio based plastics and demonstrated how large brand owners like Ikea, Lego, Ford, Toyota, Unilever, Nestle and Coca Cola invest heavily into such technologies.

We were also all inspired by Dr. Rowena Sellens, the CEO of Econic, explained how they turn CO2 into a benefit through their development of technology to make plastics from CO2. This is facilitated by their efficient catalyst developments.

At a special event for all employees we celebrated the anniversary on September 1rst. We went for a sailing expedition in the archipelago on the south coast of Norway and ended the birthday celebration with a dinner at Fevik Hotel and some Rock'n Roll for dessert. This was a well deserved happening for our excellent staff.

Presentations at the industry seminar was given by the following leading companies in their fields

Bjørn Haugland of DNV-GL gave an inspirational presentation about how the 17 UN Sustainable Development Goals drive innovation. This includes aspects of our society, technology and infrastructure. According to their prognosis, reduction in non-fossil energy cost will contribute to a faster growth and corresponding reduction in GHG emissions towards 2050.

In his presentation "Plastics – A key enabler of a resource efficient and circular economy, Kim Christiansen of PlasticsEurope, discussed how we need to promote innovation in our industry to tackle end-of-life challenges through improved dialogue and collaboration. Even if plastics provide a wide range of benefits for our society, we need to improve waste handling and sorting, stop landfilling, continuously increase recycling and avoid marine plastic littering.

Some friends, like these from Sibur/Niost, came with presents while everyone enjoyed the seafood dinner.

The celebration took place in the historical Victoria House restaurant, built around 1700 in picturesque Langesund village on the Norwegian south coast.

International Polymer Exploration Centre - A new era for Norner

Tine Rørvik, CEO

Norner plan to establish a new Polymer Exploration Centre. This will put us in a position to serve clients and partners worldwide with state of the art facilities to develop sustainable solutions as well as high quality testing.

The centre will be a separate building next to the new Powerouse and laboratory, which ensure that we can continue to focus on the entire value chain of polymers.

The facilities in the new centre include advanced polymerization and catalyst laboratory, mini pilots for new process technology, a wide variety extreme polymer material performance testing and a high tech plastic application and packaging centre.

Along with the facility on chemical and polymer analyses in the Powerhouse, this will all together be a leading centre for R&D in the sector of polymer, rubber and composites.

We realise how important our polymer competence has become in the modern society. Sustainable material solutions are key to solve technical challenges and speed up the developments needed in the polymer circular economy.

The new facilities represent a forefront toolbox in order to achieve these advanced solutions together with our customers.

Our ambition is to invite key clients to take part in the centre and work together with us to create new solutions and synergies for future business.

The centre will operate in a similar way like a Catapult, where equipment and competence can be shared based on common needs while confidentiality is proffesionally handled. This is unique in the sector and we welcome local and global clients to join us!

By this, we do strengthen our position as a Global market leader in Industrial R&D for the whole polymer value chain.

The new facilities and the investments will be a fantastic platform to serve our customers, creating new innovations as well as covering their testing needs.

The Polymer Exploration Centre and Powerhouse will be owned by the property developer R8. The Exploration Center is designed by Porsgrunn architects from Borve and Borchsenius while the Powerhouse is designed by Snøhetta and described further in this magazine.

Moving plans are currently scheduled to finalize in 2019 and we'll keep you updated!

40 years in service for the plastics industry

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It was a true milestone for the Norwegian petrochemical industry when the site at Rønningen in Bamble municipality opened 40 years ago.

The discovery of the North Sea Ekofisk oil field was announced on the day before Christmas in 1969. This was the starting point of the Norwegian oil adventure. The oil was transported through Norpipe pipeline to Teesside, UK.

As a result of this event, the construction of a petrochemical complex at the south coast of Norway was decided. An olefin cracker and VCM unit was build at Rafnes and a polyolefin site was erected at nearby Rønningen with production of LD-, HDPE and PP. The site was to be operated by Saga Petrochemicals AS which later changed to Statoil and Borealis before Ineos bought the site in 2007 and Norner was established.

The decision to build the polyolefin site was supported with the creation of a centre of research and technology.

The first technologists were employed in 1975 and the technology centre was opened in 1977 - i.e. 40 years ago.

The philosophy for the technology centre was to cover all aspects of the plastics industry from catalyst development and polymerisation via additives and polymer modification to the final application of polyolefins in extrusion and moulding.

This holistic approach has benefitted the technology centre ever since and the technology centre has an impressive track record of technology innovations.

The application and market oriented approach has been a key success factor since the beginning. During the years, the R&T centre was responsible for pipe and infrastructure, fibre and textiles, flexible and rigid packaging as well as automotive and other compounded material applications.

A long list of innovations have been realised during the years for service of the plastics industry.

This is a few examples:

- Product and catalyst development for PE metallocene catalysts
- New proprietary technology for metallocene catalysts
- Cr catalyst system with in-situ comonomer generation upscaled to full plant scale
- PE100 pipe materials
- Advanced bimodal PE film grades
- Moisture barrier HDPE materials
- Advanced PP grades for injection moulding
- Nucleation technology for faster moulding process
- Cost efficient additive solutions
- Special PP compounds for extrusion coating
- PP compounds for automotives and appliances
- Barrier technology based on in-mould labelling for injection moulding
- Developed a web based calculator for barrier properties like OTR and WVTR for final packaging designs.
- Designed own IM tools for evaluation of processability and properties of thin wall packaging PP

The Powerhouse - Building the future

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Buildings make up 40 % of the world's energy consumption – and the problem is not going away.

Today 50% of the world's population live in urban areas and by 2050, the projection is 70%. In 2050, the energy expenditure in buildings will be equal to the total energy consumption today – unless we do something about it.

Norner believes that energy positive buildings are the buildings of the future. The building can be transformed from being part of the energy problem to becoming part of the energy solution. The energy goal will need to be combined with good architecture, good indoor climate and other key environmental qualities to complete the requirements and expectations of both society and tenants.

The Building and Construction sector represents 20% of total European plastics consumption, making it the second largest plastic application after packaging. Although plastics are not always visible in buildings, the building and construction industry use plastics for a wide and growing range of applications including insulation, piping, window frames and interior design.

Plastics save resources through cost-effective production, ease of installation and long life span. In a typical house, it is estimated that the amount of energy used to produce plastics insulation products have an energy pay-back time of only one year. Moreover, these plastics can be re-used, recycled or turned into energy.

Over the past decades, plastics have inspired architects to design buildings with innovative shapes, features and dimensions. The plastics materials are constantly improved, thus contributing to reducing the cost and increasing the efficiency of buildings. Plastics are durable, making them ideal for applications such as window frames and pipes. Furthermore, their anti-corrosion properties provide them with an impressive life span which can reach over 100 years for plastic pipes and 50 years for underground and exterior cables.

With plastics, maintenance is minimised and often dispensable. Plastics are easy to install, operate and maintain thanks to their lightweight. In the case of plastic pipes, their flexibility allows them to cope with soil movements. With the key target of saving energy, plastic insulation materials require only minimal thickness to achieve maximum energy efficiency and allow energy saving while also reducing noise pollution.

As the EU imports 53% of its energy demand at a cost of more than 400 billion EUR per year, it is worth looking at investments in ways to increase energy efficiencies, and this is where the building and construction sector comes in.

In 2019, the Powerhouse Telemark will be complete and constitute the new facilities of Norner together with our new Polymer Exploration Centre. The diamond shaped and spectacular office and research facility is designed by Snøhetta. Through the Powerhouse collaboration the building is developed to produce more renewable energy than it uses for materials, production, operation, renovation and demolition than it consumes over its lifetime.

Founder of Snøhetta, Kjetil Trædal Thorsen, believes the office building will inspire internationally with it's energy solutions and architecture; "The future is all about thinking big, bold and long term, and we need someone to pave the way. With its innovative solutions and design, we believe this building will inspire commercial real estate developers worldwide to push the limits of what buildings can accomplish."

As a major tenant, Norner has participated in the multi-disciplinary approach, which is required to increase energy efficiency, reduction of emissions, use of sustainable materials and reduced life-cycle costs.

Participating in the development and moving into Powerhouse with our offices and laboratories is a step to reach our vision of developing sustainable solutions and contributes in our long-term growth strategy. In the Powerhouse Telemark, cutting-edge concepts will be used and through the collaboration, new innovation opportunities have been identified, where we look forward to challenge existing building conventions in coming developments. The 10 year growth of Norner is based on our people and their innovation capability with our clients and partners.

We will now continue our growth in Powerhouse Telemark.

- We walk the talk!

First license on Norner's Polyethylene Technology

We are proud to announce that we have signed the first license agreement for our Norner Trimodal Technology (NTT).

Norner developed and patented a breakthrough technology for production of PE polymers by Trimodal Technology (NTT). The NTT concept is based on a system of three polymerization reactors where a small fraction of a third high molecular weight polymer is introduced in a small third reactor containing comonomer.

Our polymer experts have used their deep knowledge in combination with our advanced polymerization lab to develop the new three-reactor concept. This is a smarter way of producing Trimodal materials since it enables a higher comonomer content in the highest molecular weight which boost the performance of the materials. The technology will be very well suited for applications such as pipe, blow moulding and films.

The NTT enables a cost efficient upgrading of existing bimodal plants by adding a third reactor.

The technology which was developed in Norner advanced Polymerisation Reactor Park, is now ready for first production tests in larger continuous pilots before full scale implementation.

Key material and application benefits are improved pressure and stress crack resistance, better impact resistance and excellent processability.
"We are very proud of the team effort and knowledge among our experts that have developed NTT for Norner over the last years", says Research Director Morten Lundquist.

"The agreement has a value for Norner of multimillion US dollars for the first factory and is a step stone for us to enable investments in people and assets to be in the position as a global market leader of Industrial R&D services in Polymers", says CEO Tine Rørvik

NTT technology is protected by patents and is commercialized through Norner Verdandi.

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The technology was developed and demonstrated at Norner.

Our lab pilot centre perform polymerisations and simulations:

- Gas, slurry and solution phase
- Ethylene and propylene with various co-monomers
- Single and multi reactor set-ups
- Reactor size from 0,5-17 litre
- Compounding, protoype processing and scientific laboratory

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Our testing for ageing and durability performance include:

- Processing stability testing
- UV stability, Weather-o-meter
- Long term thermal stability testing
- Ageing in various liquid media at various temperatures and pressures
- Simulation of agricultural conditions and chemicals
- Compounding of recipes
- Gas fading -, Friability - and Filter testing
- Life time predictions

Longevity testing and development for polyolefins

Polyolefins represent the main materials in the global plastics markets with a wide diversity of their applications including durable products.

Several of these end use applications demand improved ageing and durability in challenging environments like sun, heat and exposure to various chemicals. Norner carries out several client studies every year in this field and development of improved additive recipes.

Since polyolefins are especially vulnerable for oxidative attack by UV radiation and heat which may further be accelerated by certain chemicals, they need to be stabilised with antioxidants and UV stabilisers.

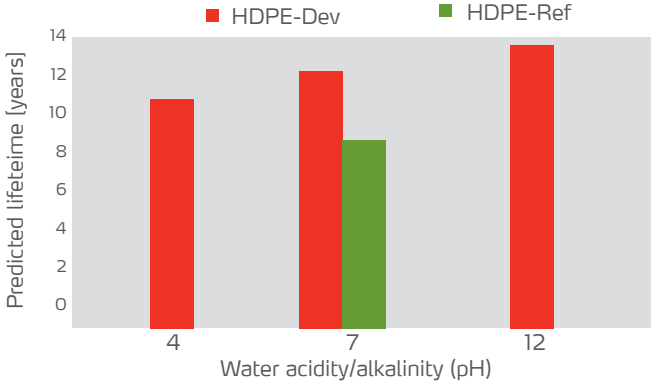
Stabilisation of polyolefins has been a core area for Norner's technology centre since it opened 40 years ago. Our labs contain a wide range of facilities for polymer modification by compounding and testing which is relevant for such demanding applications and frequently used in development projects.

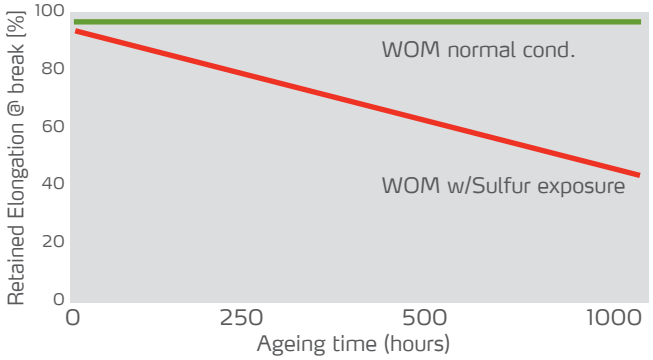
Some of the challenging applications are in agricultural and seafood farming, automotive, subsea oil&gas, infrastructure or industrial process installations. Here are two examples from recipe development projects.

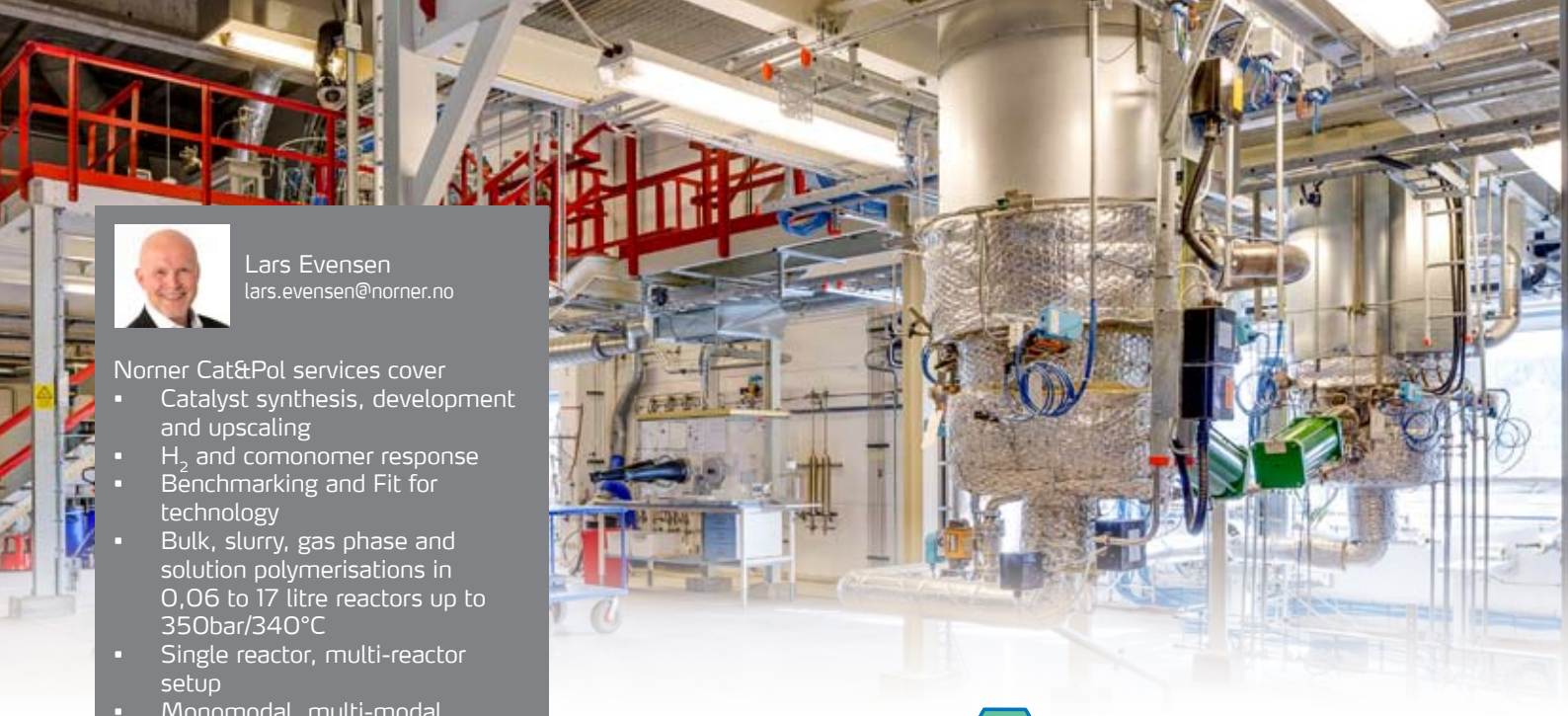
Figure 1 shows the final results of a development project for a new HDPE pipe recipe which resulted in 50% prolonged lifetime.

Figure 2 shows results from ageing in a Weather-O-Meter. We can see that pre-treatment of polyolefins with acidic substances (e.g. pesticides) may give a severe reduction in the weathering performance of polyethylene. This is highly relevant for farming installations and the agricultural sector.

With the help of our experts and laboratories we help clients to improve quality, durability and ageing performance of products for several market segments.







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Norner Cat&Pol services cover

- Catalyst synthesis, development and upscaling
- H_2 and comonomer response
- Benchmarking and Fit for technology
- Bulk, slurry, gas phase and solution polymerisations in 0,06 to 17 litre reactors up to 350bar/340°C
- Single reactor, multi-reactor setup
- Monomodal, multi-modal
- in-situ capabilities and functionalization
- Advanced polymer characterisation
- Application testing of polymers

DESIGNED CHEMISTRY

HIGH PERFORMANCE POLYOLEFIN CATALYSTS

A new innovative manufacturer of catalyst systems for PE

Even after 6 years in operation it is fair to address Designed Chemistry as a new company.

Development and manufacturing of polyolefin catalysts is a conservative market area. It is dominated by large corporations with long track records and often close ties to technology licensors.

With "new" comes also the ability to think new. Designed Chemistry has introduced novel and innovative production technologies which bring interesting performance to their silica based catalysts, and in addition reduce the environmental footprint from catalyst production.

Designed Chemistry have own bench scale polymerisation which they use both in development and quality control of their EPOC-300 series of Ziegler-Natta type catalysts.

For the Chromium EPOC-200 range and testing of extreme conditions of both ZN and Single Site EPOC-400 series, they rely on Norner's advanced bench scale reactors designed to handle the strict purity requirements from such catalysts.

Norner has been working with Chromium and Single-Site catalysts since late 1970'es and have seen interesting features when benchmarking catalysts from Designed Chemistry. Thanks to their unique impregnation technology and their decision to supply ready oxidized Chromium catalysts, Designed Chemistry can offer long lifetime in reactor from a rather flat activity profile. This gives advantages in improved reactor control, e.g. less hot-spots in gas phase processes and high activity in 2nd or 3rd reactor for multi-reactor setups for Ziegler-Natta based systems.

A very broad MWD can be achieved with one of the Designed Chemistry's Chromium catalysts. When such ultra-broad MWD is combined with good processing capabilities, it will open interesting applications and will be another area where Designed Chemistry can utilize Norner's capabilities and knowledge.

Norner offers market understanding and experience in development of advanced, value added polyolefins. By combining this with application testing of polymers produced from their catalysts, Designed Chemistry can offer tailor-made concepts to their PE producing clients.

Unlike for product development in close collaboration under license agreements, the clients now get to keep their innovations for themselves. As such, Designed Chemistry and Norner bring valuable differentiation opportunities resulting in better market position and higher profitability for polymer producers with ambitions beyond "me-too".

Aiming high in Innovation

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Norner Strategic Advisory covers
- Business & Market Strategy
- Creating Added Value
- Cost reduction programs
- Innovation – Organisation & Tools

Over the years, SIBUR – the largest integrated petrochemical company in Russia and CIS, has utilized Norner Strategic Advisory in several projects.

SIBUR is forward leaning and strengthening their position by investing additional 2Mtpa PE and PP capacity in the ZapSibNeftekhim project located in Tobolsk. They are also continuously developing their organisation and way of working, aiming for top performance toward their clients.

In Norner News #3 we shared their positive experience from Norner OTAP – Optimizing Total Additive Portfolio. Through this project SIBUR reorganized sourcing and approval of additives and secured a handsome cost saving along the way. You can read more on OTAP in Norner News #6.

In Norner News #5 you could read about SIBUR selecting Norner as preferred partner in broadening their polyolefin product portfolio to Value Added Products for their clients.
Establishing SIBUR empowered cross functional teams working strategically

towards key market segments, and the introduction of a vast number of new grades from the new ZSN capacity, has revealed the need for improved product launch capabilities. In addition to own R&D facilities (NIOST), SIBUR has also utilised Norner's technical centre for application testing and product development.

With the ZSN investment SIBUR will reach approximately 3Mtpa polyolefin capacity and decided consequently to start a feasibility study of a new PADC – Polyolefin Application Development Centre. The project was awarded to Norner who has shared its experience from operating own PADC.

The PADC will enable testing of polymer performance in finished product relevant to the market. Processing equipment, tools and moulds for various applications within moulding and extrusion is essential.

SIBUR and Norner were working closely together during the Feasibility project, designing the new PADC. Requirements to processing machinery, moulds, dies and testing equipment was established together with intelligent design of the premises to enable efficient work processes. At the end of the project SIBUR had a full overview of investment needs (CAPEX) and what to expect of operating cost (OPEX). In a final workshop, we established a way to organize the experts in the PADC to facilitate high utilization of equipment and human resource, back-up functions and clear responsibilities.

From left: Morten Lundquist - Research Director in Norner, Sergey Tutov – Director SIBUR Division Product Marketing, Olga Zheleznyakova – Expert SIBUR Strategic Development Department, Lars H. Evensen – Director Business Development in Norner, Stanislav Rosinkevich - Sr. Expert SIBUR Product Marketing, and Konstantin Vernigorov – Head of Product Development SIBUR Product Marketing

FuturePack Project

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Circular economy is high on the agenda, but we need to further increase our efforts for development of new solutions.

Norwegian researchers will now take action when the research council granted 2,5 MEUR for a project green packaging for the future - Circular Economy in practice.

Norner Research AS will lead this large research project for development of new technologies for bioplastics and recycling of plastics packaging. The project is financed by the Research Council of Norway (NRC) and 13 industrial project partners in the project called "FuturePack"

Plastics are important packaging materials where low weight/volume is combined with excellent protective properties for food in transport, retail and at consumers. Better protection prevents food wastage. But future packaging must become even more sustainable through increasing the share of biobased and recycled materials.

This will contribute to lower CO_2 emissions, better resource utilisation and reduced littering. These topics are central to the FuturePack project.

Norner will cooperate with industry partners and with the institutes Nofima, Paper and Fibre Research Institute (PFI), Østfoldforskning and NTNU IKP. The group of institutes together hold key competence in conversion of biomass to polymers, food packaging, food technology, polymer technology, recycling and plastics processing.

The Norwegian industrial partners are Bama, BEWI, Elopak, Grønt Punkt, Mills, Norgesgruppen, Nortura, Orkla, ROAF and Tine who represent various parts of the value chain of packaging, food production and recycling. Additionally, FuturePack has an exciting international advisory board including Ineos, Unilever and EPRO.

Green Dot Norway plc is responsible for financing the recovery and recycling of used packaging on behalf of the industrial sector. "We see a significant need for increasing the development of new technology that can increase recycling of packaging, especially for that which today is difficult to recycle. To achieve high goals, research is required, and we are proud that this project received grants from the Research Council of Norway.", says Eirik Oland in Green Dot Norway plc.

"We have a strong strategic focus on sustainability and circular economy in the plastics value chain through projects in the field of recycling and biobased materials. By long term cooperation with our international clients we have also acquired significant competence in this field. However, more research and competence is needed to solve our global challenges and "FuturePack" is an important project to take new steps in the right direction.", says Tine Rørvik, CEO of Norner.

"It has been inspiring and rewarding to work with the development of this project and all the positive response we have got from the industry shows that these partners puts sustainability very high on their agenda.", says Dr. Siw Fredriksen, project manager and Advisor in Green Technology at Norner.

The FuturePack project will develop a comprehensive knowledge platform for production of sustainable packaging materials from Norwegian biomass and polymer waste resources, in accordance with the principles of circular economy.

The plastics industry is today highly reliant on feedstock based on oil and gas. Focus on circular economy is a potential way to reduce the demands on finite raw materials and minimizing negative effects while still have possibility to increase prosperity.

This requires a systemic and holistic approach. Firstly, an overarching vision is that plastics never becomes waste but re-enters the economy as valuable recycled materials or chemicals. Secondly, a "green shift" to renewable feedstock will decouple plastic from fossil feedstock.

The major elements of the FuturePack project represent new knowledge and innovations for the partners and in the industry internationally.

The project will evaluate the fit of Norwegian biomass and plastics waste resources for polymer production followed by developing a technology for cost-efficient conversion of biomass and plastics waste by pyrolysis into building blocks for polymers. The chemical composition after pyrolysis needs further purification before olefins will be used in polymerisation of bio based PE and/or PP.

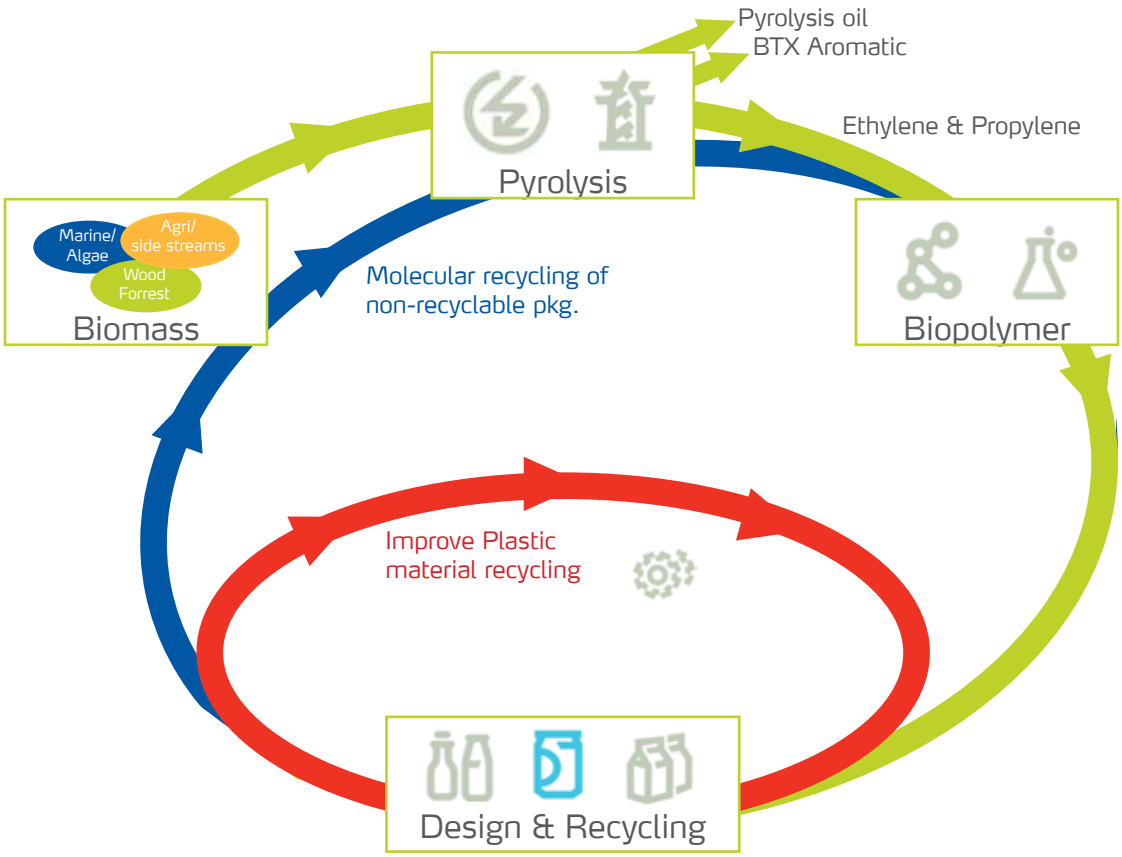
Another important aspect is the design and solutions for improved material recycling which is another important aspect of circular economy. The new technologies and value chains will be assessed by LCSA assessments.

As a global leader of industrial polymer R&D services, Norner operates an advanced technology centre for development and laboratory testing.

Norner contribution in FuturePack:

- Project leader and R&D partner
- Knowledge in bio-based raw materials (wood, algae) and plastic waste as source for ethylene and propylene production.
- Verify ethylene and propylene from biomass and plastic waste as drop-in monomers for PE and PP production in bench scale polymerisation
- Packaging material development using recycled PE and PP
- Design and develop new packaging fit for recycling in line with circular economy principles.
- Demonstrate packaging simplification through demonstrators and external collaboration.
- Test and characterise the packaging materials
- Develop competence and strategies for increased recycled content in packaging.
- Externally communicate results

FuturePack - technology for a circular economy



Let's clean the beaches

Ole Jan Myhre
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As the marine litter problem is growing we all need to take possible actions to improve the situation. This is why Norner organise a beach cleaning day.

Our ambition is to address this global challenge by acting local and continued the tradition of taking part in the national "beach clean-up" initiative in Norway. We have chosen the Rakkestad beach in our home municipality Bamble.

More that 30 enthusiastic Norner experts took part in the event.

This year we also invited several students from the University College of Southeast Norway who gladly participated. These students carried out their BSc projects or MSc thesis at Norner.

We also had visitors from our customer International Paint joining us on the beach this evening.

This is an excellent way to combine something useful and environmental friendly with a social get-together with nice colleagues and friends.

What we in practice did was to:

- Pick litter at the 200m beach
- Sort the litter in relevant fractions
- Report the findings to the Norwegian "Hold Norge Rent"
- Dispose the litter in designated waste bins

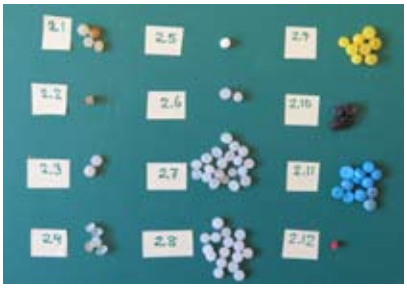
We collected 10kg of litter this year, which included metal boxes, glass bottles, rope and twines, foamed plastics, various hard plastics, plastic bottles, plastic film and textiles.

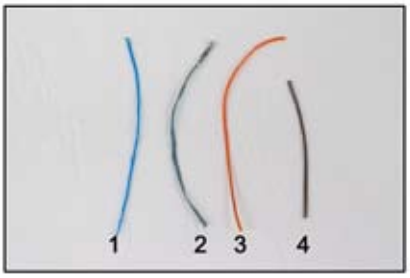
The plastic fraction was 70% of the total weight.

Next May we will be back for another clean-up and we are looking very much forward to it! New report will follow.

We challenge other plastics companies to also act local for the global littering problem.

- lets work together to reduce the litter problem!





1 = PE
2 = PP
3 = PE
4 = PE

1 = PE
2 = PE
3 = PE
4 = PE
5 = PP
6 = PP
7 = PP
8 = PE+PP

Marine litter studies

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Marine litter is a fast growing and global environmental challenge. The most visible is plastic articles floating in the ocean and onto our beach areas.

Marine litter is causing harm to marine wildlife, coastal communities and maritime activities. It is also an emerging concern for human health and safety.

According to World Wildlife Fund (WWF) and OSPAR 2009, about 6,4 million ton of litter ends up in the ocean each year globally of which 15% ends up on beaches, 15% floats into the ocean and 70% sink.

When the United Nations Environment Assembly (UNEA) met in Nairobi on December 6th 2017, a resolution was approved which concludes that waste minimization and environmentally sound solid waste management should be given the highest priority in efforts to address marine litter.

It is good news that very many nations stand behind the resolution and intentions to develop sustainable solutions.

Meanwhile there are a lot of activities ongoing to clean up beaches as well as research and investigations related to type and amounts of plastics in the oceans.

Plastics will gradually degrade when exposed to sun while floating in the sea. This makes it brittle and articles will fragment into smaller and smaller pieces. The result is an increasing amount of microplastics. Such small pieces of plastics also have many other sources.

Marine Litter Study

Our shared concern for marine littering has resulted in a Norwegian pilot project sponsored by the industry to explore and analyse samples.

Norner cooperated with the local coastal municipalities and Naturnvernforbundet in an effort to:

- Collect and systemise litter regularily on selected beaches.
- Product types were categorised.
- Norner analysed the types of plastic found
- When possible we assessed the origin of the article
- Norner organised analysis of the possible precense of hazardous chemichals
- Norner organised chemical analysis

The pictures show some examples:

- PE and PP pellets found on a beach location. Due to the colours and shapes, these probably have different origins. Such pellets are often refferred to as “nurdles” and a result of industrial activity.
- A HDPE pot for catching octopussy in the north of Africa found at Jomfruland close to Kragerø. Analysis showed that the material had been in contact with DDT.
- Ropes and fishing gear in PE and PP. Any fibres of other materials will sink.

Some key findings are:

- Majority of plastic products are foam (EPS and PUR) as well as packaging, rigid parts and ropes made from PE and PP.
- Flame retardant additives was found in foam samples.
- The HDPE pot contained DDT
- No other chemicals were found
- Many samples showed significant degradation and disintegration
- Our simulations of degradation and disintegration shows that PE packaging films need only a 1-5 years before the materials are brittle and cracks into small pieces of microplastic.

The study is financed by Plastretur, who organise plastic waste collection and recycling in Norway.

Protective coatings and performance testing

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Norner has during the last years seen an increasing demand for testing related to Protective Coating and we have invested significantly in equipment and resources within this area.

Our main target has been to cover all test methods for protective coating both for offshore and onshore industry.

In general, a protective coating is a layer applied to the surface with the intent of inhibiting or preventing corrosion. A coating is applied to the surface of an object, usually referred to as the substrate. The purpose of applying the coating may be decorative or functional. Functional coatings may be applied to change the surface properties of the substrate, such as adhesion, wettability, corrosion resistance, or wear resistance.

To ensure that the coating used for the different applications is functional, it must be tested and approved in accordance with relevant standards.

ISO 17025 Accredited testing

Norner has applied accreditation according to ISO 17025 within protective coating testing area. The approval is pending and expected early next year.

Our ambition is to fulfil the intentions given in "Joint ISO-ILAC-IAF Communique – General Requirements for the testing and calibration laboratories" which says:

"A laboratory's fulfilment of the requirement of ISO/IEC 17025 means the laboratory meets both the technical competence requirements and managing systems requirements that are necessary for it to consistently deliver technically valid tests and calibrations.
The management systems requirements in ISO/IEC are written in language relevant to laboratory operation and operate generally in accordance with the principles of ISO 9001",

Norner offers both 3rd party testing and pre-qualification testing of protective coating within different application areas.
In addition, we also perform bespoke testing "per client's request".

Our standard tests enable evaluation of the protection properties of coating systems in relation to a wide range of application and atmospheric environments in according with international standards like ISO, ASTM, NACE or CSA in addition to company specifications.

Surface protection

Norsok M-501 and ISO 20340 are the most relevant standards for protective coatings used for off-shore application. These standards specify requirements for surface preparation, application procedures and performance requirements to protective coating for offshore installations and associated facilities. It covers coatings for use in different applications like atmospheric conditions, tidal / splash zone or totally immersed.

Pre-qualification testing of protective coatings in accordance with Norsok M-501 and ISO 20340 consist of various test methods depending on the area of application.

For atmospheric conditions, the testing includes cyclic ageing, where the coating is exposed to UV, condensation, salt fog and low temperature.

Coatings for use in tidal or splash zone will in addition undergo immersion testing and the ability to withstand cathodic protection.

The pre-qualification testing of coatings for totally immersed application consist of immersion testing and cathodic resistance testing.

Structure protection

The most relevant standard for structure protection is ISO 12944. This specifies requirements for protection of steel structures, mainly intended for on-shore application. The standard includes classification of different corrosion environment and associated requirement.

Pre-qualification testing in accordance with ISO 12944 consist of immersion testing, salt fog, condensation and chemical immersion testing.

Choice of test method and duration are dependent of required corrosion classification.

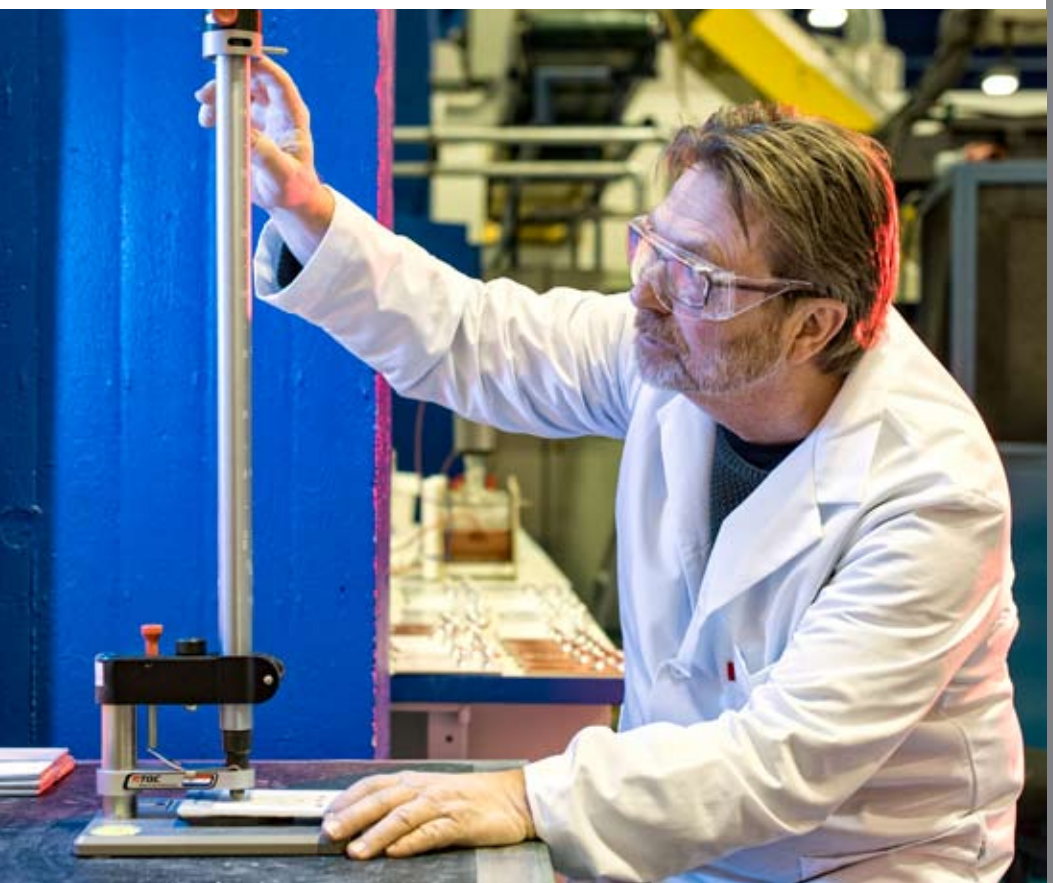
ISO 12944 has been under revision and will be finalized spring 2018. New corrosion classification groups and test regimes will be introduced, and ISO 20340 will be included as a part of ISO 12944.

Pipeline protection

Relevant international standards within Pipeline coting is ISO21809/ CSA Z245.20 /NACE SP0394-2013. These standards specify requirements for qualification, application, testing of materials for external single layer fusion-bonded epoxy (FBE) and three-layer polyethylene- and polypropylene-based coatings applied for the corrosion protection of bare steel pipe for use in pipeline transportation systems for the petroleum and natural gas industries.

Pipeline coating standards specifies extensive wide-range of testing methods within raw material testing, quality control and pre-qualification of final product.

Gel time and curing time is an example of important properties for FBE in addition to corrosion protection and cathodic resistance ability. Mechanical properties like flexibility and impact resistance is important properties, especially for multi-layer pipelines.



Protective coating at Norner

Cathodic Disbondment testing at various conditions:

- Ambient temperature at atmospheric conditions
- Steel temperatures up to 180 °C - atmospheric or pressurized conditions with controlled electrolyte temperature.

Immersion Testing in various environment:

- Hot \ Cold Wall effect –Thermal gradient – Atlas Cell
- Immersion in seawater, mineral oil or hydrocarbon fluids at different temperatures and pressure (up to 325° C and 325 bar). We have also the possibility to include aggressive gasses such as high concentration H2S, inflammable and explosive gasses.

Salt fog testing / Salt spray test for corrosion testing:

- Continuous salt spray testing NSS
- Cyclic salt spray testing
- Prohesion testing

UV xenon / UV fluorescent exposures – UV, condensation, spray:

- Different standards and test conditions available

Climate testing – under controlled temperature and humidity including:

- Fixed temperature and humidity from ÷70 to +250°C
- Cycling testing from ÷70°C to +180°C with controlled humidity up to 95%
- Cycling testing high temperature from +100°C up to 500°C
- Cryogenic exposure

Special Mechanical tests for coating like; Impact, Bending Testing, Abraser, Hardness Indentation

High temperature thermal insulation for deepwater pipelines

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Norner was invited by Shawcor for a project participation with the aim to develop innovative material solutions for subsea pipeline installations.

The project will develop a deepwater and high temperature thermal pipe insulation system capable of withstanding 180 °C fluid and 3000 m sea depth. The insulation system will be a fundamental element in future technology for multiphase pipe transport and flow assurance.

Thermal insulation of subsea oil and gas pipelines is critical in assuring flow in pipeline fluid transport. Insulations prevent flow reduction by keeping the temperature of the fluid high, to avoid solids precipitation and clogging the pipe during production shut downs and towards terminations. The maximum temperature rating for insulations on deepwater flowlines is currently 150 °C. There is an increasing trend towards deeper waters and higher temperatures for new fields in Norway and internationally. To make these resources more feasible, higher temperature insulation is required. Shawcor Norway, located in Orkanger is the primary supplier of wet thermal insulation to the Norwegian continental shelf. The wet insulation used on the highest temperature flowline ever was produced by Shawcor Norway, and there is a need to develop even higher temperature resistant insulation to meet the coming challenges in the market.

The central challenges are to develop new polymer formulations for an insulation and corrosion protection systems with sufficient flexibility for reeling at low temperatures, sustained bonding between layers and 30-year lifetime at high temperatures. Another challenge is to develop reliable test methods to demonstrate 30 years lifetime with 1-2 years testing time.

Shawcor Norway is part of Shawcor Pipeline Performance, the largest pipe coating company in the world. Shawcor's development centre for wet insulation systems is located in Orkanger, Norway. Shawcor's trademark for wet thermal insulation is Thermotite®. Shawcor has insulated more than 1200 km pipelines for the Norwegian Continental Shelf with Thermotite® products and 5000 km of conventional anti-corrosion pipeline coating. Shawcor in Orkanger has insulated pipes for flowlines all over the world, from Gulf of Mexico, Africa and as far away as Australia.

Project team; from left, Eileen Wan (Shawcor), Henning Baann (Norner), Suresh Choudhary (Shawcor, Chairman project steering committe), Espen Ommundsen (Norner), Heidi Houghton (Norner), Catherine Lam (Shawcor) and Jan Peder Hegdal (Shawcor, Project Manager)

To keep its unique and leading position in the market, Shawcor has to develop and commercialise new and more advanced products. Shawcor has excellent product and process development facilities, a strong team of material engineers, scientists and project management experts available for the development project. The laboratory facilities are advanced and equipment at different locations around the world, for instance simulated service vessel, electrical impedance spectroscopy and autoclaves. With XT180, Shawcor will again break new frontiers of development and extend the high-end market for wet thermal insulation.

Norner will contribute in selecting, designing, developing and produce laboratory-scale polymer materials, as well as experimental materials supplied by material suppliers, and test these regarding relevant performance under high temperature and pressure.

We were selected due to the unique and advanced test facilities, industrial polymer knowledge, polymer structure-properties relationship and polymer stabilisation competence. Norner will complement Shawcor with specialized polymer competence and equipment and has so far contributed with valuable results in the development of present thermal insulation systems.

Project owner	Shawcor Norway AS
Project manager	Jan Peder Hegdal, Research Manager – Global Flow Assurance Pipeline Performance
Public funding	Research Council of Norway, Petromaks 2, Project No. 269212/E30
R&D partner	Norner Research AS
Norner responsible	Espen Ommundsen

Energy Saving Buildings

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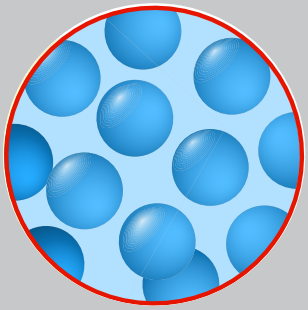
Focus on energy savings in buildings – A new project supported by Innovation Norway

There is an increased focus on the environmental aspects of the building industry. One action that will benefit energy usage globally is to increase the energy efficiency of buildings. In EU, the building sector is a major energy consumer and accounts for around 40% of the total energy usage. The energy consumption for buildings can be significantly reduced by using construction materials with high heat capacity that absorb and release heat.

Phase change materials (PCMs) are materials that can absorb, store and release heat at a constant temperature. These materials utilize the principle of latent heat thermal storage to absorb energy in large quantities when there is a surplus and releasing it when there is a deficit. When dispersing microencapsulated PCMs in gypsum board, plaster, concrete or other wall covering material, thermal storage can be part of the building structure even for light weight buildings.

The working principle of phase changing materials

Increasing temperature

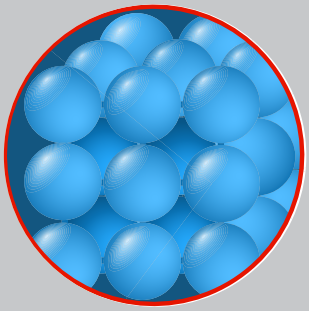


Material melts to liquid

RESULT

Indoor temperature remain constant

Decreasing temperature



Material freezing to solid

Europe is currently the largest market for PCMs, which on a global scale represented a 810 M$ market in 2016 foreseen to grow 20% by 2021. The increasing demand for energy efficiency in buildings and for a reduction in greenhouse gases to reach Europe's 2020 target is expected to be a key factor in the high market share of PCMs, and the construction and building sector along with the packaging is expected to contribute in the coming years growth.

The phase change materials are commonly divided in three categories such as organic, inorganic and eutectic PCMs. Organic PCMs can be found among paraffins, fatty acid, esters, alcohols, glycols, etc.

Norner will in a new project supported by Innovation Norway explore the possibilities and utilize our competence on polymers and polymer processing to explore a new concept using organic PCM's in a core-shell micro-structure.

When a PCM is in its solid phase it will absorb heat as the external temperature rises. The temperature of the PCM will follow the external temperature until the PCM's melting point is reached. When the external temperature reaches the melting point of the PCM, the PCM will begin to melt, i.e. "phase change".

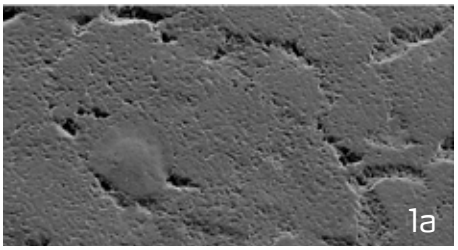
During the phase change process, the PCM will absorb large amounts of energy with almost no change in temperature. During this time, the PCM is providing a cooling effect. The amount of time the PCM will provide a cooling effect is determined by the PCM's enthalpy of melting, also called the latent heat of fusion of melting. The enthalpy varies depending on the PCM material itself.

The reverse cycle occurs as the external temperature cools. The PCM, now in its' liquid phase, can release the heat it absorbed as the external temperature decreases. During this time, the PCM solidifies, release energy and provides a warming effect.

In the current project Norner will explore a novel solution for industrial production of materials to be used as PCMs in the core and as protective layer for the shell.

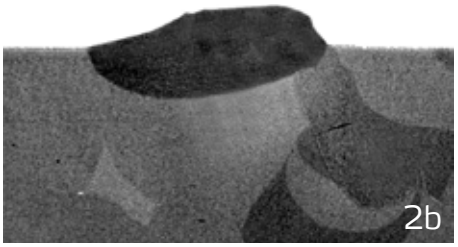
If you want to know more about the PCM development or join the project, please contact us.

Return address: Norner AS, Asdalstrand 291, NO-3962 Stathelle, Norway


1a


1b


2a


2b

At the back

Norner provides failure analysis to the plastics industry on a regular basis. Here is an example of problem solving for rotational moulding

Rotational moulding is a process where the material needs to be compounded with the right colour and additive package to ensure high quality and longevity since the process is based on sintering of ground particles.

Regularly we experience that the final product has imperfections such as orange peel surface or lumps in the surface of the moulded article. These imperfections represents both an aesthetical and a physical problem. When you are experiencing this kind of surfaces, the materials should undergo a quality check. This can be done with microscopy as described here.

Failure 1) Orange peel surface
Figure 1a shows a orange peel surface under stereo microscope. A sample was prepared by microtome cutting a thin slice from an area with the structure. The sample was investigated under polarised light. Figure 1b shows the key result of this investigation. The orange peel region is a non-pigmented material. This occur because the shrinkage of a non-pigmented particle is greater than a pigmented one.

Failure 2) Lumpy surface in a black material
Figure 2a shows a lumpy surface under stereo microscope. A sample was prepared by microtome cutting a thin slice from an area with the lumps. The sample was investigated by light microscope and dark field. Figure 2b shows the key result of this investigation. The lumpy region is a material/particle with high carbon black loading. The lumps occure because the shrinkage of high carbon black loading is lower than with less carbon black.

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You can access these earlier editions of Norner News through our homepage www.norner.no or read them at http://issuu.com/norner

NORNER**NEWS**

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norner™
The Polymer Explorers

Photo by Tom Riis, Torkel Bach, Istockphoto and Norner