

NORNER NEWS

04

**Material development
for oil & gas industry**

**Homogeneous foams with
reduced cost and weight**



norner

Innovation through Insight

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3@Norner



Katrin Nord-Varhaug

Hello, I'm a Principal Researcher at Norner. In a recent project we developed new technology for highly insulating foams. This was challenging and fun.



Morten Augestad

Hi, as Business Director in Norner I am committed to explore and utilise Norner's capability in the world market. I enjoy this kind of work very much.



Per Arne Sørlien

As the Director of Norner Verdandi I take care of our technology investments and ownership. A key area for me is CO2 polymerisation.



It is very encouraging to see that our services is growing in demand for all our key segments. When we also produce IPR for clients and get Innovation Award nominations my conclusion is that we are on the right track.

Dear reader

Would your solutions last for 40 years on the sea bed? Have you used the right material and have you verified the service life time?

Norner has during the last years built up a large project portfolio to solve key challenges and develop new solutions for our clients in the Oil & Gas sector. We share some of these stories - and more - in this magazine.

The growth in Subsea operations have challenged the whole business to deliver new technology overcoming tougher environments and lower margins. The right material solutions can cut down on weight and cost and also solve corrosion problems.

How to select the right materials and will they last during the whole service life time? This is exactly what we are here for – to answer these questions through careful material selection and testing of the solutions. We have, as an example, invested in more Norsok M-710 test capacity to satisfy our clients' needs to verify their polymer materials.

We see a substantial shift in the Oil & Gas market to go from metal to polymers.

This is also an excellent opportunity for new innovation in polymers from our Petrochemical clients worldwide where we see many opportunities.

Norner is nominated for the Innovation Award at this years ONS, one of the major Oil & Gas exhibitions in the world. We are very proud of our team that has accomplished this, and it shows the value of our genuine plastic competence.

Norner polymer expertise is also utilised for exiting Sustainable projects, such as new biopolymers from other raw materials like CO₂, wood, sugar waste etc. and securing food packaging safety. You can read more about that in this magazine.

A key company value chosen by our employees is "Imagine" - we see no boundaries and love to contribute to develop your perfect future materials!

Enjoy reading !

- Tine

Highlights

Efficient oil production with REVIVAL

With a novel reversible inflow control valve the target is to increase oil production and reservoir recovery rate.

Together with our customer InflowControl AS and an international

consortium of partners, Norner has a key role in the EU FP7 funded project REVIVAL. The new valve will have better selectivity for oil/gas. Read more on pg. 7.



Norner @ GPCA



Our CEO, Tine Rørvik was invited to give a presentation at the GPCA Research & Innovation summit organised at the Ritz Carlton hotel in Dubai on 12th – 13th March 2014.

Tine's presentation was titled; "Determining the Value of Innovation in the Chemical Business Sector".

The conference was well visited by the petrochemical sector in the region and an excellent opportunity to meet customers, make new contacts as well as demonstrate our capabilities.

Chemicals in Food Packaging



Food safety is a highly important subject for the food value chain. Most food available have packaging which is a significant and critical part of food preservation and safety. Plastics packaging do however

contain chemicals! A new project will strengthen Norner's competence in chemical substances used in packaging materials.

Read more on pg. 15

ONS Innovation Award

We are very pleased to announce that the ONS jury has recognized Norner AS a candidate to the ONS SME Innovation Award 2014.

The ONS exhibition takes place in Stavanger from August 25-28. You can meet Norner at ONS on stands K 105 and F 666.

ONS 2014 **NOMINATED** INNOVATION AWARD

The world needs new groundbreaking energy technologies. The future of the international oil, gas and energy industry depends increasingly on its ability to develop new technologies. Through the Innovation Award the ONS foundation recognise the crucial importance of cutting-edge products and solutions. Read more on www.ons.no

Management changes @ Norner

Jørgen Nyhus has taken over the management of Norner's scientific laboratories. Nyhus came from the position as Principal Researcher. He has been working in Norner for two and a half years.

Business Director Henning Baann will lead all the Oil & Gas activities in Norner AS. Baann came from the position as Laboratory Director in Norner AS. He has been leading the laboratories for the last 11 years. More info at www.norner.no



K 2013

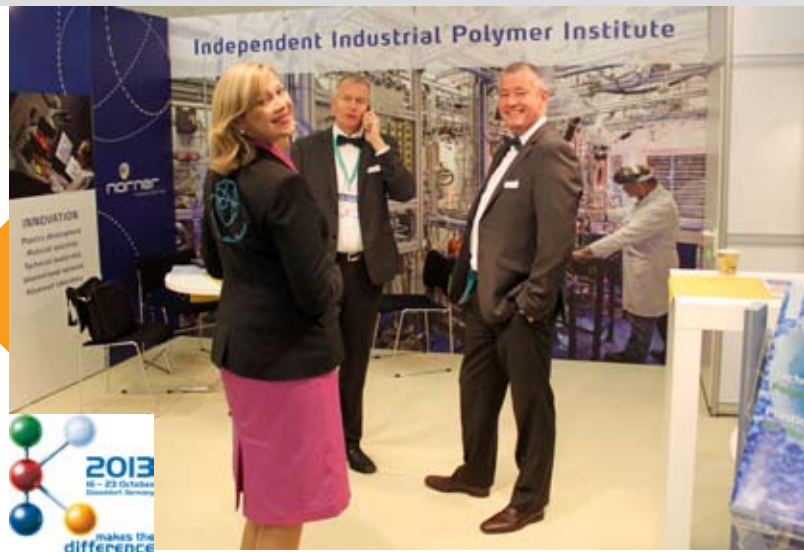


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K is the International Trade Fair No. 1 for

Plastics and Rubber industry worldwide. This makes it an important place for Norner to participate and present our technology news. We had busy and interesting days at our stand where we met a lot of customers and new business contacts.

Our visitors showed great interest in our capabilities, research and technologies. Norner offer a wide range of services for the petrochemicals and plastics industries including consulting, development and laboratory assignments.



Next K is arranged in 2016 and we look forward to be there again.

Subsea Valley 2014



Henning Baann
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The Subsea Valley Conference was arranged at Telenor Arena

in Oslo on April 2-3. The conference gathered more than 300 delegates and main focus was on technology and competence for the subsea oil and gas industry.

Norner performed an important role at the conference as an independent plastic technology centre. Our employees have more than 35 years of industrial experience working with research, innovative solutions and service life design in harsh environment.

As the subsea industry is going deeper and colder, Norner has

the knowledge to provide development, testing, verification and development of polymer materials to guide and assist companies for implementation of material replacements with polymer solutions.

Our goal is to tailor make materials with high quality for demanding subsea requirements.





Meet us at

- leading international events

ONS 2014, Stand K 105 & F 666
August 25-28, Stavanger, Norway



OTD 2014, Stand A2303
October 15-16, Bergen, Norway



Element Oilfield Engineering with Polymers
October 21-23, 2014, London, UK



Top Packaging Summit 2014
October 22-23, 2014, Helsingborg, Sweden



Polyolefin Additives 2014
October 28-30, 2014, Cologne, Germany

PolyolefinAdditives2014

Norner Academy
November 10-13, 2014, Norner site, Norway
We arrange plastics technology courses



Thin Wall Packaging
December 2-4, 2014, Cologne, Germany

THIN WALL
PACKAGING 2014

Flexible Packaging Middel East
December 8-10, 2014, Abu Dhabi

Flexible Packaging
Middle East 2014

Microscopy Labs

an inspection, troubleshooting and development tool



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Norer has the competence, equipment and resources

required to investigate product and material failures, document the reasons for it and provide conclusive reports with suggested solutions.

The production and use of products in our society involve a broad range of requirements. Unfortunately, products or components do break, disintegrate or fail from time to time. Product and material failure represents huge costs in repair, replacement, down time and involvement by personnel.

Our specialised microscopy lab provides failure analysis to a wide range of industries ranging from polymers, packaging, plastic processing, offshore and automotive. We have a dedicated team with long experience in the field of microscopy and analytical techniques. This secures that we can provide appropriate conclusions from our analysis. Surgical precision is required for sample preparation and a functional understanding of the product is necessary for the evaluations. We also carry out similar investigations to document the quality of products.

We strive to achieve a close cooperation with our customers in order to facilitate a good flow of information. Any information regarding the product, its production and use is vital for the investigations and conclusions we provide. In this way we have a high focus on meeting our customer needs.

Our microscopy team of experts deliver conclusive reports where the documentation through high quality pictures have priority combined with other analytical information.

We have the insight to make microscopy investigation provide documentation of the following materials and products

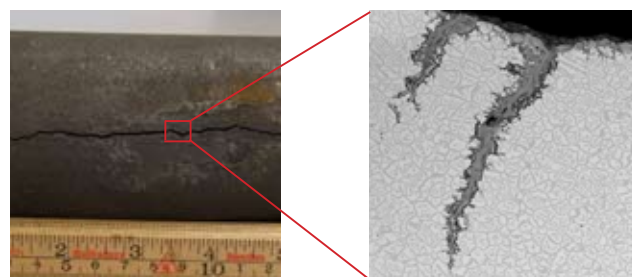
- Metals and inorganic materials.
- Catalysts, polymer powders, morphology and homogeneity.
- Plastics parts and packaging
- Injection, blow and rotational moulding, extruded pipe, cable insulation, films, laminates, compounds and alloys.

Failure categories in Plastics

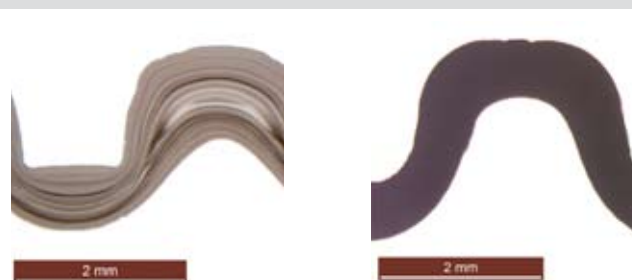
- Mechanical strain, pressure burst, stress introduced by processing or mould/product design, chemical stress cracking
- Gels and inhomogeneity, contaminations, inclusions

Failure categories in Metals

- Carburization / decarburization
- Stress relaxation cracking and stress corrosion cracking
- Fatigue, corrosion fatigue, overload and creep damage
- Hydrogen and Sigma phase embrittlement
- Dealloying and Liquid metal embrittlement



Cracker furnace tube failed due to carburization



Poor vs. good homogeneity and design of pipe wall

Testing of ozone resistance



Roger Didrichsen
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Ozone is aggressive to components of rubber, elastomers or plastics and causes surface cracks over time which propagate into component failure.

Norner recently invested in new ozone test chambers for accelerated testing of the effects of ozone on ageing and material properties. By exposing samples to high concentration of ozone, together with controlled temperature and humidity, we evaluate products and compounds with respect to ozone resistance properties.

The tests are conducted according to several international standards like:

ISO10960 - Specify a method of assessing the resistance of hoses to the deleterious effects of atmospheric ozone under dynamic conditions.

ISO1431-1 - Specify procedures intended for use in



thermoplastic rubbers to cracking when exposed, under static or dynamic tensile strain, to air containing a definite concentration of ozone and at a definite temperature in circumstances that exclude the effects of direct light.

FMVSS106 - specifies labelling, performance requirements and testing procedures for motor vehicle brake hose, brake hose assemblies and brake hose end fittings.

Efficiency in oil production



Jørgen Nyhus
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Great achievements require strong efforts. Together with our customer InlfjordControl AS and an international consortium of partners, Norner has a key role in the FP7/R4S funded project REVIVAL (Grant no. 605701).

The project will develop a novel, autonomous and reversible inflow control valve to increase oil production and reservoir recovery rate by stopping production of unwanted water and gas locally in the reservoirs.

Norner will be using its advanced testing facilities for compatibility testing to document and predict life-time performance of key components under harsh environmental conditions.



Norner have high pressure reactors for ageing studies or rapid gas decompression (RGD) testing at high temperatures in both sweet and sour media including hydrocarbons with H₂S or CO₂.

In the REVIVAL project compatibility testing is used as part of the product development (R&D).

Norner is a key provider of 3rd party testing and quality control to the Oil and gas industry according to NOR-SOK M-710 or ISO 23936 - "Selection and qualification of non-metallic materials in contact with media related to oil and gas production"

Material development - for offshore and subsea



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Plastics have a lot of opportunities as corrosion free, lightweight and durable materials for many components and applications in the oil and gas sector.

Still several companies need support to define how to utilise plastics and rubber in this sector. New explorations subsea also put continuously new demands for improved materials withstanding higher pressure, aggressive environment and colder arctic conditions. Successful implementation of plastics as replacements for traditional materials is a challenging task and is a result of the ability of the industry to develop tailor made polymer recipes meeting the demands for physical performances and life time.

Norner AS is a unique innovation and technology centre with 35 years of industrial experience in materials development and optimisation. Our lab facilities cover polymer modification and processing, prototype production, physical testing, testing of ageing and compatibility as well as failure analysis. These polymer engineering and testing services offered by Norner, facilitate better success rates of new product and material developments in the oil & gas industry value chain.

Longevity and durability verification

Performance testing at real conditions is critical for service life verification. In a recent project for demanding polymer applications (DEPA) a key

target was to understand the performance and ageing in seawater. Ageing of plastics are typically made in air and tested at several temperatures over long time. The results are used to extrapolate the life time expectations of the polymers.

Polypropylene (PP) materials under development in the DEPA project were tested both in air and sea water. This was important both to check if the (simpler) test in air would give reliable results and to verify the real performance in seawater. Surprisingly the results of ageing and degradation were very different. In these comparative tests, plastic specimens of the same material, were aged in air at 110°C vs. sea water at 90°C. After fixed exposure times, the residual degradation stability was tested by an oxidative induction time test. Even if the samples in air were exposed at higher temperature, the samples in sea water had only 20% residual stability after 4 months compared to samples in air. After careful investigation and chemical analysis we could conclude the reason to be the efficiency of various types of antioxidants.

Formulations for harsh environments

In a client project Norner was challenged to develop a new polymer material recipe to yield a step change in longevity of PP (polypropylene) in harsh chemical environments. A novel recipe of additives and stabilisers was developed to achieve a break through in service life. The new development will be a benefit for piping, liners or process installations for transportation and handling of fluids like hot water, warm hydrocarbons and various alkaline Liquids.

Material development and verification technology

The material and recipe development was made solely by Norner experts and labs and the results achieved have demonstrated more than 25 years of service life at 70°C by accelerated testing. The drastic improvement in longevity opens up new opportunities for the use of polymers.

With conventional state of the art recipes the service life of such materials would be <5 years while it has been demonstrated more than 25 years of service life at 70°C by accelerated testing for the new recipe

Fatigue testing and lifetime predictions

Failures due to poor material selection or poor design can be avoided by understanding how the material is influenced by the operational environment. Fatigue is the progressive and localised structural damage that occurs when a material is subjected to cyclic loading. Fatigue testing is an important area of testing for the oil & gas industry at Norner and is used to predict the life time of components or test fatigue properties of materials. The influence of heat, chemicals, different climates and UV radiation can be studied.

Material development and consulting

Norner is active within plastics material development and research, technology and concept investigations as well as problem solving and failure analysis. Our experience and competence cover material properties and selection, polymer foams, heat insulation and conductivity, physical properties and ageing as well as flame retardancy.

We support companies with developments and quality assurance in the field of buoyancy solutions for risers, pipes and seismic cables.

Our experts and labs can support material development to ensure sufficient service life design in harsh environment as well as performance assessment of new solutions.

We help companies to increase their value creation through increased competence, technical documentation, process enhancement, product development and quality improvement. Our capabilities cover testing services, material and solution development and technology consulting.





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Norner takes a role in our sustainable future by extending capability and competence in Biopolymers.

Biopolymers can be defined in several ways and a typical way of classifying them is categorising them into biobased raw materials and biodegradability. Some materials can be both produced from bio-based raw materials and be bio-degradable like polylactic acid (PLA). Others can be from bio-sourced raw materials like BioPE, but are not biodegradable. Variations of the two categories, including blends, are common.

The importance of bio-based materials grows, but it is difficult to point out a clear winner among the different polymers under development. Traditional plastics like PE, PP, PA and PET have also interesting development initiatives to be sourced from bio origin but the technologies involved can be challenging and costly.

More recent polymers from bio-sources include PEF and PHA, and important technical progress has been made. Both PEF and PHA have interesting properties for several applications and it can be expected more news related to these in the years to come.

The initiative on PEF by Coca Cola, Danone and others is an example of this. Another example is the non-competing industries cooperating within biopolymer development such as the recent announced cooperation between Heinz (with access to bio waste from its ketchup operation) and Ford vehicle group.

Through several bench-mark studies, Norner has explored that Biopolymers can offer a lot of potentially sustainable and also cost efficient products like:

- Side- and waste-products from the forestry industry can be a cost efficient raw material and give interesting properties. This can benefit the paper industry and yield sustainable polymers.
- Wood Polymer Composites has shown high growth rates both as a durable building material and as performing materials in the automotive industry.
- BioPE. Braskem has already launched sugar based PE with success some years ago and Sabic announced recently they will be on the market with PE from bio-oils. BioPE can be 100% from renewable raw materials and can in principle be used for all areas where PE are used today.
- PHA is a "new" polymer produced by living organisms. The polymer has very interesting properties for advanced packaging and within the health care sector.

Bio-degradable polymers are competitive and interesting choice for niche areas where bio-degradability supports the application. One example may be mulch films. Whether biodegradable polymers are the solution to plastic littering is highly questioned, but both the efficiency of recycling systems, regional consumer habits and infrastructure for waste management influence the importance of the biopolymers as a sustainable solution to littering.

Norner continues to perform application studies and the expertise build-up of biopolymers with the purpose of supporting application development and implementation in e.g. the FMCG market. Bio-materials have been tested on our application machinery such as blown film and injection moulding following a thorough investigation and bench mark of article properties disclosing both interesting and surprising features.

Norner is also doing extensive research in another category of sustainable polymers based on CO₂. These materials may also become bio based. Norner has developed extensive know-how and IPR in the field.

Biopolymers are "hot in the news" and more can be expected. We look forward to discuss biopolymers with You !

Homogeneous foams with low void sizes, low cost & lighter weight



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Norner has participated in an exciting EU funded project with the target to develop low cost, lightweight, Highly Insulating Polymers (HIP) for refrigerated transport, heating and cooling installations.

The project has been funded by the European Commission under the Seventh Framework Programme. 11 partners contributed to the project.

The basic idea has been to produce microcellular foam by using high internal phase emulsions. The emulsion consists of an aqueous phase and a monomer phase.

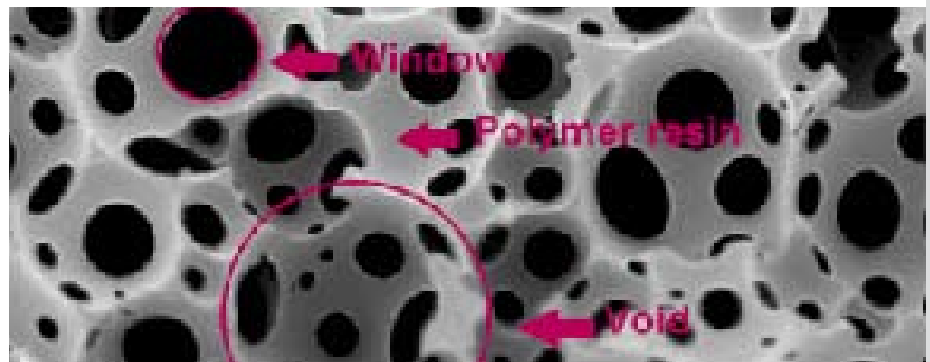
Norner's main contribution was to develop a process which can produce high internal phase emulsion (HIPE) materials with close control of porosity and pore size distribution. The aqueous phase is the internal phase and the monomer phase is the external

phase. By proper control of the components in the internal and external phases, the project has been able to develop a formulation which is homogeneous and have small voids.

In a high internal phase emulsion, the amount of the aqueous phase can be as high as 95vol%.

we could produce homogeneous foams with a void size of around 1 μm . Low void sizes are important in order to obtain good insulation and low thermal conductivity.

It was very rewarding to participate in this project. It attracted high interest from the insulating industry and had partners needing insulation for small heating and



A step forward for the insulating industry

The two phases are insoluble, and in order to mix them properly, high shear mixing is needed. By applying a high shear emulsion pump,

cooling items, such as i.e. water heater up to larger cooling systems, such as i.e. refrigerated vehicles. September 2013 marked the end of the HIP project. The consortium collaborated well throughout the project duration and the research objectives have been met.





Novel Catalyst Development - a Norner Verdandi investment



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Norner R&D team is working together with the Eonic team of researchers to develop novel catalyst technology.

EONIC TECHNOLOGIES

Eonic Technologies Ltd, a spin-out from Imperial College London, develops and commercialises novel catalyst technologies that use carbon dioxide as a feedstock to manufacture polycarbonates and polyols that contain 30-50% CO₂ by weight.

Eonic Technologies started operations in 2012 after initial investment from Imperial Innovations and Norner Verdandi to develop the technology further towards commercial applications. The current technology is covered by a number of worldwide patents and patent applications

A further £5.1 million investment in 2013 by Jestream Capital and Imperial Innovations will be used to scale up and commercialise the technology.

Eonic's catalysts are suitable for use with captured CO₂, enabling polymer producers to replace non-

renewable petrochemicals with waste CO₂, reducing feedstock costs and environmental impact.

THE TECHNOLOGY

Eonic's catalysts provide a commercially viable way to chemically modify CO₂. Whilst abundant and cheap CO₂ is in a very low energy state. It needs to be activated with a sophisticated catalyst and combined with a more reactive partner.

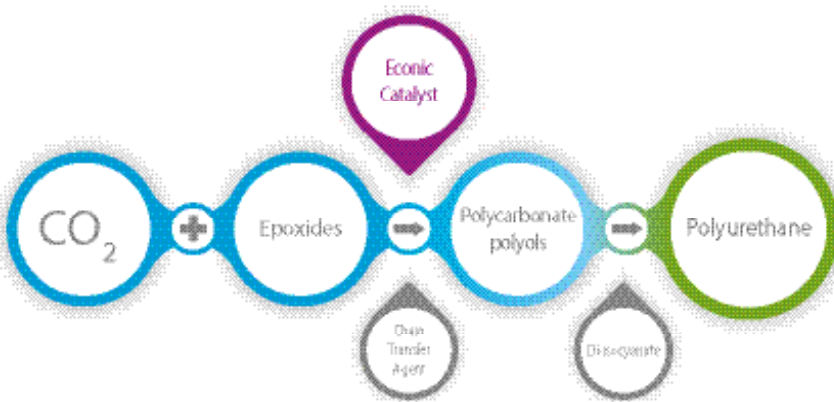
Eonic's catalyst is a homogeneous complex that dissolves in the epoxide, is highly active at low loadings and suitable for use with captured CO₂. This unique catalyst

THE BENEFITS

With Eonic's catalysts, feedstock costs for polyols drop dramatically enabling increase in profit margin and market penetration.

This disruptive technology will make polycarbonate polyols viable for a much wider range of applications, markets and users.

The replacement of petrochemical feedstock with CO₂ carries significant environmental benefit. For each tonne of CO₂ as feedstock, a total of three tonnes of CO₂ is saved, thanks to avoided epoxide production.



has low pressure requirements enabling utilisation of existing polyol manufacturing plants.

More information at:
www.eonic-technologies.com

Norner Verdandi offer licensing opportunities in pipe technology



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Norner Verdandi AS will transform good technological ideas into profitable business in cooperation with Norner, their research communities and international customers.

Norner is continuously evaluating the IPR potential of technology developed for clients, in collaborative research or as a result of own ideas and developments resulting in a portfolio of IP rights. Norner Verdandi was established to expand these opportunities and to commercialize new and exciting technologies.

Norner Trimodal Technology (NTT) for polyethylene (PE) is a good example. The NTT concept is based on a system of three polymerisation reactors where a small fraction of a third high molecular weight polymer is introduced in a small third reactor containing comonomer. We offer the possibility for upgrading existing bimodal plants by adding a third reactor.

In addition to several advantages compared to existing trimodal and bimodal plants, the technology utilises

the possibility to produce the HMW fraction earlier in the process, allowing better comonomer incorporation compared to conventional technologies.

Our promising mechanical properties indicate a potential for high quality PE100RC pipe grades.

The technology has been developed in Norner advanced Polymerisation Reactor Park, and is now ready for the first production tests in larger continuous pilotes before full scale implementation. The technology is patent protected.

Proprietary reactor technology for next generation HDPE

The technology offers polymer producers a potential for increased revenue through:

- Licensing Norner Trimodal Technology.
- Developing it further into own (proprietary) trimodal process.
- Develop own (proprietary) HDPE trimodal pipe grades and optionally trimodal grades for other applications like blown film and blow moulding.
- Become a technology leader by selling licenses to others.





Staying ahead of healthcare requirements



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Norner has long experience in polymers used in healthcare packaging and medical devices.

The healthcare market has stringent requirements for product safety, quality and consistency. The authorities require extensive documentation regarding regulatory compliance for materials used in pharmaceutical applications.

Being an independent plastics institute Norner provides analytical services, technology developments and consultancy.

Based on our client needs our support can cover wide range of analytical and chemical testing and services.

- Polymer long term stability studies.
- Polymer additive and composition analysis.
- Investigation and detection of potential contaminants/foreign matters in products.
- Quality control and product consistency.

ANALYTICAL AND CHEMICAL SERVICES

- Analysis of additives and monomers in packaging
- (EC) 1935/2004, (EU) 10/2011, REACH and FDA expertise
- Overall migration testing according to EN 1186
- Identification of possible SML components
- Specific migration testing according to EN 13130
- Notification services for US and EU food contact regulations
- Analysis of Bisphenol A
- Analysis of Phthalates
- Heavy Metals in toys
- Odour and taste testing
- Analysis of volatiles

**Norner - a partner for
healthcare packaging and
medical devices**



Read more on www.norner.no or contact us.

Chemicals in Packaging

A new project for increased food safety



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New research, competence and analytical methods for chemical substances used in packaging materials shall improve food safety.

Food safety is a very important subject for the parties in the food value chain. Most of the food articles available in the market are supplied in packaging which is a significant and critical part of the food safety. The packaging protects the food and contributes to a longer shelf life. It is extremely important to avoid that the food is contaminated by substances migrating from the packaging to the food; especially if such substances are suspected or found injurious to health.

An example of a substance that has been focused lately is Bisphenol A (BPA), which is a component in the epoxy lacquer used on the inside of tin cans as well as a monomer for making Polycarbonate (PC). BPA is on the list for suspected hormone mimicking substances, and it has been found in food packed in tin cans. Extensive work is going on in the value chain to find replacements for BPA.

At the moment it is only migrants from plastic materials that are harmonised and regulated within EU. There are a number of other packaging materials and components which could be in contact with

food and which are not harmonised or regulated with respect to migration into food. One example is 4-methyl benzophenone which has been found in various breakfast cereals and caused by the printing inks used on the packaging carton board.

In EU work is ongoing to regulate various substances used in packaging materials, and to define maximum migration limits to avoid health risk. There is a need to monitor to what extent migration and leakage from various packaging materials into food happens and the potential problems associated with this.

A research project partly funded by the Norwegian agricultural authority was started up in February 2014. The project has 10 partners whereof 8 are from the food value chain. The other two partners are the Norwegian research institutes Norner Research and Nofima.

The project will last for 3 years and Norner will contribute to establish new and needed competence with respect to chemical substances used in packaging materials. New analytical methods for detection and determination of such chemical substances in food packaging materials will be developed by the research institutes. Norner will have special attention to "non intentionally added substances" (NIAS).

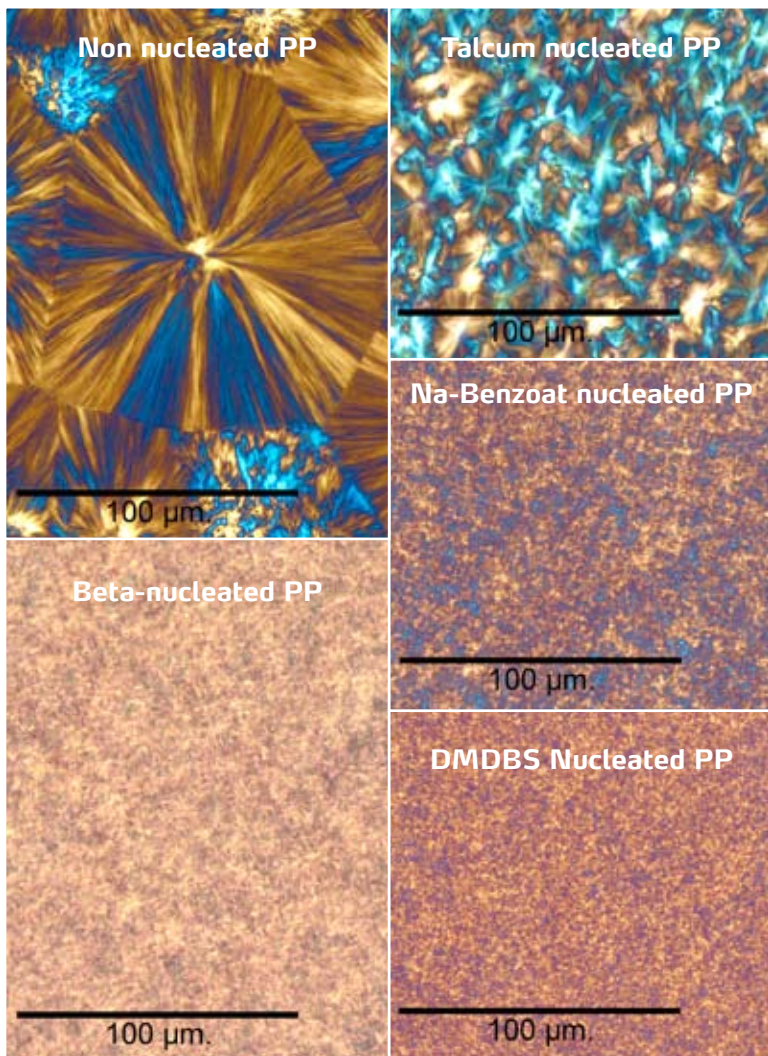
The project results will form a basis for selection of safe packaging materials and increased food safety.



KIM
trygg emballering

Project participants





At the back

Thermoplastic materials have either a semi-crystalline or amorphous solid state structure. The crystallinity of PP can be significantly changed by the addition of nucleators.

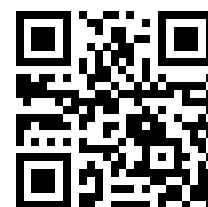
Nucleation is used to modify the solidification, stiffness and/or optical performance of polypropylene (PP). The effect of various nucleators can be assessed by optical microscopy under polarised light as demonstrated with the images here to the left.

Chemical derivatives of benzoic acid like sodium benzoate is an effective nucleating agent. Other nucleating agents include minerals such as kaolin and talc. These additives offer decreased cycle times and increased output and profits. Clarifying agents are usually organic, non-polymeric molecules. All clarifying agents also act as nucleating agents, but nucleating agents are not necessarily clarifying agents. Most clarifiers on the market are chemical derivatives of dibenzylidene sorbitol (e.g. DMDBS).

Beta nucleation of PP can produce improved physical performance.

Did you miss earlier editions?

You can access these earlier editions of Norner News through the following QR code or at <http://issuu.com/norner>



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