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NORNER NEWS

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3@Norner



Ravindra Chowreddy

Hello, I am managing the work of developing mulch films from co-streams in food production such as potato peel. That's fun and sustainable.



Morten Lundquist

Hi, as Research Director in Norner. I am very excited about the results we achieve for clients with our lab reactors. That is very inspiring.



Roger Didrichsen

Hi, I take care of the protective coating testing and have been busy developing several new methods based on our customers request. Cool!



I am pleased to see how many of our projects which deals with technology for a better sustainability. This fits well with the international ambitions of circular economy and the green shift. I would say that we are on the right track.

Dear reader

New materials innovation – part of the solution for a green shift and a transition to a low carbon economy.

In this edition of our customer magazine, I will draw the attention to some key trends we in Norner see will be part of the answer to achieve a low carbon economy.

We operate daily advising and performing research and development together with our clients worldwide. The topics vary from base feedstock through polymer raw materials and all the way to end products at the consumer market.

During the last few years, we have experienced a growth in demand to explore and innovate within feedstock and materials from renewable sources and to replacing metal with lighter polymers. The industry is moving from visionary thinking to real commercial action.

Many of the large brand owners are now frontiers on sustainable material utilization- either through bio-based polymers, weight reduction or through recycling. Coca-Cola is a good example utilizing recycled PET and is a leading business driver to grow sustainable material volumes.

There is a growing demand to replace fossil with bio-based feedstock. Today, sugar waste is already the commercial cornerstone, but we are happy to see that the focus on wood and other natural fibres have grown

significantly. Not only to produce biofuel, but also further to green materials.

In addition, natural fibres, are also more frequently investigated as reinforcement in different compounds - also commercially available.

The increased sustainable innovation effort will speed up the green shift. We have selected one of our amazing new projects to show an example on new materials innovation where potato peel is used as raw material for production of agricultural soil film.

Another aspect I would like to highlight, is the green shift within the Oil&Gas sector. Strong drive and a high activity level on replacing metals with lightweight solutions. An important contribution to a more sustainable and cost efficient Oil&Gas industry.

Read about Exposure testing (on pg. 6-7) to make sure that your choice of polymers are the right.

I believe that the high focus and market drive to innovate towards a low carbon society is a positive sign for the future.

*Green wishes and good reading!
 - Tine*

Highlights

New web page

Welcome to the new web page of Norner!

Just go to www.norner.no and see for yourself how we have transformed the style and content. The aim of the reshaping project has been to make our homepage more customer friendly.

The main change has been to cluster our services according to the segments of our clients. If you are in oil&gas, polymer production or consumables you will easily find all relevant info at one site. And, now you can also read it on your mobile device!



Expanding Testing Services for Coatings



Norner offers several testing services to the the Oil&Gas and Marine sectors. During the last five years, we have grown our service offering in testing of protective coatings and lately we have included "new tests". Read more on pg. 6.

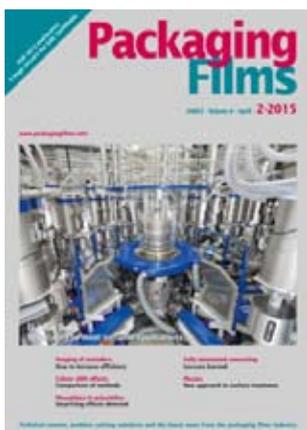
Nordic Conference



Norner was invited to present results from a multiclient project called "Chemicals in packaging" at a Conference on packaging food compliance in Oslo in June. The project is owned by Elopak and includes food producers, whole sellers and packaging producers.

So far the project has only positive results and the industry as well as Norner will strengthen significantly our competence in chemical substances used in packaging materials. Our project manager, Jorunn Nilsen, gave the presentation.

Norner article in Packaging Films 2/15



Our Additives Specialist, Svein Jamtvedt was invited to write about antioxidants by the magazine editors. The result is a well written in-depth review of the types of antioxidants used in PE and their effect on polymer degradation. You can request a copy from the magazine editors.

Successful seminar in Biopolymers



Norner has made several projects on bioplastics materials and polymer science during the last ten years. This has given us good insight in the technology and raw materials. This experience was shared in our Bioplastics Seminar last March.

The seminar covered a comprehensive introduction to the different materials and their properties and applications. Furthermore the different raw materials used during production and trends in the regulations.

New employees

We have the pleasure to welcome and present our four new R&D employees:
 Jostein Mathiassen, BSc in gas and energy technology,
 Yvonne Hed, PhD in multifunctional dendritic macromolecules
 Sara Ronasi, PhD in chemical process and product engineering
 Petri Myllytie, PhD in forest product chemistry and polymer technology



SCG Chemicals - our new owner



Tine Rørvik
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In December 2014, SCG Chemicals acquired the majority of shares in Norner Holding

and since August 2015, they are a 100 % owner.

Through this strategic investment, SCG Chemicals target to grow and strengthen Norner further as a global independent innovation partner for the plastics value chain.

SCG Chemicals has been focused on continued improvement of their R&D capability for High Value Added products (HVA) and was already an important client of Norner.

"Norner is a market leader in polymer and plastics innovation and will be an important part of the jigsaw to SCG Chemicals in many areas of product innovation." says Cholanat Yanaranop, President of SCG Chemicals and Chairman of Norner Holding.

"We are very proud to have SCG Chemicals as a strategic investor and are confident that their strategic visions and financial power will give Norner a good platform for future growth internationally." says Tine Rørvik, CEO Norner. "Our experience after the first half year is excellent and the new owner has great confidence throughout the organisation".

Norner remains a fully independent institute offering advisory, development and laboratory services



From the celebration of our new ownership:



From left: Jon Pieter Fløto, Major of Bamble Municipality, Tine Rørvik, CEO Norner, Cholanat Yanaranop, President of SCG Chemicals, and Terje Riis Johansen, County Major of Telemark





Meet us at

- leading international events

OTD 2015, Stand E4526

October 21-22, Stavanger, Norway



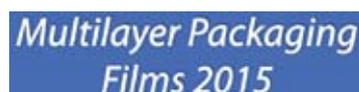
Scanpack 2015, Stand C03 30

October 20-23, Gothenburg, Sweden



Multilayer Packaging Films 2015

October 26-28, Cologne, Germany



Polyolefin Additives 2015

October 28-30, Cologne, Germany



Overflats 2015

November 4-5, Bergen, Norway



Thin Wall Packaging 2015

December 2-4, Cologne, Germany



Oil & Gas Non-Metallics 2015

December 8-10, London, UK



Subsea Valley Conference 2016

April 5-7, Oslo, Norway



ONS 2016

Aug. 29 - Sep. 1, Stavanger, Norway



K'2016

October 19-26, 2016, Düsseldorf, Germany



Extended testing capabilities of protective coatings



Roger Didrichsen
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It is an increasing interest for our testing services of protective coatings.

We are working hard to continuously expand our testing range. This expansion is three-fold; increasing capacity, introducing new tests and investing in new equipment.

For many of our NORSOK-501 customers, the expansion into High-temperature cathodic disbonding (HTCD) testing according to system 7C should be of great interest. We have designed a set-up, which allows for gradual capacity expansion, meeting customer demands. The HTCD testing will be introduced to selected

customers this fall.

Norer is also expanding and introducing new tests using our high pressure autoclaves. Examples of interest could be ageing testing in corrosive fluids and/or testing including gas decompression. Fluids could be crude oil, synthetic oils, gasmixes of H₂S, CO₂ and CH₄, sea-water and more. We are more than willing to discuss customer specific tests in this range.

Coating activities at Norer is not limited to 3rd party testing. As an advanced polymer institute, we have equipment (4000 m² of labs) and research competence that could support customers with a range of development interests.

Fields of interest could be high-temperature curing, mechanical surface

properties, behaviour in extreme cold climates or other.

We welcome good dialogs on R&D topics and testing that could benefit our customers. Our institute's industrial background has given us long experience in product development and in achieving fund from public bodies (e.g. National research councils or in EU Horizon 2020).

We increase capacity, introduce new tests and invest in new equipment.

No task is too small nor too big. We cannot do everything, but we are willing to look into any customer needs and try our best to find ways to solve them.

Meet us at the coating conference "Overflate 2015" in Bergen Nov 4-5.



Autoclave exposure testing



Henning Baann
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Norner has expertise within high pressure and high temperature testing under critical conditions by using advanced autoclaves.

We are an innovation partner with advanced test facilities. We also assist in selecting the optimal material for your needs. We are performing market studies for clients, as well as finding cost optimal material solutions that meet even the stringent requirements.

We offer a range of capabilities, from small 200 ml autoclaves up to 5 litre autoclaves. The autoclaves are made for temperatures up to 325°C and pressure over 300 bar.

With more than 35 years' experience in handling extreme pressures and gases, it was a natural move for Norner to meet the increasing demand from the Oil & Gas industry for verification and documentation of material behaviour at extreme conditions.

Exposure and compatibility testing is a wide area. Typical media can be salt water, but also various oil compositions and liquid mixtures are defined and used. Typically CH_4 , H_2S and CO_2 according to customer requirement.



The exposure testing is typically followed by mechanical testing, hardness, swelling, additive residues and microscopy evaluations. Life-time prediction is crucial since materials are expected to have very long life time, also in critical environment. Norner typically uses Arrhenius plot to calculate this.

In addition to standard testing, we offer tailor-made and functional testing. Test equipment is built up to suit the individual need from clients, and test parameters are being agreed in order to secure closest resemblance with the specified environment the polymer shall be exposed to.

The most relevant test standards at Norner are;

- Norsok M-710 incl. RGD
- ISO 23936 part 1 (Thermoplastic) & 2 (Elastomer)
- ISO 12736, Wet thermal insulation coatings for pipelines, flow lines, equipment and subsea structures
- ISO 10423, Annex F, Drilling and production equipment -- Wellhead and Christmas tree equipment
- API, CSA and NACE standards



Bench reactor pilot lab - our unique R&D tool



Morten Lundquist
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Our development reactors for olefin and polyolefin process optimisation are used to improve the profitability of our clients.

We can be your strategic partner for consultancy, to cut your production cost, increase your revenue, and understand and solve production problems in your operations. We have the industrial expertise to partner up with leading clients world side.

Our clients recognise and appreciate the expertise we have in polyolefin production technologies, including catalyst optimization, raw material specification and qualification, using industrial class equipment.

Two examples of our achievements are our recent inventions for trimodal HDPE and multimodal PE Metallocene. These technologies show improved product performance and increased production economy.

We are now expanding our assets and capabilities in industrial small test pilots

and have conducted client projects for increased profitability for a variety of olefin and polyolefin processes. As a result we have now available industrial autoclave reactors for studies on increased profitability in olefin process technologies. We have conducted studies on optimizing alkane hydrogenation and alkene dehydrogenation.

Improved Olefin Profitability

With an efficient removal of impurities like acetylene we are now inviting clients for technology developments.

We are also in position to discuss a number of other processes like new low temperature methanol synthesis process, conversion of carbon dioxide to fuel, chemicals, polymers and other.

Our autoclave reactors are designed with wide operational windows, enabling investigations of a variety of homogenous and heterogeneous catalysts for the processes mentioned.

ETHYLENE

The global demand for polyethylene is increasing, and has reached more than 100.000 million tons annually. The C2 feedstock comes from hydrocarbon

steam cracking units of sizes typically ranging from 0.5 - 1 million tons/year.

Acetylene is then a by-product, and acts as a poison to the catalysts used for polyethylene. Trace removal of acetylene is a major challenge to the ethylene producer, and off-spec incidents may cause loss of production of 1.000+ tons.

A test rig for troubleshooting and prequalification of new catalysts may increase profitability of the ethylene production significantly. Such a rig, with the necessary infrastructure has been designed for installation at Norner and can be tailored to customer needs.

Our customers can perform advanced studies at Norner's specially designed reactor for hydrogenation processes.

PROPYLENE

There are several chemical reaction routes to propylene. Metathesis reactions is one way of producing propylene from ethylene and butene using homogeneous or heterogeneous catalysis. Alternatively, propylene can also be produced by dehydrogenation of propane.





Norner has autoclave reactors for both routes and is looking for partners for further developing technology for conversion of ethylene to propylene.

BUTENE

Upgrading of crude C4 fractions for value added olefins may involve several processes. One process could be hydrogenation of butadiene to valuable olefins. Another process could be dehydrogenation of butane. An optimization of the process can result in a profitability increase in the range of millions of Euros per year.

In a time where cost minimization are crucial for economical operations, search for the right raw feed, the right catalyst, understanding the competing chemical reactions and presence and

amounts of impurities will all have an effect of the profitability.

Our experience covers:

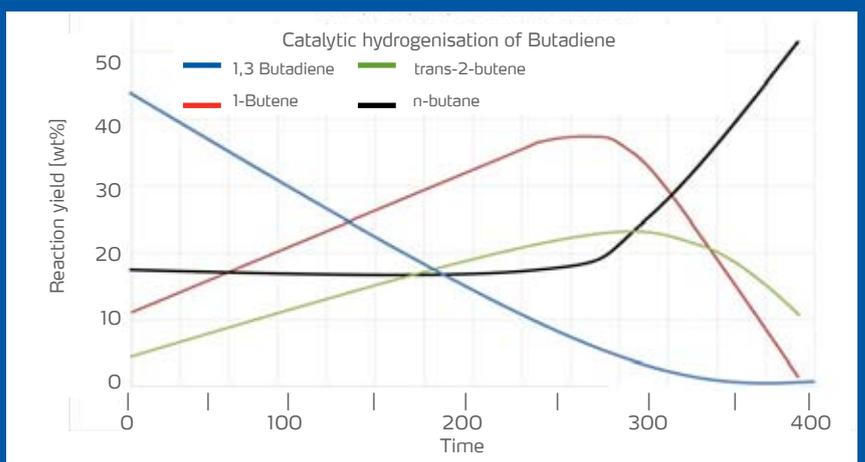
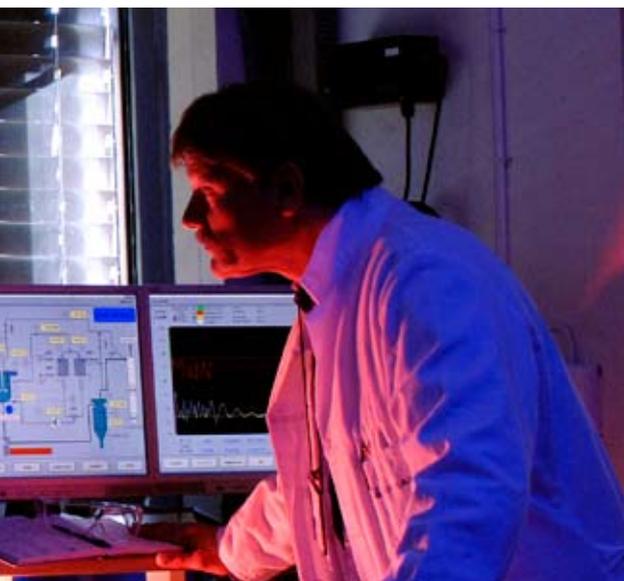
- ethylene dimerization, oligomerization
- hydrocarbon cracking (on purpose propylene)
- alkane dehydrogenation
- alkene hydrogenation
- ethylene to propylene conversion
- Fischer Tropsch, methanol synthesis
- Polyolefin processes – all types, all catalysts and cocatalysts, comonomers

Norner offer "One-stop-shopping" projects within olefin and polyolefin research, technology development and troubleshooting for commercial

processes, including experts from our wide network as well as student work for larger projects, in addition to Norner experts and assets in industrial autoclave reactor set-ups with relevant infrastructure. Projects include; testing, development and optimization of homogeneous and heterogeneous catalyst systems.

EXAMPLE

Fine-tuning of the hydrogenisation process of butadiene is very complex. It is influenced by process factors as well as catalyst. As a function of time there will be different balance of the components in the reactor and the optimisation of 1-butene yield is critical for the production economy.



Simulating Packaging barrier and product shelf life



Ole Jan Myhre
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The main idea of food packaging is to contain and protect the food through the distribution and retail chain to the consumer. The time a product can remain fresh for consumption is its "shelf life" and this article discuss how this is influenced and how you can simulate this.

Food are produced or prepared and packed in many different ways. The food can be:

- fresh meat, poultry, fish
- cooked, cured, dry, salted
- fresh vegetables
- dry flour, rice or pasta
- prepared foods, ready meals
- liquid juice, milk and beverages
- etc

In this article we will look specifically on plastics barrier packaging and how to estimate the shelf lif by simulation.

SHELF LIFE

A good definition of shelf life is: "The period between the manufacture and the retail purchase of food product, during which time the product is of satisfactory quality in terms of nutritional value, flavour, texture, appearance and safety."

Obviously, the shelf life of a packed product will have a complex dependency of several factors such as:

- the products nature and "activity"
- the environment in the distribution chain and especially temperature
- the properties of the package and especially its permeability

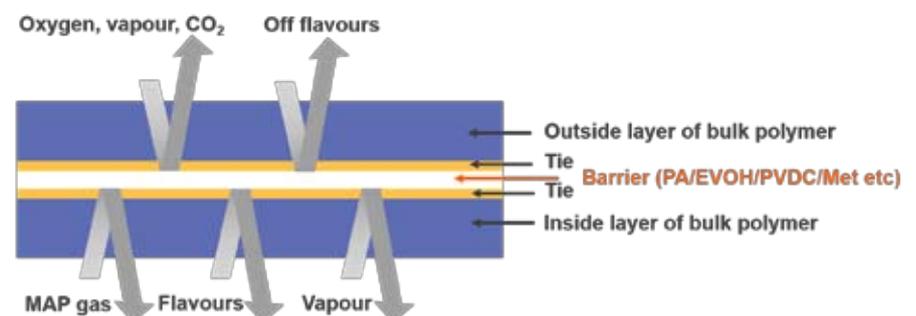
The way a product deteriorate is also many including: microbiological and/ or enzymatic deterioration (aerobe and anaerobe), oxidation e.g. Lipidic oxidation of fish or Rancidification of fatty foods, moistening, drying and other changes in taste, odour or colour.

A key aspect of the package is its barrier against gas permeation and how well it can maintain a specific inner atmosphere with concentrations of O_2 , H_2O , CO_2 , N_2 .

In particular, we will look at examples of meat products where oxygen permeability is of high importance and cereal products where moisture permeability is the key.

PERMEABILITY

Plastics seems impermeable but that is not correct. Conventional packaging polymers such as PET, PE or PP have a rather high permeability for O_2 and give limited protection while for moisture they give a good protection. Some other polymers like PA and EVOH on the other hand have high barrier against O_2 and protects food well. These different materials can be combined in order to obtain the right performance - like in below figure.



SIMULATION

Norner have developed a web based calculation tool for oxygen transmission rate (OTR) and water vapour transmission rate (WVTR).

The calculator is available for free on our homepage www.norner.no.

It allows the user to specify:

- Various package types
- The package dimensions
- The type and thickness of different polymers in the wall of the pack
- The (storage) temperature and relative humidity
- The time for which permeation shall be calculated.

BENEFITS

The calculator is easy to use and flexible in how you can specify the package and conditions which allows:

- Storage/transport condition can be specified and varied
- You can use it to generate data for your packaging system as a basis for correlation curves
- When you know the product tolerances, shelf life can be estimated
- Virtual testing of various package types and layer constructions
- Compare performance of structures to their anticipate dcosts

Examples of calculation and simulation

Meat has a natural high activity and is affected by the presence of oxygen which may lead to microbiological activity and turn the meat bad.

We shall calculate the shelf life of a piece of beef in a vacuum pack. The packaging film is a 7 layer PE/PA/EVOH structure.

The input data for the calculation is:

- The following 7-layer structure: 40µm PE / 4µm Tie / 5µm PA6 / 3µm EVOH32 / 5µm PA6 / 4µm Tie / 40µmPE
- Film surface area 25x40cm²
- Relative humidity 65%

We calculate the O₂ ingress at different times and storage temperature and plot the results as shown to the right.

We specify the O₂ limit to 1ml

CONCLUSIONS

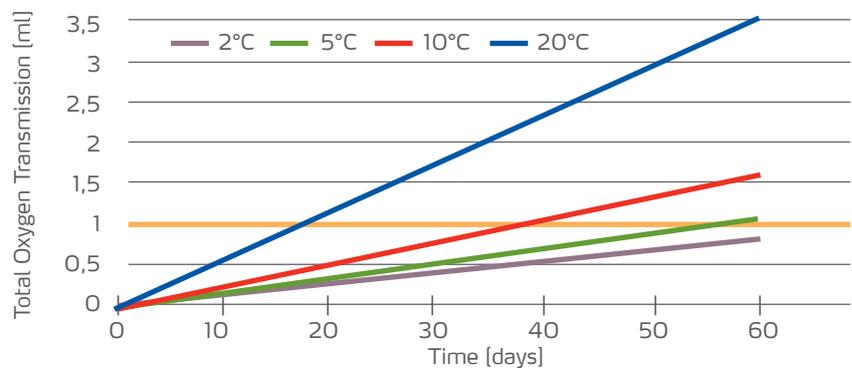
Under the specified conditions:

- The shelf life is >60 days at 2°C
- At 10°C the shelf life is only half

Similar calculations can be made for alternative packages.



Case 1 - Meat / OTR



Cereals are dry and with a very low activity. Their shelf life will naturally be long but a critical issue is moisture increase by which they may turn soft.

We shall calculate the shelf life of cereals in a PE pouch.

The input data for the calculation is:

- The following 3-layer structure: 10µm HDPE / 10µm HDPE / 10µm LDPE
- Film surface area 30x50cm²
- Temperature 20°C
- Relative humidity inside 0%

We calculate the H₂O ingress at different relative humidity in the storage and plot the results as shown to the right.

We specify the H₂O limit to 15g

CONCLUSIONS

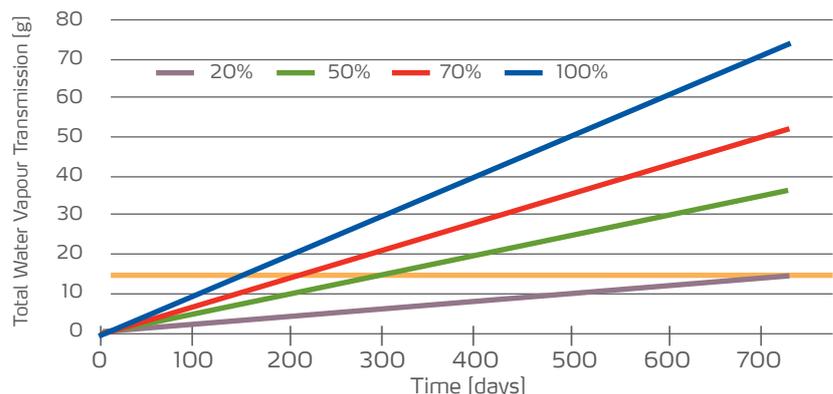
Under the specified conditions:

- The shelf life is 700 days at 20%
- At 50% the shelf life is only half

Similar calculations can be made for alternative structures or thickness.



Case 2 - Cereals / WVTR



Packaging Development Centre - our expertise - your benefit !



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If you are a packaging producer or a brand-owner using packaging there are numbers of challenges every day.

Lightweighting, biopolymers, shelf life optimisation, output in packaging production or filling line, liability like migration, organoleptic, cost saving, sealing/welding and many more...

We can name so many. Often cross functional competence is needed to move forward.

COMPETENCE GAP IN PROJECTS

A successful packaging need to fulfil a set of requirement specific for the application relevant. In addition cost, environment, design and marketing are key success criteria. Norner is well positioned to support your project team with competence you may miss in your own organisation.

Our services may include:

- Advanced laboratory tests and documentation
- Deep polymer understanding to properly select performing materials.

- Competence of additives, modifiers and colorants used
- Details of liability for food, pharma or other compliance

Many packaging producers and brand owners of today are looking into innovative routes to differentiate their products. In such a process, it can be hard to avoid coming out of the organisations comfort zone. Through involvement in very many packaging projects and through development done for non-packaging applications, we have a wide comfort zone. We suggest you make our wide competence to your benefit.

Norner do not know your good ideas for a packaging, but we may know how to bring them forward.

Examples of technology we have brought into packaging projects are:

- Biomaterials processing and performance
- State of the art barrier technology
- New seal solutions
- New processing technology like MDO (Mono oriented film)
- Polymer composites

WHAT IS YOUR BENCHMARK?

Packaging are a competitive business.

Not only do you need to compete with companies producing similar products like yourself, but there are also outsiders knocking on the door.

A rigid portion pack of e.g. 300 ml can today be delivered in a number of solutions like:

- PP injection moulding
- PP thermoforming
- PS thermoforming
- PET thermoforming
- PLA thermoforming
- Laminated cardboard
- Moulded pulp
- Tinplate
- Glass

Many questions arise. What will be the winner of the future? What are the property differences among the alternatives? How can the alternatives be modified to expand the application window? Cost? Environmental issues?

The type of questions raised are often ending up at the desk of Norner because performance documentation, material understanding and processing experience are needed to get the full picture.

Norner do not know what all the important questions raised in the packaging industry will be in the future, but you can trust us in the ambition of being there and find out the answers.



Norner Strategic Advisory



Per Arne Sørlien
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Norner has an extensive industrial experience, which we use to create value for our customers.

We help clients to be successful in strategic choices, to create added value, to achieve a superior cost position and to set up innovation organization and tools.

In all these areas Norner has experience and methodology that, when facing complex issues, identifies elegant and profitable solutions which serves as a foundation for sound business decisions.

The key services Norner delivers within strategic advisory are:

Business & Market Strategy

- Strategic studies
- Market & Product
- Raw materials & feedstock
- Technology strategy
- Product harmonisation

Create Added Value

- Value added product strategy
- Asset capabilities

Cost reduction programs

- Raw material optimisation and sourcing
- Make/Buy strategies

Innovation, Organisation & tools

- R&D portfolio strategy
- Innovation centre (R&D and PADC) design & operation
- Empowered X-functional teams
- Segment development teams

SOME REFERENCE PROJECTS

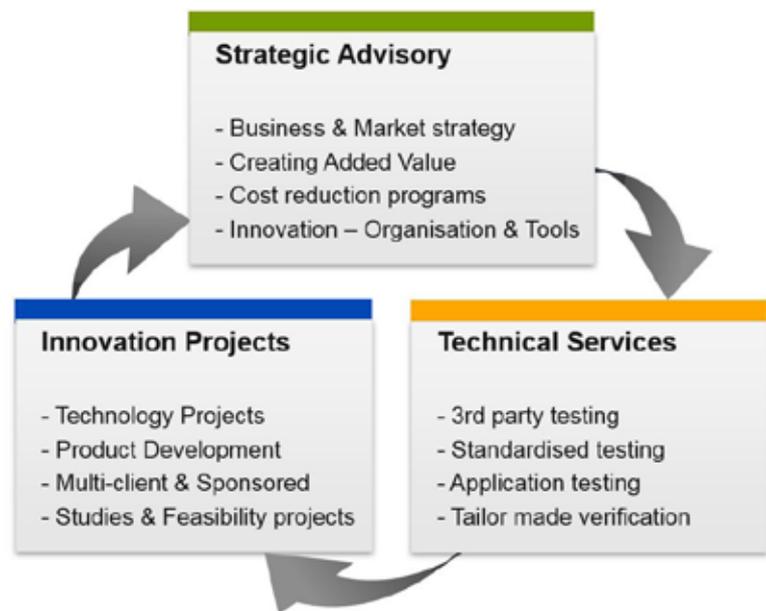
1 - A global market leader within household products has a target to dramatically increase share of bio-based materials within 2020, Norner has advised on bio-based polymers and their alternative routes from raw material to polymer

2 - An international food ingredients company wanted to enter a new market segment with existing products. Norner analysed the new market, advised on product strategies and trained their organisation.

3 - A polymer producer wanted to understand the opportunities in a new segment. Norner analysed the segment, identified opportunities and

developed high value added product strategies

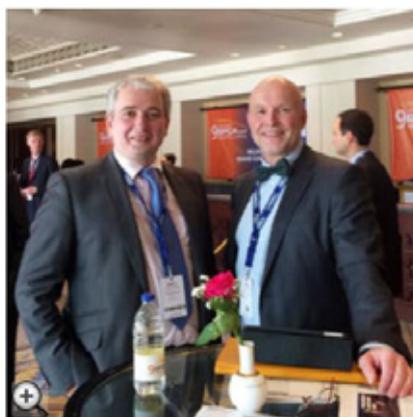
4 - A brand owner identified a need to better understand the raw material influence on the packaging. Norner has reviewed their portfolio, specs and advised on a harmonised approval process for polymers in packaging.



03-10-2015

Sibur Selects Norner Strategic Advisory to Implement Value Added Products

Sibur Group, Moscow, Russia, has selected Norner AS, Stathelle, Norway, as its preferred partner in their initiative to broaden their polyolefins product portfolio for customer needs. Sibur has decided to improve their strong market position by offering Value Added Products to special segments and new applications.



Sergey Komyschan, Sibur's Managing Director – Head of Basic Polymers Division, and Lars H. Evensen, Director Business Development at

As part of the project, Norner, the Independent Industrial Polymer Institute, will support Sibur in streamlining interaction between the company's business functions, such as sales and marketing, development, technical support, strategic marketing and Sibur Technologies Centre in developing new products and establishing new segments in the polyolefin market.

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Soil film plasticised potato peel



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The objective in the SOILFILM project is to develop mulch films from food waste streams.

In SOILFILM project, Norner has already developed plasticized biodegradable film from potato peel - the waste product generated from potato processing industry. In addition, Norner is exploring the possibility of utilizing other co-streams of the food industry in the project such as chicken feather from the poultry industry.

Norner is an R&D partner in the project, which is funded by the Norwegian Research Council led by NIBIO (earlier Bioforsk, Norway). VTT (Finland) and University of Nebraska (USA) takes also part. Four industrial collaborators in the value chain support the project.

The objective of the project is "to develop biodegradable mulch film formulations from the co-streams

of the food industry, which can be sprayed directly on the soil of row crops to form a strong film and protect crops against the growth of weeds".

The project started up in 2014 and will have a duration of four years. The potential co-streams of the food industry have been assessed and competence has been acquired in the project to develop film-forming formulations.

Field tests will be carried out at NIBIO to investigate the effectiveness of films against weed growth.

Norner develops mulch film from potato peel

Food processing is one of the most important industries globally. The co-products and waste from the food processing industry must be handled in an appropriate manner to avoid any environmental violence.

Potato peel and chicken feather have been chosen as the main co-streams of the food industry in the project for

the development of biodegradable sprayable mulch films. Potato is the world's fourth most important food crop, with an estimated annual production of 376 million tons in 2013. Processed potato in the form of ready-to-eat products such as frozen products, chips and French fries, generates large amounts potato peel, which is currently used as animal feed or treated as a waste.

Similarly, feather is a by-product in the poultry industry. According to OECD agriculture statistics, in the year 2012, the world's poultry production was 106 million tons (ready-to-cook). As feathers constitute a significant part of the total weight of a chicken, the amount of feather generated can be estimated to 15-20 million tons.

Co-products of food processing are inexpensive and affordable. If the suitable applications for the co-streams of the food industry are developed, it adds value to inexpensive materials with improved sustainability.



Non Intentionally Added Substances in Plastics



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New research, competence and analytical methods for chemical substances in plastics reveal new components.

Human health and safety is a very important subject and the topic of Non Intentionally Added Substances (NIAS) in plastics receive more and more attention for just this reason.

During the last 10-15 years several cases of questionable NIAS have been published such as:

- Presence of 2,4-DTBP in drinking water - a residue of antioxidant.
- Presence of Tin in baby diaper - a catalyst residue.

Now NIAS has been introduced as a concept in the EU Plastic Regulation for food contact materials. This has resulted in increased focus in the industry.

Regulation (EU) No. 10/2011 gives a clear definition for NIAS:

Any impurity in approved substances used

- Reaction intermediates formed during the production process
- Decomposition products
- Reaction products

The production of food contact materials (FCM) can never be free of NIAS. FCM are often very complex, e.g. multilayer, combinations of different materials, use of adhesive and printing inks.

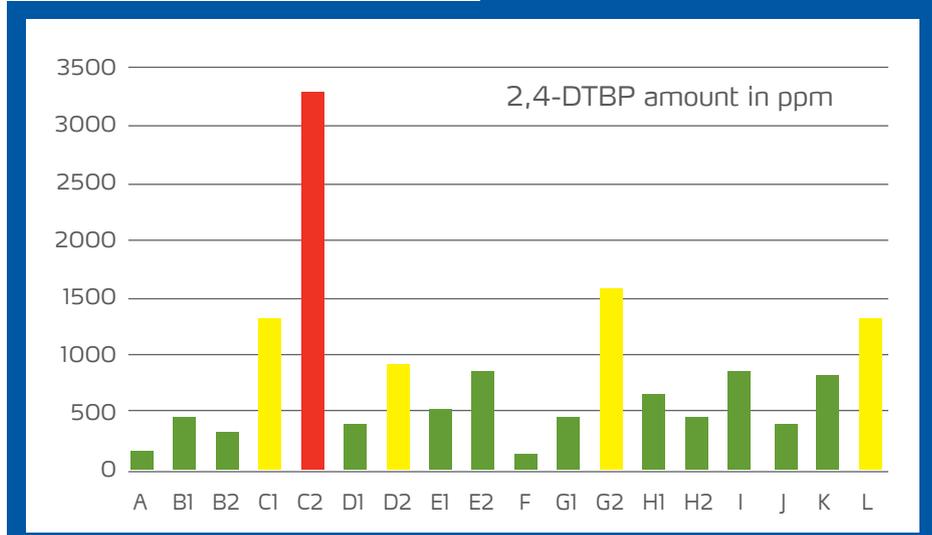
The challenge is to know the presence of what types of NIAS that are present in the FCM. Another challenge is how to analyse NIAS because they will be present in low concentrations (should be max. 0.01 ppm).

Norner has long experience in working with FCM and NIAS. We have an extensive range of relevant analytical methods and may help you solve your challenges with NIAS in FCM, both in a pro-active approach and by analytic expertise.

We help our clients in additive qualification procedures and analysis"

EXAMPLE

We have investigated the quality of the conventional and fully food approved antioxidant AO168. We analysed the content of one of the most well known substances of NIAS, 2,4-DTBP in this additive from several suppliers as well as several samples from some. The result is shown in the graph and illustrates that the purity of AO168 vary significantly depending on the supplier. This is one factor to take into consideration when selecting your supplier.



At the back

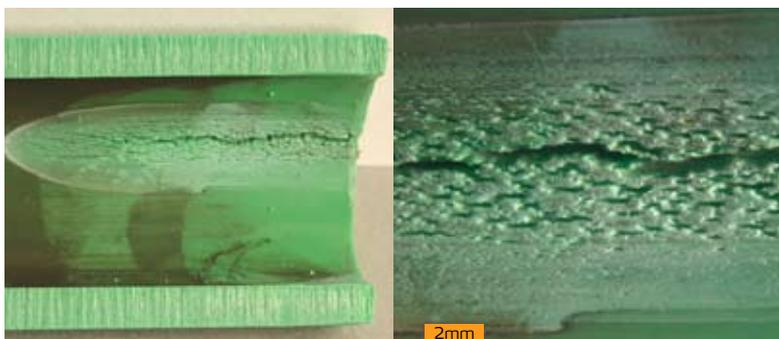
Norner provide failure analysis to chemical industry on a regular basis. One of these customers had a failure in a PP pipe for hot water supply and we got the task to find out why!

When failure occurs in a chemical plant, it is important to find out why and prevent it to happen again. At the start of our investigation, it was clear that the failure had developed over long time. We used a combination of light and scanning electron microscopy and supported the diagnostics with both FTIR spectroscopy and thermo analysis.

The failure had an appearance of a chemical attack or stress cracking. We found out the following facts:

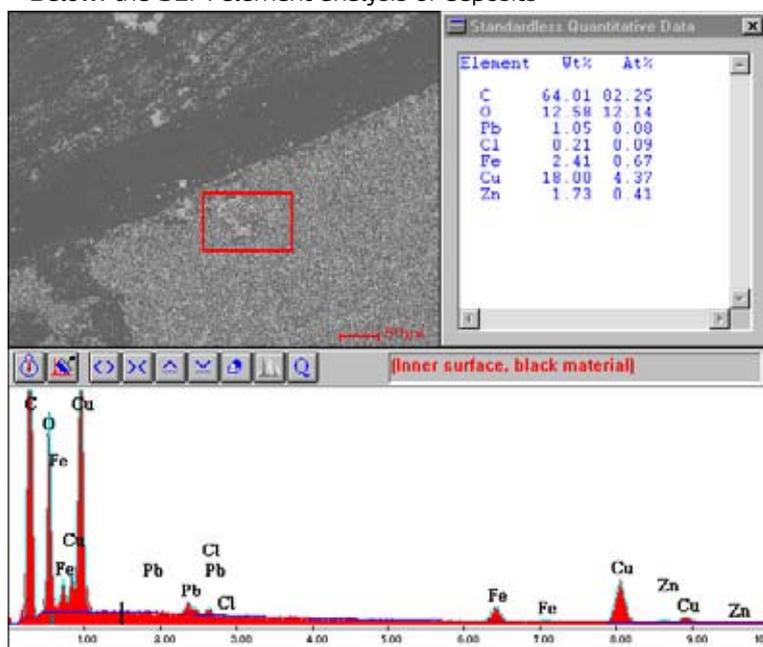
- The PP was highly oxidized, hence degraded
- Polymer at the crack had low thermal resistance
- The pipe sample was partly covered with a blackish deposit on the inner wall.
- SEM element analysis of this deposit revealed high levels of copper.

Conclusion: The long-term stability of PP is drastically reduced in the presence of copper. It acts as a promoter for degradation and special additives are needed in order to protect the polymer. This was not the case and therefore the PP material could degrade and fail in this case.



Above: the pipe and inner surface

Below: the SEM element analysis of deposits



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