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NORNER NEWS 21

Investing in a new Polymer Exploration Centre

High focus on circular economy

Quality and leadership in coating testing

norner™
The Polymer Explorers

Contents

New Employees at Norner

We are happy to announce that Norner is growing and we are hiring new permanent employees. Despite of the difficulties related to Covid-19, Norner has had a strong economic year. We are proud of our new employees who will strengthen our teams in areas like circular economy, healthcare and renewable energy. They all bring valuable knowledge and competence to build Norner for the future.

Anita Winsnes
Strategic Advisor

Albrecht Dix
Principal Business Developer

Arezoo Banaei
Project Controller

Silje Gudmundsen
Senior Engineer

Øystein Eksner
Senior Engineer

Jan Lyberg
Engineer

Kalpana Papasani
Engineer

Håkon Sverdrupsen
Engineer

Marianne Gremmertsen
Engineer

Ronny Ervik
Senior Consultant

Tom Anders Torgersen
Senior Engineer

Susanne Palmquist
Senior Researcher

Our Sustainability Goals

Leader

Dear Reader

Norner's creation was based on a vision – a vision to be the global market leader of industrial R&D services in polymers by exploring opportunities and discovering sustainable solutions. For almost four years I have enjoyed working with my highly competent colleagues and excellent customers worldwide. I can assure you that this vision is more alive than ever.

After 562 days with Covid-19, Norway and several other countries in the EU now see an end to the pandemic. We will likely experience a fast recovery, but also see some long-term effects. When we move on, we should bring with us everything we have learned from life during a pandemic, where we organized our lives differently with less travelling and physical meetings and a more flexible working life, making digital meetings the new normal.

During these 562 days, Norner has been in continuous development. 2020 was a record year. This year will be even better. As most business frontiers move towards a rapid, green shift, the need for new developments and innovations increase, so do our investments in Norner.

> Heading towards a New Normal with a rapid, green shift

Norner has never received so many new colleagues as we have this year. Key competence from all over the world. We are strengthening our teams in all segments, but in particular in the strong growth areas as circular economy, renewable energy and health care. Over the last 3 years we have also invested all-time high in new laboratory equipment and pilot lines. We have never been in a stronger position to support our customers.

For Norner, 2022 will be a memorable year. We will be moving into our new Polymer Exploration Centre. 4600 square meters with laboratories, pilot hall and offices. Located in Porsgrunn, at the bank of the Porsgrunn river, neighboring the Powerhouse of Telemark, and nearby one of the largest green industry clusters in Europe. It is also located near the railway station with excellent connection to Oslo, as well as in proximity to Torp international airport.

The new Polymer Exploration Centre will be a modern international research and technology center for the plastics industry and provide research services throughout the value chain. The creation of this new center will ensure that Norner develops a leadership in the development of future sustainable plastic solutions. We eagerly look forward to welcoming you to our brand-new Polymer Exploration Centre and to further explore new and sustainable solutions, together.

Navigating towards a New Normal with a rapid, green shift.

Enjoy the reading!

- Kjetil Larsen, CEO

Four at Norner

Carlos Barreto Soler (42)
Senior Researcher at Norner AS
From: Garagoa, Colombia
Lives in: Hovet, Porsgrunn, Norway

I grew up in a small town in the mountains and was motivated by my family to get a good education and go after my dreams. My dream was to have a career in plastics R&D. I studied Chemical Engineering at Universidad Nacional de Colombia in Bogota and did my master's degree in advanced materials focusing on applied nanotechnology in plastics at Chalmers University of Technology in Gothenburg, Sweden.

After my master, I sent my CV to companies all over Europe and the US searching for the right opportunity. Finally, I managed to get this dream opportunity of being part of Norner. This company had the perfect combination of chasing my dream career located in a beautiful country. I moved to Norway, got married, started a family, and completed my PhD in Polymer Technology at the University of Oslo & Chalmers as part of my job duties at Norner.

I have a huge appreciation for living in proximity to nature. I only need to travel 5 minutes from my house to be in the forest, while work is only a 15-minute drive away. After 13 years at Norner Norway has become home, and I always miss the quiet nature in Norway when I visit my home country.

The best thing about working at Norner is people's passion for plastics. You are allowed to dream big with your feet on the ground and be part of projects that could have a positive impact on society. I love the complexity and variety of the topics we are addressing. I have developed not only on my technical knowledge and research skills, but also my softs skills to maximize the impact on customers. This is extremely motivating!

Sara Rund Herum (37)
Senior Engineer at Norner AS
From: Porsgrunn, Norway
Lives in: Porsgrunn, Norway

I grew up in Porsgrunn, but as part of my education as a Laboratory Technician I moved to Trondheim for an internship at Statoil research centre. I ended up working with acidity crude oils at Statoil for 2 years, before moving to Oslo for a job opportunity at SINTEF, working with micro systems and nanotechnology for seven years.

Then I decided to move back home to take some subjects at the University of South-Eastern Norway (USN). After a year and a half, I started working at Amiblu in Sandefjord were I worked four years. I had followed Norner on LinkedIn and Facebook for a while and was impressed by their expertise. They had many interesting projects and were expanding and developing. When Norner had a job opening for someone with my experience, I did not hesitate.

I have been a Senior Engineer at Norner for two years now, and I love it here. I get to be involved in many different projects, which I have learned a lot from. We have great possibilities for professional development, which makes it easier to see the bigger picture and the job even more interesting. My co-workers are incredibly knowledgeable and always helpful. I feel proud to be a part of Norner and their expertise.

Jorunn Nilsen (60)
Principal Researcher
From: Askøy, Norway
Lives in: Porsgrunn, Norway

I did my education within physical chemistry in Trondheim and was looking for a relevant job opportunity. Many of my fellow students were hesitant to work in Grenland Norway, as the area was thought to be quite polluted. But when an exciting job was offered in Statoil Bamble, I took the chance and moved to Grenland with my family. It has been a lovely place to live, with lots of nature, close to the sea and the mountains. Today Grenland is known as one of the leading sustainable industrial regions of the world. I have remained in the same workplace for 31 years, working in Norner since it was founded in 2007. I get to work independently and do lots of versatile tasks.

Most of my work is related to sustainability. How can we use less plastics, make it thinner and stronger? How can we develop new ways of using recycled materials? Sustainability motivates me and it is important to convey that plastics are amazing materials which can be part of the solution if used and recycled correctly.

Cesar Barbosa (46)
Senior Researcher
From: São Paulo, Brazil
Lives in: Skjelsvik, Porsgrunn, Norway

I grew up in São Paulo in Brazil and always knew I wanted an education in hard science. I have a master's degree in Chemistry from Universidade de São Paulo with a research internship at the University of York, finalizing my PhD in catalysis in Brazil in 2004. I worked at Braskem in Brazil for 9 years before deciding I needed to try something new.

I knew I had better chances of finding the perfect job in Europe, so I sent applications and used my network and LinkedIn to find opportunities. Then Norner had an opening, and after an initial interview online, I was invited to come to Norway for an interview in person. My wife did not want to move away from her family and friends, but when I was offered the job in 2019, she agreed to give it a go. Luckily, she could do her job in IT from Norway, so the change was not too overwhelming for her. We decided to send our daughter to a local school, as we felt this gave her the best chances of being successfully integrated.

My wife and daughter are so happy here, and they are the most important aspects of my life. Norway is a calm and spacious place to live, with great balance between work and family life. Norner gives me the opportunity to work with highly educated people, and even though we have different positions and experience we learn from one another.

We may speak different languages, but we have a scientific understanding in common. My best advice for someone moving to a new country is to start with an unbiased and open mind attitude. Travel and make your own experiences, be open for making new connections. It could be the best thing you ever do.

A new era begins

Welcome to Our New Polymer Exploration Centre

Norner's new headquarter, the Polymer Exploration Centre, is situated on the riverfront in Porsgrunn Norway, one of the most exciting industrial regions of the world.

Kjetil Larsen
kjetil.larsen@norner.no

Polymer Exploration Centre is a 5000 sqm modern international research and technology centre for the plastics industry and provide research services throughout the value chain.

The facilities in the new centre include laboratories for advanced testing of chemical and mechanical performance of polymers and composites, mini pilots for new process technology, a wide variety of extreme polymer material performance testing and a high-tech plastic application and packaging centre.

It will be a global leading centre for R&D in the sector of polymer, rubber, and composites.

We will continue to strengthen our advanced polymerization and catalyst laboratory in the current location, as well as larger scale processing equipment.

LEADING THE WAY

With more than 40 years in the industry, Norner today has customers in over 60 countries and has experienced a strong growth in recent years. The creation of this new centre, and entering the Future Materials Norwegian Catapult Centre, will ensure that Norner develops a leadership in the development of future sustainable plastic solutions.

> We have made large investments in new machinery over the last three years, making our research and production facilities one of Europe's most modern

"This brand new high-tech building is tailor made for Norner," says CEO Kjetil Larsen. "We will have a unique combination of state-of-the-art premises located in one of Europe's biggest green industry clusters with highly competitive equipment and competence."

Polymer Exploration Centre is designed for the innovation of tomorrow's sustainable polymer solutions. High-tech machinery, laboratory instruments and tools are combined with areas for discussions and collaboration.

"We have made large investments in new machinery over the last three years, making our research and production facilities one of Europe's most modern," says Larsen. "Our new premises will give our customers a bigger and better experience when they visit us. The labs and production areas are designed specifically for working with our clients, which we think will result in even greater innovation. Together."

VISIONS FOR THE FUTURE

Norner covers the whole polymer value chain from catalyst and process development, polymerisation, polymer modification, polymer additivation and industrial applications of polymer to innovative solutions for plastics in a circular economy.

We provide R&D and technical services to various industry segments where innovative solutions of plastics and composites are requested. We want to create value for our customers, owner, and the society through innovation supporting UN's sustainability goals. We look forward to welcoming you to our new international research and technology centre in 2022.

Plastic Packaging Provides Major Environmental Benefits

For all retail sales, whether it takes place in stores or online, we need packaging. The products are packed for transportation from production to the point of sale and then home to the consumer. Food is then stored in the packaging until it is consumed.

Ole Jan Myhre
olejan.myhre@norner.no

Plastic packaging has several environmental benefits due to their material properties. It provides excellent protection even if the packaging is thin and light and thus minimizes the use of resources and materials. Norner's technology centre contributes to the development of new and improved packaging solutions in collaboration with Norwegian and international industry.

ENVIRONMENTAL BENEFITS

Producing plastic packaging requires significantly less energy and emits less CO2 than materials such as glass, paper, or metal. Due to their low weight and volume, plastic packaging also saves large energy and transport costs. Packaging fulfils many functions, but the most important is increasing the food's shelf life and hygiene while not affecting the food with substances from the packaging.

PLASTICS ARE SAFE

Norner is a leading research and development organisation in plastics and packaging and has organized several research projects focusing on chemicals in and migration from plastic packaging. These projects have focussed both on the possible chemicals contained in the plastic materials used for packaging as well as more complex issues of printing and lamination.

Plastic packaging is basically produced from PP, PE, PET and PS and by conventional extrusion and moulding processes. In principle all grades intended for packaging and consumer goods are all food approved when these grades leave the polymer producer. The packaging producer may add colour pigments to the materials, but normally nothing more. This means that the materials contain only small amount of additives which are all fully approved by the strict EU food contact directive EU 10/2011.

During our research we have cooperated with food and packaging producers and tested food contact migration of approximately fifty different packages. We have not found any substances of concern.

It is also good to keep in mind that the mentioned materials has not been manufactured or added any substance of concern. They do, for instance, not contain phthalates, PAH's or BPA.

HIGH QUALITY RECYCLING

Plastic has a low cost which provides affordable and effective packaging, but this is also a challenge as plastic has a low value as waste. Since more and more EU countries put a ban on landfills, the plastic waste must be treated as a resource.

There is great potential for increasing material recycling of plastics significantly in the next few years through new technology and material knowledge. Norner is already strongly involved in this, and we want to play an important role.

For plastic to be recycled, it must be separated into different materials, and this is strongly influenced by how the packaging or product is designed. New regulations and requirements for plastic recycling will make virgin plastic materials and products that are not designed for recycling more expensive.

There is a large increase in the demand for recycled plastic with high purity and quality to produce new packaging.

Norner, with its large pilot and development center in Telemark, will be strongly involved in this development.

RAPMUS

– Reduced ageing and active preservation of plastics in museums and collections

Art is valuable and need care to last. The preservation of objects made with plastics are less understood, and the risk is reduced longevity.

Jorunn Nilsen
jorunn.nilsen@norner.no

The RAPMUS project is establishing a common ground for plastics conservation in Norway and a meeting point for conservators and plastics industry expertise from Norner.

Museums and art collections represent and administrate our common memory. The collections acquire and contain an increasing extent of materials and material combinations of different polymer materials. These materials have limited longevity, and they constitute major conservation challenges in an eternity perspective.

Conservation of objects made of polymer materials in public and private museums, as well as art and design collections, is a young research field which is not yet well developed. It has only been paid attention to during the last 25-30 years. There are still many basic challenges, especially when it comes to active treatment of the objects. The consequence of these unsolved challenges has been and still is that objects literally disintegrate and will be lost. These challenges can best be solved in collaboration between polymer scientists and technologists, museum conservators and administrators.

As part of this comprehensive research project running from 2017 to 2021 several museums and collections have met with researchers from Norner who design plastics for the industry, to establish a common knowledge base for plastics conservation in Norway. The goal is to raise the awareness and knowledge about plastics degradation and treatment options among the wast amount of plastic collections, and to develop procedures for stabilizing aged plastics when preventive methods are insufficient. Furthermore, there is a need to establish a common language and nomenclature to describe plastic objects within heritage collections.

Active conservation by repair and/or mechanical intervention in the objects

Kira Wager.
Foto: Ignat Wiig/Oslo Open.

is an undeveloped and complicated field. When degradation of polymer materials has started, it is very difficult to stop it. Longevity and the required storage conditions will be different for different polymer materials. An important part of the project has been to develop suitable methods and techniques which do not change the object visually, and which are not harmful to persons who perform the treatment, or to the environment in general. In addition, it has also been a target to find and recommend use of materials with good ageing properties, e.g. well stabilised polymer materials with excellent longevity at normal storage conditions.

COLLABORATION PROJECT

The RAPMUS project is a collaboration project where Norwegian museum conservators together with Norner Research and the French institute Centre National d'Evalution de Photoprotection (CNEP) have co-operated to solve the mentioned challenges. Conservators from a wide variety of museums and collections has been involved and worked together with researchers from Norner and CNEP. Artist Kira Wager, who paint with oil on PVC plates has also been a participant in the project.

Active "post-stabilisation" of plastics
Active methods for increased longevity or service lifetime of ready-made plastics are seldom available. In the polymer industry, the stabilization of plastic is done by mixing in stabilisers and antioxidants during the melt-processing step.

RADICAL INCREASE IN LONGEVITY

In the project we carried out a study on how ready-made plastics could be post-stabilized. Various stabilization systems and techniques were used to stabilise two materials (PP and PVC) which have very different structure and properties. After the post-stabilization, the plastic parts were exposed to accelerated ageing in oven (e.g. 130 °C for PP). It was demonstrated that the inherent lifetime of ready-made plastic can be extended up to 1900% by "post-stabilization" compared to an untreated reference. This was achieved only with unique combinations of stabilisers while other did not show any improvement at all. This is illistrated in the figure below.

PROJECT HIGHLIGHTS

- Successful development of methods and techniques for post-stabilization of ready-made plastic objects, without any visual changes of the object.
- Demonstrated increased longevity of oil painting on PVC, when stored at the right conditions
- Increased awareness and attention to plastic materials in museums and collections through qualitative and quantitative surveys on the types and conditions of plastic objects in the collections, including focus on the environmental conditions for the objects.

RAPMUS PROJECT FACTS AND FIGURES

Reduced ageing and active preservation of plastics in museums and collections is a project funded by "Regionalt Forskningsfond Vestfold og Telemark"

The project was planned for 36 months, but has been prolonged due to the Covid pandemic.
(01.09.2017–31.08.2020)

Project owner:
Museums of Vestfold County

Project partners:
- Norner Research and CNEP
- National Museum of Art, Architecture and Design
- KORO
- Norwegian Science Museum
- Norwegian Industrial Museum
- Museums of Rogaland County
- Art collections of Oslo Muncipality
- Museums of Trøndelag County
- Contemporary Artists
- Norner Research, project manager: Jorunn Nilsen

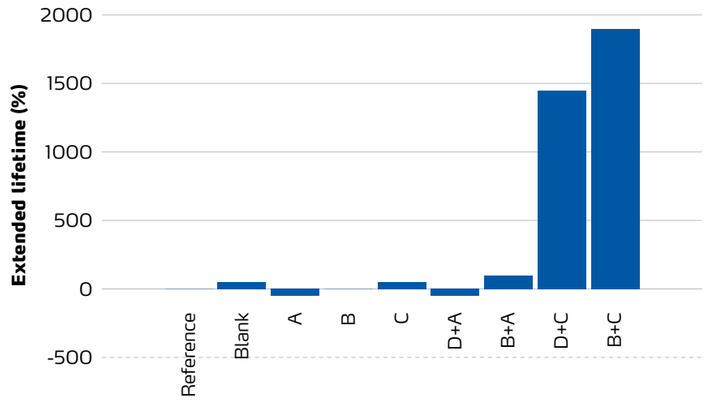


Figure: Effect on the extended lifetime in % of re-stabilisation with various tested stabiliser combinations.

Design for recycling:

The Circular Economy Starts Here

Waste and pollution are design flaws rather than inevitable by-products of the things we make. By changing our mindset and harnessing new materials and technology, we can ensure waste is not created in the first place but managed as valuable resources and recycled into high quality materials.

Thor Kamfjord
thor.kamfjord@norner.no

Plastic packaging, which accounts for over 60% of the collected plastic waste, will need to transition to a major generator of recyclable plastic waste. Depending on the characteristics of the demand and end market applications, some of this packaging waste will be recycled into packaging, some will go into other sectors. From an economic and technical perspective, it is paramount to understand the matching between recyclability standards and end market applications.

In ensuring the circular transition for plastics and plastic packaging, design for recycling is among the key aspects. Features like compatibility of materials, easy separation, use of additives, pigments, and type of labelling, play a role in determining the recyclability of a given product.

Making recyclability a key requirement and incorporating it with other performance criteria such as product safety, shelf life or branding will enable a sustainable use of resources.

Design efforts are needed to ensure polymers can be correctly sorted and contaminants can be effectively removed during the recycling process.

The Design-for-Recycling approach aims to make plastic products or product parts more easily recyclable, where the objective is to ensure that a consistent quantity of plastic waste is effectively recyclable and can be absorbed as recyclates into new products.

NEW EU STRATEGY

In 2018, the European Commission released European Strategy for Plastics in a Circular Economy where it urged the plastics industry and its value chain to encourage and ensure a shift in production of plastic packaging. This has triggered several brands to announce pledges to work towards increased recyclability of packaging.

Due to the increased interest and demand for guidance in design for recycling, Plastics Recyclers Europe launched the RecyClass Platform, a comprehensive cross-industry initiative that works to advance plastic packaging recyclability and to establish a harmonized approach towards recycled content calculation and traceability in Europe.

RecyClass

Developing Circular Plastic Packaging

RecyClass is now driven by the interest of the major brands, retailers, converters, raw material producers and recyclers to advance recyclability of plastic packaging and use of recycled material. It is a value chain platform which aims at filling an existing gap between the different industry actors and bringing the knowledge of recyclers to the packaging designers.

ENHANCES THE RECYCLABILITY OF PLASTIC

With a scientific and industry aligned approach, RecyClass enhances and evaluates the recyclability of plastic packaging. The platform offers Design for Recycling Guidelines which provide insight in the design of different components of a plastic packaging and give guidance to the users on how they can improve the overall recyclability of their products.

As the recyclability of a specific product is determined by the recyclability of the different components of a packaging and their combination in a specific recycling stream, RecyClass has established a harmonized methodology to test the recyclability. The scientific testing following the Recyclability Evaluation Protocols, will be done by independent laboratories accredited by RecyClass. The outcome of such assessments is used to update Design for Recycling Guidelines, based on the scientific data and the impact that a given plastic packaging will have on the quality of the different recycled material streams.

FREE-TO-USE ONLINE TOOL

A free-to-use RecyClass online tool is made available, that assess the recyclability of a plastic packaging and shows to which extent it is suitable for recycling.

The analysis will provide the user with a report and a classification for the analyzed package, where Class A represents the best recyclability of a package, while class B, C, D and E represent increasingly lower recyclability. Finally, class F represents packages that are not recyclable and may be only incinerated.

In addition, the online tool provides specific indications and recommendations on how to improve the packaging design to make it compatible with current recycling technologies. The tool is continuously reviewed and maintained by recycling experts.

In addition to being a tool for packaging designers, RecyClass provides the opportunity to certify the recyclability the plastic packaging.

CONSUMERS CHOOSE SUSTAINABLE PRODUCTS

As awareness is rising, consumers are more likely to choose more sustainable products based on educated decisions. The RecyClass certification is operated through accredited and independent Certification Bodies who audits the RecyClass tool analysis results together with documentation from the packaging supplier.

Plastic packaging recyclability can be certified according to:
Design for Recycling, which enables classification of the technical recyclability of plastic packaging in the EU market.

Recyclability Rate, which rates the effective recyclability of a plastic packaging in the specific geographical area where the packaging will be used.

At Norner, we are proud to be a RecyClass Certification Body and support the packaging value chain to make the plastic packaging circular.

We are also looking forward to offering scientific evaluation of both rigid and flexible packaging according to the RecyClass Evaluation Protocols to test new product solutions, innovative technologies and further develop the Design for Recycling Guidelines. This will allow the plastic industry to accelerate on the journey toward a sustainable and circular use of plastic materials and ensure that these valuable resources can be recycled into high quality materials.

INTERESTED IN MAKING PLASTIC PACKAGING CIRCULAR?

PLEASE CONTACT:

tanja.radusin@norner.no for RecyClass Certification

ronny.ervik@norner.no for RecyClass Evaluation Protocols

Creating Higher Value Recycled Plastic

Growing consumer demand and legislative requirements drives innovation in recycled plastics. Yet recycling rates are too low and the quality of recycled materials are generally lower than virgin. How can we improve this situation?

Yvonne Hed
yvonne.hed@norner.no

FuturePack was a large Norwegian R&D project which ended in 2021. It was supported by the Norwegian Research Council and led by Norner Research with the aim to evaluate and develop new technologies for renewable plastics and improved recycling of plastics packaging. Some key studies were carried out on how recycling can be tuned to give better quality and value which we will discuss here.

One of the key findings of our research was how antioxidant is consumed during recycling, resulting in poorer quality plastic materials. Adding new stabilizers can play an important part in increasing the quality of recycled plastics. Another interesting study of the research project was related to the odour identification and reduction strategies for recycled plastics.

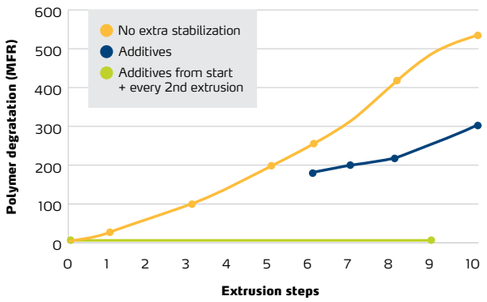
IMPROVED QUALITY BY ANTIOXIDANTS

Antioxidants are crucial to avoid degradation of the polymer in recycling. Figure 1 shows three scenarios for how the MFR (viscosity) increases and mechanical properties are altered with repeated melt-extrusion. This happens due to chain scission of the PP polymer chains. The brown line/bars represent a case where we did not add any antioxidant and the MFR increased dramatically while the mechanical properties were reduced. In the case represented by the blue curve we added antioxidant at the fifth extrusion which shows that the degradation was stopped or reduced. But, even better, if antioxidants are added from start (1000 ppm B215), and at every recycling step, as in the green curve/bars, the degradation can be avoided (figure 1a) and the mechanical properties is kept (Figure 1b). This shows clearly the impact and importance of continuous stabilisation to maintain the properties and performance.

IMPROVED QUALITY BY DE-VOLATILISATION

Recycled plastics are normally more or less contaminated and this can cause smell of different nature and intensity. This is a main challenge and it is crucial to be able to minimise. The FuturePack project studied various techniques and principles for odour

1a)



1b)

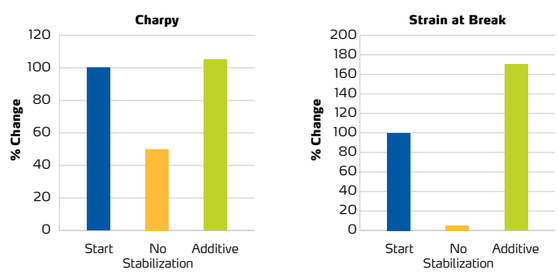


Figure 1a): *MFR increase of PP without extra stabilization, and the effect of adding extra antioxidants added after 5 extrusions and added from start and at every recycling step.* ***Figure 1b):*** *Effect of mechanical properties after 5 times extrusion without extra stabilization and mechanical properties after 4 "recycling steps" with continuous re-stabilization (1000 ppm B215) from start and at every recycling step, i.e., every second extrusion.*

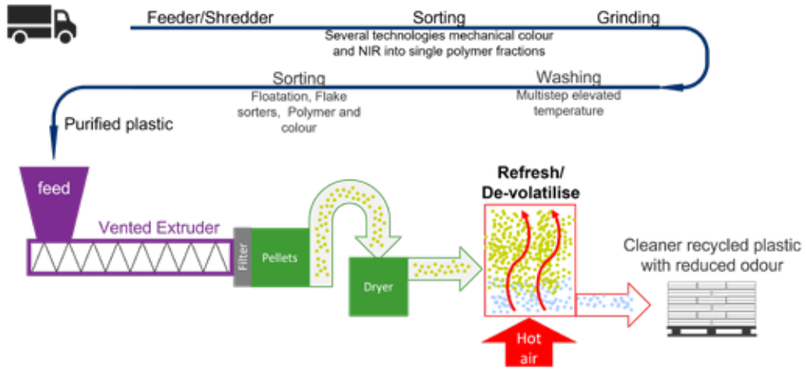


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Figure 2: *The Refresher is the last process step in above description where pellets are treated with hot air for a fixed amount of time.*

reduction. Additionally, we developed analytical methodology and strategies for the assessment of the smell.

In a case study we used hot washed flakes of HDPE from the Norwegian recycler IVAR, produced from household waste. These were sent to EREMA for recycling in their pilot centre where we could test the efficiency of the EREMA Refresher technology for odour reduction.

The principle of the EREMA Refresher and its place in the value chain is shown in the figure 2. This process relies on hot air flushing of pellets to remove any high and low volatile substances including odour components. The pellets are already hot after the extrusion process and are maintained at a temperature of at least 60° C and flushed with hot air for an extended period. The intention is that this will reduce the odour due to de-volatilisation of the pellets.

The flakes were extruded at EREMA and Refreshed for 0, 3, 5, 7 and 22 hours. The resulting samples were further studied by Norner. First, they were evaluated by an odour panel. The odour intensity results after the EREMA refresher treatment of the HDPE PCR are shown in Figure 3. This demonstrates a clear reduction of the odours versus increased time and treatment in the EREMA Refresher. Secondly the samples were analysed by GC-FID which gives a quantitative measurement of the total content of volatile components which is strongly correlated to the odour reduction.

Also, a third analysis strategy has been developed which use a GC-O-MS. This means that the components are identified as being with/without smell by an operator sniffing and smelling one part of the gas flow before the detector is identifying which substance it is. In this way we can evaluate the odour by number of substances and their possible risk by the identification. We could see that the number of odour components were drastically reduced 90% from 54 to 5 with 22h time in the refresher, but even after 3h the number was reduced with 50%.

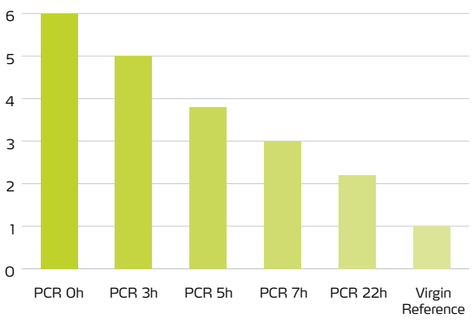
We have also compared the results with a virgin HDPE reference. Please notice that the content of volatiles (VOC) in this virgin reference is significantly higher even if the odour contribution is clearly lower in the panel. This shows that analysis of total volatile content is not the best way to assess the odour quality.

The two cases clearly shows that the re-additivation and de-volatilisation are two important contributors to the quality and value of recycled plastics.

PROJECT FACTS

The FuturePack project had following Norwegian industry partners; Bama, BEWi, Elopak, Grønt Punkt, Mills, Norgesgruppen, Nortura, Orkla, ROAF and Tine, representing various parts of the value chain for food production, packaging and recycling. The participating R&D institutes were Norner Research, Nofima, RISE PFI, Norsus and NTNU IKP.

3a)



3b)

Sample	GC-FID VOC (area/g)	GC-O (no. odor substances)
PCR 0h	905	54
PCR 3h	158	27
PCR 5h	147	Not analysed
PCR 7h	87	21
PCR 22h	22	5
Virgin HDPE 1	697	4

Figure 3a+b): *Norner forced ranking by odour panel plus GC-FID and GC-O results of HDPE PCR from household processed at EREMA Refresher for 0, 3, 5, 7 and 22 hours.*

The Magic of Blow Moulding

The advantages with the All-Electric technology are 50% less energy consumption than the older technologies, 70% less maintenance costs and less time spent on required machine maintenance.

Magic monolayer and CoEx 3-layer machine. Fully electric with 3 extruders with a screw diameter of 38mm and L/D of 24. Different moulds from 0,5 to 3 litres can be used, many moulds are available in the Application Centre. Leakage test of bottles are done in-line on the machine.

Blow moulding has an untapped potential for using recycled materials. How can we manufacture bottles with a high percentage of recycled materials that are strong, durable, and fit for further recycling?

Tom Arne Henriksen
tom.arne.henriksen@norner.no

Norner has been working extensively with recycling technology, recycled materials, and product development with recycled materials. Developing and testing PCR (post-consumer recycled) is part of our Recycling Pilot Centre. Recently we installed a new 3-layer coex extrusion blow moulding machine from Magic. This will enable us to evaluate many more aspects of using recycled plastics in such bottles.

PCR BLENDED WITH VIRGIN MATERIAL

Our blow moulding machine makes it possible to make products containing a varying degree of recycled materials. Bottles can be made with 100% PCR or as a middle layer in CoEx bottles, with 10-90% PCR in the middle layer. The PCR material can also be blended with virgin material to ensure that the finished bottle is of high quality.

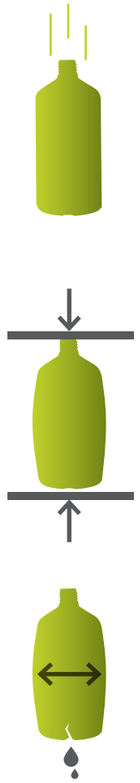
Lining the bottles with virgin materials has the added advantage of mixing in new plastic when the bottles are recycled, ensuring higher quality of the future recycled material. Our goal is to use less fossil resources and make an environmentally friendly product based on recycling of plastics.

MINOR CHANGES CAN HAVE A BIG IMPACT

Norner develops and produces mono and multi-layered products and has experienced that you may notice significant changes in the end results with small but important changes to the settings of the blow moulding machine.

The produced bottles are tested and compared to reference materials through a series of methods, described below, including pressure and temperature testing. In many cases the materials are developed and improved in our labs before the finished products are tested for quality and the material is further improved.

Norner is becoming a part of the polymer development chain and has gone from developing and producing polymer to developing and producing finished products for testing.



Bottle Testing at Norner

DROP TEST

A drop test is used to measure the impact strength of the bottle by dropping bottles from different heights to find the drop height causing breakage. Bottles are filled completely with water, sealed with a cap, and dropped from various heights. If the bottle breaks the hight is reduced and if it doesn't the height is increased to find the hight where 50% of the bottle statistically breaks.

TOP LOAD

This compression test measures the stiffness of a bottle but can be used on other products as well. A bottle is placed in a tensile testing machine between two plates which are pressed slowly towards each other until the bottle collapses. We record the force which can be applied before the bottle collapses and how far down it can be compressed until it collapses.

BOTTLE ESCR

Environmental Stress Crack Resistance (ESCR) testing is used to determinate how well plastic materials can resist specific liquids. For HDPE bottles we test how they withstand surface active substances such as detergents. Bottles are then filled with a surfactant solution, like Igepal® and stored with a slight internal pressure at elevated temperature. The main criteria is the time it takes before bottles are cracking and starts to leak.

Unlocking Recycling Challenges with Flexible Packaging Laminates

Plastic packaging comes in many shapes and forms. With its numerous properties, it offers protection to the packaged goods. It also helps reduce the carbon footprint, as a much lighter alternative to other materials.

Petri Myllytie
petri.myllytie@norner.no

Katrin Nord Varhaug
katrin.nord-varhaug@norner.no

The combined properties of materials or layers in multi-layer packaging, are what makes it specifically effective in the protection of goods, prolonged shelf life, and thereby optimised management of food waste. Such flexible packaging materials typically contain various oxygen barrier materials together with polyolefins.

But the complexity of these structures also makes it nearly impossible to recycle these films, leading to the growing amount of multi-layer packaging waste. This is where two EU H2020 projects, TERMINUS and MANDALA come in and Norner takes part in both.

TERMINUS

TERMINUS aims at unlocking the recycling of multi-layer packaging containing smart enzyme polymers with triggered intrinsic self-biodegradation properties. These polymers act as adhesives or tie layers in the design and manufacturing of multi-layer plastics for food and non-food applications.

The technology will be applied to biodegradable PUR-based adhesives for adhesive lamination and extrusion coating lamination, and polymers and tie layers in blown film extrusion. Tie layers are needed to bond the dissimilar materials in the laminate and it is a very smart concept if controlled biodegradation of these adhesives and tie layers would enable the separation of the different layers of the packaging. These can then be recycled using conventional recycling methods.

Increasing the recyclability of multi-layer packaging will significantly aid the efforts of reaching the European plastics and packaging recycling targets, as well as contribute towards the establishment of a circular economy for packaging.

PROJECT IMPACT

The successful implementation of Terminus concepts will result in several environmental and business benefits:

15%
improvement in economic efficiency

55%
reduction of plastics in landfills

65%
overall CO_2 footprint reduction

80%
reduction of multi-layer plastic packaging in landfills

MANDALA

The MANDALA project ambitious target is to develop new adhesives with dual functionality (easy to split and barrier properties) by incorporating thermoreversible covalent bonds and radiation absorbing nanoparticles, which at the same time will generate a tortuous path enhancing barrier properties that are critical for end-user.

In addition, new polymer blends with increased biobased and recycled content of film layers will be developed. Their combination in a multilayer product will set the basis for new food (meat, ready-to-eat) and pharma (pill blister) packaging products.

MANDALA project will demonstrate that the de-lamination technology can be up-scaled and applied to reach intermediate solutions for multilayer/ multimaterial packaging (being biobased or not) progressively helping to become the end-of-life more sustainable by recovering all fractions and providing clean streams for their biodegradation or recycling.

The MANDALA project presents a sustainable solution for the plastic packaging sector, focusing on 3 fundamental pillars: eco-design, adhesives with double functionality and end of life, with the aim of finding a sustainable and effective solution for multilayer packaging in the medium term, insofar as recycling the conventional materials as well as the use of biopolymers.

This new packaging format will satisfy the business needs thanks to its barrier properties, and the design will facilitate recycling as it will be possible to separate the multiple layers through the development of a thermo-reversible adhesive.

> The MANDALA project ambitious target is to develop new adhesives with dual functionality

NORNER CONTRIBUTION

In both projects, Norner contributes with key facilities and research.

- Polymer modification with compounding
- Barrier testing of films and laminates
- Developing barrier simulation technology
- Film development by formulating, extrusion and testing
- Polymer material for film extrusion

The MANDALA and TERMINUS projects are financed by EU through Horizon 2020. More information about the projects is available on the Cordis EU database as well as on the projects individual websites.

Testing Pharmaceutical Packaging

Pharmaceutical packaging needs to fulfill very strict requirements and their use is regulated by the continental medical authorities. EU and USA have a long tradition of such regulations but during recent years the procedures have been significantly updated.

Hany Anwar
hany.anwar@norner.no

These regulations are published in European and US Pharmacopoeia which companies have to comply with to ensure that pharmaceuticals sold in Europe and US will not be harmful or pose any health risk. These regulations provide restrictions to the use of any physiological hazardous materials in pharmaceutical packaging.

The regulations give guidance on both the chemical compositional requirements of components for the pharmaceutical packaging as well as chemical toxicity levels for potential extracts of either inorganic or organic contaminants.

Norner is an ISO 9001 certified laboratory and we have experience in performing these tests. Recently, we have increased our capability for analysis of plastics for pharmaceutical packaging. In this way we will help our medical customers ensure that their plastic packaging systems for pharmaceutical use are safe for the consumers.

Norner is prepared to perform testing according to this list of European (Ph. Eur.) and United States (USP) Pharmacopoeias.

PH.EUR. GENERAL CHAPTERS:

- EP 3.1.3 Polyolefins
- EP 3.1.4 Polyethylene for Containers without Additives
- EP 3.1.5 Polyethylene for Containers with Additives
- EP 3.1.6 Polypropylene for Containers and Closures

USP GENERAL CHAPTERS:

- 661.1 Plastic Materials of Construction
- 661.2 Plastic Packaging Systems for pharmaceutical use

Testing includes FTIR Identification, differential scanning calorimetry (DSC), heavy metals, nonvolatile residue, and buffering capacity (Acidity or Alkalinity), UV Absorbance, Total Organic Carbon, HPLC/UV, Sulfated ash, Reducing substances and TLC for Plastic Additives Testing.

Norner will provide our customers with all necessary documentation for the European (Ph. Eur.) and United States (USP) Pharmacopoeias.

Norner will continue to expand our services for the healthcare industry. Testing of pharmaceutical packaging made of other polymers such as e.g. PET is expected to be part of our validated service offering during the coming months.

Materials and Manufacturing Processes for Medical Devices

Norner supports many companies, including entrepreneurs, in polymer material selection and processing.

Toralf Hustveit
toralf.hustveit@norner.no

Heidi Nornes Bryntesen
heidi.bryntesen@norner.no

One of our focus areas is the healthcare industry. This industry experiences a significant growth, and Norner is expanding our portfolio of services to meet the specific needs towards this industry. We have been able to support a lot of companies with our knowledge about polymer materials and regulations for the healthcare industry.

Recommendation related to material selection and processing of the end products is one of our key areas. Several innovative founders and SMB's have been supported via the Norwegian Catapult Programme. This program is offered with the purpose of accelerating the process from concept to market. Norner is a part of the Catapult program as an owner of Future Materials Catapult Centre, one of 5 Catapult Centres in Norway. One company Norner has supported the last year via this program is MUB Medical Solutions AS (MUB).

INNOVATION SUPPORT

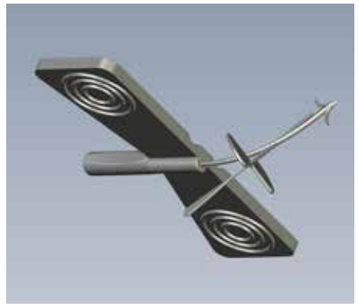
MUB was established in 2018. Their business idea is to develop, produce and bring to market products meant to solve everyday challenges in the primary health care service. The founders of the company developed a novel solution named Sutrips for the sewing of wounds, in order to simplify wound treatment. The Sutrips set consists of a steel needle with a small handle that can guide a thin thread with a strip function to close the wound. Using Sutrips will simplify procedures and save time when replacing traditional sutures.

MUB approached Norner for an assessment of the design of the product and, in addition advice for relevant production methods and choice of raw material. This included selection of polymer materials for the different plastic components in the kit, production techniques and advice for potential producers. The combination of the actual polymer material candidates, production technology and the thin long strips proved to be a challenging task.

In this project, we recommended polymers that comply with the required US and European medical device legislations, and at the same time have the required properties and viscosity that enable an automated and efficient production.

The thin strip unit itself, which is the functional part of the system, has very small dimensions and is

Micro Injection Moulding machine - Photo: Wittmann Battenfeld GmbH.



definitely a candidate for production in a micro injection moulding process. Moulding of micro components can in certain cases be performed with small conventional injection moulding machines, but in addition, special machines have been developed which to an even greater extent enable high precision and tolerances for products weighing even less than 0.1 gram.

The need for small precision plastic components is increasing, especially within the health tech segment as the market for less invasive micro medical implants and components continues to grow worldwide.

To enable mass-production of products containing micro components, at a reasonable cost, a high level of automation is required. Micro injection moulding makes it possible to automate and at the same time, take advantage of the same techniques being used in conventional injection moulding, such as multi-component moulding, overmoulding, use of inserts etc.

MUB was introduced to a company that may be a relevant partner and supplier in the next phase, including the production of functional prototypes, a «proof of concept» study and injection moulding in a micro injection moulding machine.

Norner has Received Lloyd's Approval for Marine Coating Testing

In March 2021 Norner received certificates recognizing the approval in accordance with both IMO Resolution IMO MSC.215(82) and IMO MSC.288(87) for our Marine coating testing. This is an essential quality standard for test laboratories internationally.

Anita Thoner
anita.thoner@norner.no

Norner has developed a leading position in third party test services for protective coatings and invested in modern laboratory test facilities. We experience an increasing need for test services for coatings and strive to offer a complete range of relevant tests for our clients. This new achievement is a big step to reach this ambitious goal.

> A Lloyd's approval proves that our lab is technically leading in quality management and competence

Norner is, with this approval, an independent testing institute accredited for the International Maritime Organization (IMO) and Performance Standards for Protective Coatings (PSPC) test standards.

The relevant standards are IMO Resolution MSC.215 (82) for Seawater Ballast Tanks and IMO Resolution MSC.288 (87) for Cargo Oil Tanks. Norner is now accredited by Lloyd's Register to perform both of these tests. A Lloyd's approval proves that our lab is technically leading in quality management and competence. We also have an ISO/IEC 17025 accreditation within protective coating.

SEAWATER BALLAST TANKS

This approval includes qualification testing of protective coatings in accordance with resolution MSC.215 (82), annex 1. The test used in this specification is based on simulation of conditions that occurs inside a ballast tank, filled with seawater. The protective coatings are exposed to different parameters such as temperature cycles, dry-wet conditions, and cathodic protection. To achieve this complex environment a wave tank has been constructed.

Test panels will, when they are installed in tanks, be exposed to similar conditions that occurs in in a real-life ballast tank, including continuous splashing of seawater.

After 180 days the protective coatings will be examined for corrosion, adhesion and cathodic disbondment properties.

The ballast testing also includes a condense test. Test panels are placed in a chamber where they are exposed to water condense. The panels are visually examined after 180 days.

CRUDE OIL CARGO TANKS

This approval includes qualification testing in accordance with annex 1 in resolution MSC.288(87).

The tests in this standard are designed to simulate the two main environmental conditions to which the crude oil cargo tank coating will be exposed, both in the vapour phase and in the liquid phase in a loaded condition.

In the vapour test, test panels with protective coating are exposed in a gas tight chamber. The gas inside of the chamber is a standardized gas composition, based on the vapour phase in a crude oil tank.

The panels are exposed to the gas at fixed temperature and examined for damages after 90 days exposure time.
To test the resistance to crude oil, the test panels applied with protective coatings are immersed

in a standardized test liquid. Crude oil is a complex mixture of chemical materials that can vary in composition over time. To overcome this, a standardized liquid is used to simulate crude oil. The formulation is given in the IMO resolution.

The panels are immersed at fixed temperature and examined for damages after 180 days exposure time.

Since both methods involve hazardous materials, such as H2S, a very high HSE focus is a necessity when performing such tests.

FULL RANGE OF COATING TESTS

This latest certification from Lloyd's will give Norner the ability to serve our clients with a complete range of coating tests which is appreciated. "We continuously develop our laboratory services through investments and quality management to satisfy our demanding customers. It is very rewarding for us to achieve this Lloyd's certification and it confirms that we are focusing on the right area,» says Henning Baann, Business Director in Norner.

According to Lloyd's list of approved institutes, Norner is one of few institutes in Europe approved for this type of testing. We intend to strengthen our position in this area and have plans for further expansion in personnel and equipment. A new state of the art development and laboratory facility is currently being built and will be ready in January 2022. The coating lab will be an essential part of this new building, and further expansion is secured through this investment.

Norner offers both 3rd party testing and pre-qualification testing of protective coating within different applications. Our wide range of methods cover cathodic disbonding, corrosion, immersion, and UV testing as well as climate exposure procedures and various physical properties. Typical standards are ISO 12944-6, ISO 12944-9 and Norsok M-501. These standards include ISO 15711: Determination of resistance to Cathodic disbonding, ISO 6270: Determination of resistance to humidity, ISO 11997: Resistance to cyclic corrosion and ISO 9227: Corrosion test in artificial atmospheres. All these standards are covered by our ISO 17025 accreditation.

Sustainable Composites

Society has a strong focus on circular economy and sustainable solutions. The UN has defined 17 sustainability goals that society and companies must succeed in creating a better world.

Carlos Barreto
carlos.barreto@norner.no

Katrin Nord-Varhaug
katrin.nord-varhaug@norner.no

It is important that all industries contribute to less waste, more reuse, and more sustainable solutions. This also applies to us who work with composites. When companies choose material solutions, composites will often represent a more sustainable solution than for example metal.

In the aerospace and automotive industries, replacing metal with composites has resulted in significant weight reductions, which in turn contribute to lower fuel consumption and CO2 emissions. Choosing a composite can also make the product more durable and give it a longer lifespan than other materials.

The downside is that these materials are challenging to reuse and recycle, especially composites made of thermosetting plastic.

THERMOPLASTIC COMPOSITE SOLUTIONS CAN REPLACE TRADITIONAL THERMOSETTING COMPOSITES

From 2013 - 2017, Norner participated in a large EU project, Walid (Wind blade using cost-efficient Advanced Lightweight Design), to develop new thermoplastic composite solutions in wind turbine blades.

Traditional wind turbine blades are usually made of glass and carbon-reinforced thermosetting plastic, which is difficult to recycle. In this project, we developed and demonstrated, together with 10 other European companies and institutes, that it is entirely possible to use thermoplastic composites in components such as rotor, wind turbine tip (leading edge) and reinforcement inside the wind turbine wing (shear web).

The advantages of replacing thermosetting plastic with thermoplastic are that it is easier to recycle, it is easier to repair damage and it gives a shorter cycle time during processing.

Another benefit was weight reduction, which is especially important for offshore wind turbines, where the challenge is to make longer wind turbine wings that can produce more wind energy. In addition to developing new materials, it was important to demonstrate how the thermoplastic components could be manufactured using an automated lay-up process.

SUSTAINABLE DESIGN OF COMPOSITES

Sustainable design means looking at the entire life cycle of the product, choosing materials that make the product easy to repair, materials that can be recycled and to use recycled materials. In several projects where Norner is responsible for material development, we investigate the possibility of using fewer types of materials in product development.

> Sustainable design means looking at the entire life cycle of the product

One way to achieve this for composites could be to use fiber and polymer from the same polymer family, which will make it much easier to recycle the products. These composites are known as Self Reinforced Composites. Examples of this could be using polypropylene fiber in a polypropylene base.

Another exciting project that started in January 2021 is REVOLUTION. In this project Norner will develop monomaterial composite products from recycled household plastic. The plan is to use these products in car interiors for electric cars, which need materials with low weight that are easy to recycle.

CIRCULAR ECONOMY IS CRUCIAL

Every year, Norner works in more than 30 countries around the world with innovation projects for our customers where we help them realize the UN's sustainability goals and develop a circular economy for plastics.
The projects have a common success factor – value chain collaboration.

REVOLUTION

In this H2020 project, Norner will develop monomaterial composite products to be used in car interiors for electric cars, which need materials with low weight that are more circular (easy to recycle and incorporate recyclates in their compositions).

REVOLUTION brings together leading organisations from European stronghold industries such as automotive, chemicals and plastics. The automotive industry is represented by STELLANTIS through Tofas, CRF and Tier 1s Farplas and MAIER. LyondellBasell, Clariant, Altuglas and Heathland provide strong representation of the European excellence in plastics, chemicals and circular materials. These are joined by leading research organisations, like Fraunhofer IAP, IMEC, IDENER, Norner and VTT to bring a solution to market that addresses the entire value chain. The project coordination excellence by FARPLAS and ICONIQ INNOVATION will also be a key for success.

REVOLUTION focusses on overcoming the challenges hindering the use of recycled materials, but more broadly, restricting the widespread adoption of circular economy principles in the automotive industry. Forthcoming ELV directives are expected to recognise the potential for plastics to enable a circular flow of materials in the automotive sector. Implementing minimum post-consumer recyclate (PCR) targets in any new plastic components in vehicles are currently being discussed. These targets will disrupt the automotive industry.

One of the key roles of Norner in this project is to demonstrate the production technology, material composition and performance potentials of a rear back-seat panel using Self-Reinforced Polyolefins (SRPO) with a weight reduction of >50% compared to the current steel alternative.
This work will involve several disciplines at Norner from compounding and polymer modification to film extrusion and moulding. It will also involve external partners where we can explore industrial upscaling of the developed concepts.

Developing the Market for Recycled Plastics

The vision of a circular plastics system and a pollution free environment will require extensive collaboration, innovation, system changes and significant financing to fulfil.

Thor Kamfjord
thor.kamfjord@norner.no

Jørgen Nyhus
jorgen.nyhus@norner.no

New legislations, regulations and directives will come into force and change the current "take-make-use-dispose" economy into a net-zero and circular economy.

One of these measures is the EU Plastic Bags Directive, which states that countries should either introduce a national reduction target for lightweight plastic carrier bags, or ensure that these bags are not provided free of charge at the point of sale of goods or products. As the plastic carrier bags serves as an important part of the waste management system in Norway, it was opted for the latter.

To provide a solution, the largest actors in the Norwegian grocery, retail and trade sectors, established the Norwegian Retailers' Environment Fund – Handelens Miljøfond (HMF), to ensure that from every plastic bag sold, approx. 5 € cents (50 øre) is collected in a fund and earmarked to reduce the environmental issues due to plastics. The fund, being privately owned, is not bound by bureaucracy or public rules and regulations and is able to turn around quickly in urgent matters, and to take risks in order to achieve desired environmental results.

The fund finances both national and international initiatives aimed at reducing and preventing plastic pollution e.g. through clean-up projects and support for technology and innovation. The fund's stated goals are threefold: 1) Prevent and clean up plastic pollution, not least in relation to marine littering 2) Reduce the use of plastic carrier bags 3) Increase resource efficiency by supporting measures to increase plastic recycling. Since 2018, the fund has awarded more than 40 M€ to a variety of 400 projects, covering clean-ups, closing knowledge gaps and technology development, which can accelerate the transition to a circular plastics economy.

Norwegian Government's view is that this financial mechanism serves as a sufficiently effective measure to meet the national obligations in the EU Directive 2015/720 on lightweight plastic carrier bags, but that it also provides a double impact making a significant and lasting difference to the environment.

Norner has the last years been collaborating with the Retailers Environmental Fund to explore how plastic recycling can be increased and how the use of recycled materials can be implemented in the industry. The different reports are publicly available and describes how Norway can achieve 50% plastic recycling of all plastic waste within 2025 and how a zero waste and circular plastic economy in Norway can be achieved.

We also take part in many of the industry projects which is supported by the fund, where our insight in polymers, plastic conversion, recycling and laboratory capabilities are utilized.

One of these exciting projects is with ISOLA, where the target is to use post-consumer HDPE and PP to protect building constructions for more than 50 years – giving value and long life to recycled plastics.

ISOLA CASE

The Norwegian company ISOLA AS is a major producer of building products to the Nordic market, with many well-known brands. One of the production lines, former Platon factory, at the city of Notodden, is producing floor- and foundation wall membranes by extrusion and thermo forming.

ISOLA and Norner collaborate in the project, which is financially supported by the HMF, with the goal of establishing recycled HDPE and PP as a major feedstock for the foundation wall plate products.

> Different providers of recycled plastics are invited to qualify materials for the production

Different providers of recycled plastics are invited to qualify materials for the production. Norner support ISOLA with processing evaluation, laboratory test data, pilot scale extrusion trials as well as guidance to different aspects of product quality and follow-up.

The project is ongoing with ambitious milestones in 2022. Hopefully the results in the project can ensure safe utilization of recycled materials on the kiloton scale and open other product groups for recycled plastics as feedstock.

TAKING ACTIONS TOGETHER TO BOOST THE EU MARKET FOR RECYCLED PLASTICS

To reach the European ambitions of plastic recycling and increased use of recycled materials collective actions are required.

Norner has therefore joined the Circular Plastics Alliance, which aims to boost the EU market for recycled plastics to 10 million tonnes by 2025. The Circular Plastics Alliance is an initiative under the European Strategy for Plastics where voluntary pledges by the industry are made to produce and use an increased volume of recycled plastics. At Norner we support the suppliers of recyclates to increase the quality of their materials and the converters and end-user to successfully introduce recyclates in the products.

To reach the target, the analysis by the Circular Plastics Alliance shows that over 80% of the increase in recycled plastics should come from packaging, the remainder from other sectors like agriculture, construction, automotive and electrical and electronics.

The current state-of-play shows that the European sorting capacities needs to increase by at least 4.2 million tonnes by 2025 and recycling capacities by at least 3.8 million tonnes.

The installed recycling capacity is already 8.5 Mt but not fully utilized. Projects like this with ISOLA bring important contribution because it will push for not only volume but also high quality.
The Circular Plastics Alliance regularly updates its roadmap in cooperation with all interested stakeholders and authorities, and we certainly welcome our partners to join the alliance and committing to action.

COLLIN MULTILAYER FILM AND SHEET LINE

Norner has recently invested in a state-of-the art pilot scale 7-layer film line from renowned market leader COLLIN Lab & Pilot Solutions. This multi-functional line is capable of producing from 1 to 7 layers of blown and cast films of width up to 550 mm, and is designed to allow production of symmetrical films consisting of a range of different material types, including barrier and tie layers. The line will be installed in Norner's new Polymer Exploration Centre in the beginning of 2022 and will strengthen Norner's position as a leading polymer R&D and Process Application Development Centre.

Investigating Failures in Pressure Pipes

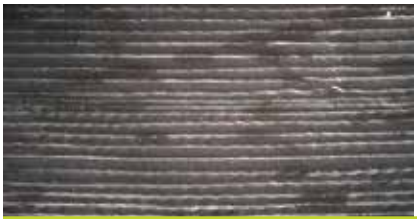
Welding is a common practise when installing and joining pipelines of polyethylene (PE). This is however a complex procedure which require an accurate welding operation.

Failures are not uncommon and Norner has often been involved in failure analysis in such incidents. The failure mode and root cause vary from case to case. Here we show you an example of failure analysis we have carried out recently.

Picture 1 shows the location of the failure initiation. It started at the inner wall

Picture 2 is a close-up picture of the failure initiation. **Picture 3** shows the pattern of the surface where the failure started and **picture 4** shows the pattern in the area adjacent to this. The failure has thereafter propagated as a brittle fracture around the circumference.

The pattern in this area is a replica of the welding tool and it is no or little signs of plastic adhesion. This indicates that the pressure in the welding phase was either too low or unbalanced and thereby created a local area without the right conditions for co-melting and co-crystallisation.



Asymmetrical welding beads both on the inside and outside as well as the replicated pattern of the welding tool reveal a poor fusion where the fracture has started. A visual inspection of the weld bead should reveal this.

The cause of the fracture is therefore concluded to be due to that a sector of the welding zone has been exposed to a too low pressure. This caused a poor fusion of material from the two pipe ends.

There are, however, several issues related to pipe welding which are difficult to discover by visual inspection, such as contaminated weld surfaces, cold-seal due to excessive pressure, long dwell times, material oxidation due to too long heating time or high temperature. Other kinds of initiated fractures in the weld line or notches hidden by the weld bead are also difficult to detect visually.

Norner AS Asdalstrand 291, NO-3962 Stathelle, Norway
www.norner.no ı post@norner.no ı Follow us:

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