Polyolefins Moulding
Thin Wall Packaging
About Borealis

Borealis is a leading provider of innovative, value creating plastics solutions. With more than 40 years of experience in the polyethylene (PE) and polypropylene (PP) business, we focus on pipe systems, energy and communications cables, automotive and advanced packaging markets. We are strong in Europe and growing in the Middle East and Asia-Pacific through Borouge, our joint venture with the Abu Dhabi National Oil Company (ADNOC). Our technology shapes plastic products that make an essential contribution to the society in which we live. We are committed to lead the way in ‘Shaping the Future with Plastics’.

With EUR 5 billion revenue in sales and 4,500 employees, Borealis is headquartered in Vienna, Austria with innovation centres, customer service centres, and main production sites in Europe and the Middle East. Borealis has representative offices and operations in Asia, North and South America.

At its heart, the company’s four values of Responsible, Respect, Exceed and Nimblicity™, define its way of doing business. For Borealis, success is achieving value creation through innovation.

Borstar® is Borealis’ proprietary technology supporting differentiated PE and PP products. Borstar is a registered trademark of Borealis A/S.

Learn more about us at www.borealisgroup.com
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Market introduction

Over 40% of the world polypropylene consumption is used in packaging applications. In rigid packaging, polypropylene consumption is growing at more than 8% per year, of which approximately 3% can be attributed to substitution of other plastics. This makes polypropylene one of the most successful polymers amongst those used in this segment. As shown in the Western European example below, polypropylene is expected to further strengthen its position in this segment.

Polyethylene has for many applications been replaced by polypropylene, but is still an important material for some thin wall packaging segments like cartridges, UN approved open top containers and soft lid applications.
Borealis is a leading polyolefins supplier to the thin wall packaging segment. We view this market as strategically important, and show our commitment by supplying materials for both consumer and industrial applications which keep pace with the latest trends and fulfil the needs of the whole supply chain.

**A long-term commitment to thin wall packaging**

For many years Borealis has been a very active partner in polyolefins for thin wall packaging. Borealis was an early innovator in the market with tailormade grades for pails and consumer packaging and today offers a complete product portfolio for this segment. All grades contain optimised additive formulations, such as antistatics and nucleators, and are often co-developed together with several stakeholders in the value chain (resin suppliers, converters, specifiers). In polypropylene for transparent packaging, Borealis also made an early breakthrough with grades specially tailored to replace glass in consumer packaging.

**A growing preference for PP**

Nearly 35% of all polypropylene converted in the rigid packaging segment is used to produce thin wall containers, and PP is expected to further strengthen its position in this segment at the expense of both glass and metal. With benefits such as low density, high impact, transparency and easy injection moulding operation, the growing preference for polypropylene in this segment is easy to understand. New PP grades which combine improved properties and high flow make progressive downgauging possible to further reduce weight, but also new design possibilities. This has significantly changed the competitiveness of injection moulding versus thermoforming.

<table>
<thead>
<tr>
<th></th>
<th>Food</th>
<th>Non-food</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>• Confectionery &amp; bakery</td>
<td>• Building materials &amp; equipment</td>
</tr>
<tr>
<td></td>
<td>• Hotel &amp; catering</td>
<td>• Industrial consumables</td>
</tr>
<tr>
<td></td>
<td>• Preproducts</td>
<td>• Chemicals, paints</td>
</tr>
<tr>
<td></td>
<td>• Dairy &amp; yellow fat</td>
<td>• Adhesives</td>
</tr>
<tr>
<td>Consumer</td>
<td>• Convenience food</td>
<td>• Household chemicals</td>
</tr>
<tr>
<td></td>
<td>• Confectionery &amp; bakery</td>
<td>• Cosmetics</td>
</tr>
<tr>
<td></td>
<td>• Frozen food, ice cream</td>
<td>• Digital media</td>
</tr>
<tr>
<td></td>
<td>• Dairy &amp; yellow fat</td>
<td>• Electronics &amp; DIY (do it yourself stores)</td>
</tr>
<tr>
<td></td>
<td>• Everyday commodities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Fruit, spices, sea food, pet food</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Thin wall packaging
Environmental advantages

From an environmental viewpoint, the value of thin wall injection moulded polypropylene as a single material solution is increasingly recognised. The material can be used for pot, lid and label, offering intuitive environmental advantages compared to glass with metal lid, plastic coated cardboard or PP with a PE lid. As with polyethylene, polypropylene only needs very low concentrations of additives and all Borealis grades are approved for food applications.

The market

Pira estimates that nearly 29 bn thin wall containers (TWCs) were used in Western Europe in 2004, which translates into some 800,000 tonnes of PP resin. Eastern European consumption reached an estimated 120,000 tonnes of PP in the same year, with Poland accounting for approximately 15% of this volume. The Western European market for TWP has been growing at 3.4% p.a. over the last five years and an even stronger growth rate of 4% p.a. is predicted up to 2010. At the same time, the average Eastern European growth rate of 7.5% p.a. is forecast to increase to 9% p.a. and will be driven by the Russian demand, albeit from a rather low base. Consumer food TWCs are the largest end-use application, accounting for just over 70% of the total with TWCs for consumer non-food and industrial food & non-food making up the remainder.

While Germany is the single largest market for TWP, Poland is probably the most dynamic. Polish economic growth picked up from 1% in 2001 to 5% in 2004. Additionally, the EU accession in May 2004 has stimulated consumer goods production, especially food, which without customs duties can now be competitively exported to the West. The Polish consumer is also more open to new packaging solutions such as jams or mustard in TWP which offer better price and functionality (lighter shopping, less likelihood of breakage), while the conservative German, French or British consumer will typically prefer traditional glass jars for jam or mustard.
Packaging and consumer trends

The main growth drivers for the TWC market are:

- Consumers are purchasing more pre-pack foodstuffs, including products in TWCs
- Consumers show increasing preference for chilled foodstuffs and tend to opt for a chilled soup in a TWC rather than a retorted tinned soup
- Consumers are looking for lighter and shatter-resistant packs which include convenience features such as microwaveability and added-value items such as sporks (a combination of spoon and fork), so TWCs are a perfect match for their needs
- Brand owners are increasingly competing with own labels and select in-mould labelled TWC to differentiate their products and add a premium look
- The retailing and catering sectors prefer TWC as they offer the better sturdiness and stackability when compared to thermoformed containers

Important features to strengthen the trend

In-mould labelling is a cost-effective form of TWC decoration for consumers where a premium look is combined with a moisture and grease-proof labelling solution. In recent years, legal labelling requirements have become an additional factor, making food producers switch from off-set printing to inmould labelling as the latter can cope much better with the increased amount of information which needs to be put on products such as margarine tubs.

Product visibility is much appreciated by the consumer who likes to check foodstuffs freshness or see the colour of the paint. This increases the demand for transparent PP grades which show above-average growth rates and now account for the majority of use.

Tamper evidence TWCs, especially in-mould labelled TWCs, offer premium looks and tamper evidence. Brand owners very often select them for new product launches. Built-in tamper evident solutions avoiding welding and adhesion of foil is a competitive advantage of TWC.
Creating new concepts and adding value for the stakeholders

Partner for growing value

BU moulding has selected to serve the industry with a partner approach. As a partner Borealis has a strong market approach and puts major efforts into identifying the real needs in the value chain. This approach ensures the best synergies of polymer properties, article design and end-use needs to create value for the stakeholders in the value chain. Borealis also believes this approach increases the speed of new development in polyolefins, as a shared value chain understanding ensures that all product requirements are identified in the early phase of development.

To support this thinking even further, projects with research institutes and universities as well as co-operation with our suppliers are part of Borealis daily life.

Partnership through the value chain

Polypropylene for industrial containers is present and future

Pail grade development has been a important task for Borealis for many years. Through joint projects with our partners we have developed tailor-made grades for industrial containers and not only offered faster processing solutions, but also successfully replaced tinplate containers. Recently, Borealis has contributed to the successful introduction of packaging solutions for paint in state-of-the-art decorated translucent and transparent containers, by working closely with the specifier.
Consumer packaging for the future

Challenging targets have been set by the food industry for packaging concepts for products like margarine and ice cream. By putting high focus on taste & odour and food packaging regulations, in combination with requirements for packaging processing and packaging physical performance, Borealis has successfully participated in the introduction of low weight margarine tubs, as well as injection moulded and transparent ice cream packaging. The outcome has been replacement of cardboard or thermoformed packaging.

Borealis disposes of a range of competitive technologies that afford to translate application requirements into specifically designed polymer products. Notably Borealis’ proprietary Borstar process is particularly qualified to tailor the molecular architecture of both PP and PE, thus combining both application processability and excellent mechanical properties. Borstar uses a multi-reactor system that offers unparalleled possibilities of designing polyolefins for specific applications.

Borstar PP

The first commercial plant went on stream in May 2000 in Austria. It produces a wide range of added value polymers that are recognised by customers to be at the leading edge of modern PP technology.

The unique process configuration and the proprietary enhanced catalysts offer the following benefits:

- Improved stiffness/ toughness balance
- Better creep resistance
- High clarity
- Possibility for very soft products
Thin walled products made from nucleated polypropylene exhibit enhanced mechanical properties, better temperature resistance, and in case of random copolymers, higher clarity / transparency.

The unique Borealis Nucleation Technology (BNT) provides rapid solidification and a highly uniform crystalline structure, offering high stiffness and excellent impact properties without the addition of an external nucleator during the pelletising process. The latter aspect is particularly important when it comes to food applications where low taste and odour levels are among the key requirements.

Quick demoulding, high output during the injection moulding process and a more uniform shrinkage that is less dependent on different colour pigments are other key application benefits of BNT.

**Borstar PE**

The bimodal molecular weight distribution (MWD) and the controlled comonomer incorporation result in the following characteristics, compared to unimodal products with narrower MWD:

- Improved flowability
- Better stress cracking resistance (ESCR) at a given density

The technological process window of Borstar is larger than any of the other established polymerisation processes can attain. The resulting large product scope window offers an exciting perspective for future developments.

**Controlled crystallinity leads to uniform shrinkage**

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Rigid injection moulded packaging for industrial and consumer applications has gone through tremendous changes over the last 15 years. Injection moulded polyolefins and particularly polypropylene have taken huge market shares from alternative packaging concepts.

This trend has been significant in many areas such as consumer food where PP has taken shares from glass, tinned packaging and cardboard. In the nonfood area also, PP and HDPE pails have replaced metal as packaging solutions for chemicals, paint or industrial pre-products.

**Real market needs**

Specifiers like brand owners, fillers or even supermarket chains use packaging as an important arena to profile and display their products. In combination with increased converting efficiency this has driven developments forward. Through dedicated marketing teams and contacts to the players in the value chain, Borealis has taken the complex market needs into the company and R&D.

**Product development - a key factor for success**

The main benefits of polyolefins are:
- Very high performance / cost ratio
- Low density and packaging weight
- Environmentally accepted
- Easy processing
- Very broad property window

This trend has been significant in many areas such as consumer food where PP has taken shares from glass, tinned packaging and cardboard. In the nonfood area also, PP and HDPE pails have replaced metal as packaging solutions for chemicals, paint or industrial pre-products.

**Market demand**

<table>
<thead>
<tr>
<th>Weight reduction</th>
<th>Material impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential for faster production</td>
<td>Increased flow at same level of impact and stiffness</td>
</tr>
<tr>
<td>Better stackability</td>
<td>Nucleated, sufficient stiffness, good mould release</td>
</tr>
<tr>
<td>No dust collection, easy de-moulding</td>
<td>Increased stiffness</td>
</tr>
<tr>
<td>Interchangeable moulds, freedom for second supplier</td>
<td>Better anti-static packages</td>
</tr>
<tr>
<td>User friendly, easy-to-open lids</td>
<td>Shrinkage limitations</td>
</tr>
<tr>
<td>Transparent pails</td>
<td>Separate softer lid material</td>
</tr>
<tr>
<td>Hot fill possibilities</td>
<td>Transparent impact resistant</td>
</tr>
</tbody>
</table>

**Material impact**

| High stiffness and crystallinity |

Figure 5: Polyolefins have replaced traditional packaging materials

Figure 6: Technology pull from the market
Properties for performance

Polyolefin grades are generally modified in the polymer structure and only very small – typically less than 1% – amounts of external additives are used. The table below shows some properties of a typical moulding polypropylene.

![Figure 7: This illustrates the antistatic additives migrating to the surface where they interact with humidity to form efficient antistatic performance](image)

Special features

**Antistatic**

Polyolefins are by nature insulators and will not conduct static decay. This is overcome by using antistatic additives, which increase the electric conductivity on the surface of the polymer. This reduces problems of dust collection and sparks. It also eases the stacking of very low weight articles.

**Nucleation**

By using a nucleator the polymer structure is modified and the properties of the product improved. In addition to the use of conventional nucleators and clarifiers, Borealis has pushed the technology even further via its proprietary nucleation technology BNT.

<table>
<thead>
<tr>
<th>Polymer Structure</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homopolymer</td>
<td>• High stiffness</td>
</tr>
<tr>
<td></td>
<td>• Integrated hinge</td>
</tr>
<tr>
<td></td>
<td>• Thin wall transparency</td>
</tr>
<tr>
<td>Random copolymer</td>
<td>• Superior transparency</td>
</tr>
<tr>
<td></td>
<td>• Impact at ambient temperature</td>
</tr>
<tr>
<td></td>
<td>• No stress whitening</td>
</tr>
<tr>
<td>Heterophasic</td>
<td>• Superior impact at ambient temperature</td>
</tr>
<tr>
<td>copolymer (block)</td>
<td>• High subzero impact</td>
</tr>
<tr>
<td></td>
<td>• Opaque</td>
</tr>
</tbody>
</table>

Table 2
**Tailormade products**

**With its focus on transparent polyolefins Borealis has continued to grow in this segment**

For many years Borealis has been recognised as a supplier of state of the art PP randoms. On offer now is a complete selection of randoms and tailor made grades like Borpact™. Borealis has transparent products for packaging applications including

- Pails
- Consumer packaging
- Ice cream
- Media / DVD packaging

**Borealis grows the Borpact product range - high impact transparent polyolefins**

**Borpact SG930MO** – combines transparency and deep freeze impact at easy filling.

The **Borpact SG930MO** offers the converter easy filling of multicavity moulds even at wall thickness of 0.6 mm. Due to the good form stability after injection moulding and the optimised additive package, the converter will experience the best demoulding and destacking properties in the market for transparent, deep freeze resistant materials. The end-user will observe a very good deep freeze impact resistance and see-through transparency, but also features like high gloss, very low stress whitening and excellent taste and odour properties are on offer.

The **Borpact SE920MO** is our MFR 12 solution for applications where very good transparency and high impact is needed. The stiffness and creep / stacking performance is very good and the grade has antistatic additives.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Borpact SG930MO</th>
<th>Borpact SG321MO</th>
<th>Borpact SE920MO</th>
<th>Raco RF365MO</th>
<th>Heco BH345MO</th>
</tr>
</thead>
<tbody>
<tr>
<td>MFR</td>
<td>g/10 min</td>
<td>25</td>
<td>25</td>
<td>13</td>
<td>20</td>
<td>45</td>
</tr>
<tr>
<td>Tensile modulus</td>
<td>MPa</td>
<td>850</td>
<td>600</td>
<td>900</td>
<td>1150</td>
<td>1400</td>
</tr>
<tr>
<td>Charpy notched, 23°C/0°C/-20°C</td>
<td>kJ/m²</td>
<td>11/6/3</td>
<td>20/8/6.5</td>
<td>8/4/-</td>
<td>5.5/-/-</td>
<td>6.5/5/4</td>
</tr>
<tr>
<td>Impact falling weight, 0°C/-20°C</td>
<td>J</td>
<td>26/28</td>
<td>25/25</td>
<td>20/5</td>
<td>-/-</td>
<td>30/22</td>
</tr>
<tr>
<td>Haze 1 mm plaque</td>
<td>%</td>
<td>25</td>
<td>68</td>
<td>21</td>
<td>8</td>
<td>100</td>
</tr>
<tr>
<td>Gloss, 20°C</td>
<td>%</td>
<td>75</td>
<td>-</td>
<td>-</td>
<td>75</td>
<td>41</td>
</tr>
</tbody>
</table>

Table 3
**Borealis RJ470MO - a high fluidity MFR 70 random copolymer**

**RJ470MO** is a product from the PP random copolymers family. The grade is specially made to combine very high fluidity while maintaining good stiffness/impact balance of a typical random PP. Very fast crystallisation allows cycle time reduction in comparison with conventional random copolymers currently in the market.

**RJ470MO brings benefits to the conversion industry:** **RJ470MO** is an opportunity to replace standard random copolymer of MFR 40.

**Output increase:**
- Reduced cooling time due to high crystallisation temperature
- Low melt temperature associated with very high flow
- Good demoulding properties

**Competitive property profile:**
- Excellent stiffness/impact balance
- Excellent transparency
- Good antistatic properties
- Good denesting properties

**Typical application areas include:**
- Thin wall packaging:
  - Food (dairy, confectionery, convenience food)
  - Non-food (cosmetics, media, electronic)
Polypropylene meets low weight demands

Low weight and downgauging is a continuous area of concern for consumer packaging. Polypropylene’s lower density together with low wall thickness lead to low weight. The thin wall requires easy flow polypropylene and accordingly Borealis has designed grades with MFR 60 – 100. This MFR meets even the most difficult flow requirements and can, despite the high MFR, offer a good balance of mechanical properties.

Borpact SG321MO - a high impact and soft random PP for lids and containers

Borpact SG321MO is a product from the PP random heterophasic copolymers (RAHECO) family. The grade is specially made to combine low stiffness and low temperature impact resistance with contact transparency and low blooming behaviour.

Borpact SG321MO brings benefits to the conversion industry: the easy flowing Borpact SG321MO is an opportunity to replace blends of random PP and plastomers but also for some applications replacement of LLDPE or LDPE is possible.

This includes:
• Better hot fill properties and transparency than LLDPE/LDPE.
• Better cost position, transparency and impact than most PP / Modifier blends.

Typical application areas include:
Lids, tubes, small flexible boxes, thin wall containers, ice cream containers, low temperature applications.
**Borealis offers that little bit extra**

In addition to the broad product mix offered for thin wall packaging applications we have also dedicated some grades with specific property profiles which allow you to profile your packaging as something special.

<table>
<thead>
<tr>
<th>Type</th>
<th>MFR 230 °C/2.16 kg [g/10min]</th>
<th>Main characteristics</th>
<th>Typical packaging applications</th>
<th>Why</th>
</tr>
</thead>
<tbody>
<tr>
<td>BJ356MO</td>
<td>100</td>
<td>Very high flow, impact and stiffness</td>
<td>Dairy and margarine</td>
<td>Thin wall possibilities, fast cycle</td>
</tr>
<tr>
<td>BH980MO</td>
<td>45</td>
<td>Excellent gloss</td>
<td>Cosmetic, confectionary</td>
<td>Aesthetics</td>
</tr>
<tr>
<td>Bormod™ BE961MO</td>
<td>13</td>
<td>Very high impact, excellent processing</td>
<td>UN, large pails, low temp. pails</td>
<td>Durability</td>
</tr>
<tr>
<td>Borpack, SE920MO, SG30MO, SG321MO</td>
<td>12-30</td>
<td>Transparency in, combination with high impact</td>
<td>Ice cream, paint, lids, various high profiled brands</td>
<td>To promote content in a durable transparent container</td>
</tr>
<tr>
<td>RJ470MO</td>
<td>70</td>
<td>High flow, excellent transparency</td>
<td>Consumer pack</td>
<td>Thin wall possibilities, fast cycle</td>
</tr>
</tbody>
</table>

Table 4
Borealis Moulding specialises in supplying advanced polyolefin plastics for injection, rotational moulding and blow moulding processing technologies. Through leading Borealis technologies such as Borstar, and BNT (Borealis Nucleation Technology) and a product portfolio for a wide range of applications like bottles, thin wall packaging, caps and closures, transport packaging, houseware and healthcare, Borealis has over 40 years established a leading position on the moulding market across Europe.

Borealis believes that customer-driven innovation is the only way to achieve and sustain progress. In the moulding industry, Borealis has pioneered the development of several leading edge solutions. For example, low temperature impact, transparent polyolefins have opened up new opportunities in deep freeze display packaging. In the ISBM segment, biaxially oriented PP has reduced the weight and increased the transparency of bottles. Through foresight and focus on customer needs, Borealis continues to provide innovative solutions for the moulding industry that add real value throughout the value chain.

We know the high value that our customers in the moulding industry place on product consistency and processability. We pride ourselves on the performance of our products, and through ongoing investment in upgrades and new plant programmes, we continue to set new records for output efficiency and product reliability.

Borealis believes that responsiveness is the foundation of fruitful customer partnerships. Business Unit Moulding ensures this through the resources of strategically placed Borealis hubs across Europe: Borealis Scandinavia, Borealis Central Europe, Borealis Belgium and Borealis Finland, an innovation centre at Borealis Scandinavia in Bamble, Norway, and a strong sales force across Europe.