CASE STUDY

Borealis and FAP are minimizing the environmental impact of foam applications

In partnership with

FAP

BOREALIS

بروج Borouge

CO_2 used as blowing agent in the extrusion process for physically foamed Daploy™ WB140HMS polypropylene

Background

Lighter weight. Strong. Excellent insulation properties. These and other characteristics have made polymer foams the preferred material for a wide range of applications in major industries such as consumer products and packaging, automotive, and construction. While styrenic foams such as expandable polystyrene (EPS) and extruded polystyrene (XPS) are recyclable, it is costly and cumbersome to do so. Far too much polystyrene waste is landfilled or incinerated. Policymakers have proposed using legislation, punitive taxes, and/or disposal fees to hasten the phasing out of polystyrene foam. Thus pressure is mounting for plastic producers to identify commercially viable alternatives to styrenic foams which can be more efficiently recycled, and at lower cost.

Challenge

Borealis and its long-standing partner FAP, a leading producer of equipment for the physical foaming of expanded polypropylene (EPP), set out to make low-density foam applications that are more easily recyclable. The performance properties that have ensured the popularity of polymer foams would have to be maintained – or even improved. By leveraging their expertise in polypropylene resins and foaming technology, respectively, the partners aimed to improve physical foaming processes in order to offer innovative material solutions that are affordable, resource efficient, and more environmentally compatible.

Solution

Extrusion is the most commonly used foaming technology. It can be used to produce polypropylene (PP) foams of various densities: ultra-low (from 25-100 kg/m3); low (100-300 kg/m3), medium (300-700 kg/m3), and high (>700 kg/m3). In the physical foaming process, hydrocarbons (such as isobutane or n-butane) are used to produce low-density foams. Inert gases, like supercritical nitrogen (N2) or carbon dioxide (CO_2) are typically used to produce higher density foams of 100 kg/m3 to 150 kg/m3 and more. When compared to other physical foaming agents, noncombustible CO_2 reduces the industrial hazard class in the physical foaming process. It is also easier to store, and fairly inexpensive.

FAP and Borealis focused their collaborative efforts on achieving better process stability in the foaming process when using liquefied CO_2 as the blowing agent along with the Borealis resin Daploy™ WB140HMS, a long chain-branched PP polymer developed for the PP foam extrusion process.

In contrast to conventional PP, WB140HMS offers a combination of high melt strength and low melt viscosity due to the shear thinning effect caused by the branch structure. Its excellent foamability and consistency are complemented by its easy processing. This further enhances the efficiency of the closed-loop production of PP foam.

Having tested the use of CO_2 as a foaming agent in the laboratory for many years, FAP was able to develop a new machine with twin screws which was based on the FAP EXT 753 extrusion line. To foam EPP using CO_2, the screws had to be designed in such a way as to maintain the necessary pressure in the gas injection zone at high temperatures. This ensured the high quality and controlled atomization of gas into melting. Further testing led to the development of suitable extrusion dies, as well as dies to control the expansion and crystallization of the polymer after leaving the extrusion head.

Photos: courtesy of FAP

Benefits

This collaboration between Borealis and FAP features several "firsts" and offers numerous advantages.

- The first low density, lightweight and recyclable solution that uses supercritical CO_2 as the blowing agent in the extrusion process.
- The novel FAP extrusion line set-up results in application weight reduction potential of up to 90%.
- CO_2 as blowing agent yields a foam blown product with a lower environmental footprint.
- A non-crosslinked grade, Daploy WB140HMS PP yields foams in the extrusion process that match and even exceed EPS in many performance aspects – and are 100% recyclable.
- Daploy WB140HMS ensures excellent product foamability and consistency in the production process; as a food-grade resin, it can be used to replace EPS in food packaging applications.
- Closed-loop production: all material waste generated during production is immediately turned back into granules and fed back into the process, thereby reducing the use of virgin raw materials – with no compromise in mechanical performance.
- Foamed HMS PP can be crushed at end of life and used to make high-quality recyclate, further closing the loop.

The performance properties of polymer foams at a glance

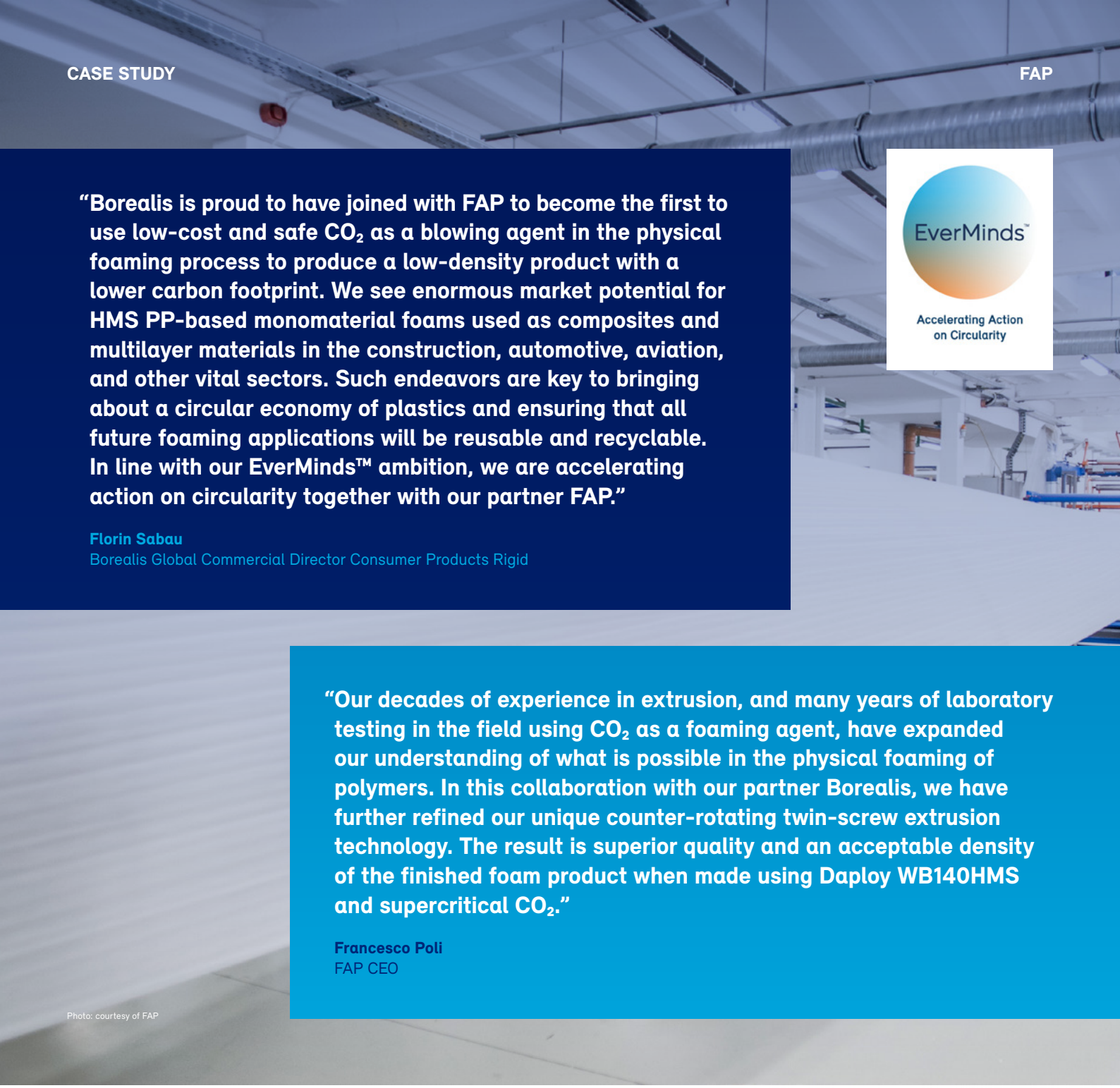
- **100% recyclable and reusable, with no waste generated in its closed-loop production**
- **Non-toxic and non-allergenic**
- **Outstanding energy absorption**
- **Excellent thermal insulation characteristics**
- **Resistant to chemicals, water, high temperatures**
- **Impact resistant**
- **Glue-less lamination possible with wide range of materials (such as polyethylene, metal foil, metalized BOPP films)**

Thanks to the variety of densities available, polymer foam has become an essential material in diverse sectors.

- **Consumer products and packaging: disposable tableware, clamshells, cups**
- **Automotive: insulation, energy-absorbing panels**
- **Construction: sound and thermal insulation for interiors and roofing**

Compared to conventional polyethylene and polystyrene resins, physically foamed Daploy WB140HMS PP can withstand very high operating temperatures of up to 125° C. When extruded on the FAP EXT 753 extrusion line, a thickness of 5 mm and density of 50 kg/m3 can be obtained. The table below summarizes its characteristics:

Physically foamed Daploy WB140HMS produced on FAP EXT 753 (thickness 5 mm/density 50 kg/m3)	
Thermal conductivity	0.034° C W/m
Compressive strength 25% (MPa)	0.05
Water absorption within 24 hours, in %	0.7
Application temperature	from -40° C to 125° C
Impact noise reduction index	22 db
Elongation at break, in %	65.5
Residual deformation when compressed by 50% in 72 hours, in %	10



"Borealis is proud to have joined with FAP to become the first to use low-cost and safe CO_2 as a blowing agent in the physical foaming process to produce a low-density product with a lower carbon footprint. We see enormous market potential for HMS PP-based monomaterial foams used as composites and multilayer materials in the construction, automotive, aviation, and other vital sectors. Such endeavors are key to bringing about a circular economy of plastics and ensuring that all future foaming applications will be reusable and recyclable. In line with our EverMinds™ ambition, we are accelerating action on circularity together with our partner FAP."

Florin Sabau
Borealis Global Commercial Director Consumer Products Rigid

EverMinds™
Accelerating Action on Circularity

"Our decades of experience in extrusion, and many years of laboratory testing in the field using CO_2 as a foaming agent, have expanded our understanding of what is possible in the physical foaming of polymers. In this collaboration with our partner Borealis, we have further refined our unique counter-rotating twin-screw extrusion technology. The result is superior quality and an acceptable density of the finished foam product when made using Daploy WB140HMS and supercritical CO_2."

Francesco Poli
FAP CEO

Photo: courtesy of FAP

Borealis and Borouge packaging solutions are making everyday life easier

date of issue: **May 2024**

Borealis is one of the world's leading providers of advanced and sustainable polyolefin solutions. In Europe, Borealis is also an innovative leader in polyolefins recycling and a major producer of base chemicals. We leverage our polymer expertise and decades of experience to offer value-adding, innovative and circular material solutions for key industries such as consumer products, energy, healthcare, infrastructure and mobility. .

With operations in over 120 countries and head offices in Vienna, Austria, Borealis employs around 6,000 people. In 2022, we generated a net profit of EUR 2.1 billion. OMV, the Austria-based international oil and gas company, owns 75% of our shares. The Abu Dhabi National Oil Company (ADNOC), based in the United Arab Emirates (UAE), owns the remaining 25%.

In re-inventing essentials for sustainable living, we build on our commitment to safety, our people, innovation and technology, and performance excellence. We are accelerating the transformation to a circular economy of polyolefins and expanding our geographical footprint to better serve our customers around the globe. Our operations are augmented by two important joint ventures: Borouge (with ADNOC, headquartered in the UAE); and Baystar™ (with TotalEnergies, based in the US).

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