

# Building blocks to circularity

A new resin technology could mark a major milestone in pursuit of a plastics circular economy. **Steven Pacitti** investigates

These are new times with new challenges and drivers. Everywhere you turn it's circular economy this, or sustainability that, and plastics packaging is a focal point. With the European Plastics Strategy demanding recyclability, reusability or compostability by 2030, the Single-Use Plastics Directive and the Packaging and Packaging Waste Directive (PPWD) requiring 50 per cent of plastics to be recycled by 2025, new recycling laws are emerging in every country across the EU and beyond, as each nation gears up to meet increasingly strict targets.

Flexible plastics have faced the brunt of the environmental backlash and initiatives such as CEFLEX have been engaging companies along the flexibles value chain to develop circular solutions. Another collaboration has taken shape across three continents, and this could be set to enable film manufacturers to realise fully recyclable PE monomaterial structures without sacrificing stiffness and clarity. Monomaterial structures are, of course, critical to achieving brand-owner commitments to making all plastics packaging 100 per cent recyclable, reusable or compostable.

Canadian PE producer Nova Chemicals has developed high-density resin technology for the biaxially-oriented PE (BOPE-HD) market. It says this provides recyclable multilayer film structures with significantly improved physical performance versus blown film. Food packaging, heavy-duty sacks, e-commerce and other demanding applications are key targets.

"BOPE is a transformative technology that can be considered the second wave of all-PE structures, because the biax film process dramatically improves film stiffness, toughness, barrier, tear and optics versus blown film. It represents new opportunities to replace non-recyclable, mixed-material packaging," says Owen Lightbody, team leader for performance films technical service at Nova Chemicals, in an exclusive interview with *Plastics in Packaging*.

Nova Chemicals introduced recyclable film designs for all-PE packaging such as stand-up pouches in 2016 (moisture barrier) and 2017 (moisture and oxygen barrier) and ready-to-recycle resins in 2019, and the company started to seek out collaboration partners when it recognised there was a need for BOPE-HD.

Discussions with German stretching line manufacturer Brückner Maschinenbau started in May 2019, and as the collaborative approach progressed the two companies realised that they needed a like-minded film manufacturer to validate their findings. During K 2019, Portuguese converter Polivouga joined the BOPE-HD development team.

Both Brückner and Polivouga viewed the addition of a new building block to create recyclable packaging as an important organisational objective, and the three firms shared technical expertise and even cultural traditions as the partnership deepened.

"The primary challenge in developing BOPE-HD was achieving reliable production with HDPE, as the higher crystallinity of HDPE compared to PP makes it very challenging to run on the biax equipment," points out Lightbody. "Resin development was needed to expand the orientation window, allowing HDPE to be processed on existing tenter frame lines."

Highly specialised resins that offer a tailored viscosity profile for the tenter frame process, extremely low gels and lot-to-lot consistency are required due to the processability requirement of defect-free film. While resin innovation was needed, Brückner also fine-tuned its equipment designs for PE, as the machinery manufacturer's senior sales manager Sebastian Ruhland explains.

"Generally, the BOPE films can be produced on a regular BOPP line, with an approximately 50 per cent drop in output for BOPE-LLD and even more for BOPE-HD," he states. "To over-

come this limitation, during K 2019, we introduced BOPP/BOPE hybrid lines, which bring output back to a typical situation.

"We are offering a 6.6m-wide hybrid line with a maximum output of 3,150kg/h for BOPE-LLD, and 3,345kg/h for BOPP. Besides this, we are offering an 8.7m-wide hybrid line with a maximum output of 4,800kg/h for BOPE-LLD, and 6,350kg/h for BOPP. The BOPE-HD output situation is currently under development."

The first hybrid line was sold to a European customer in January 2020 and further invest-







*Food packaging, heavy-duty sacks, e-commerce and other demanding applications are key targets for BOPE-HD*

ments are expected in the short term, adds Nova Chemicals.

As outlined by Ruhland, there are two grades of BOPE film available: BOPE-HD for a stiff, printable base film, and BOPE-LLD as a sealable film, for example in laminates with BOPE-HD. Ruhland began working in new business development for BOPE in 2018, starting with BOPE-LLD and continuing now with BOPE-HD.

With hybrid lines, customers have the flexibility to switch between BOPP and BOPE-LLD as well as BOPE-HD with only a few



*Hybrid stretching lines will allow converters to easily switch between BOPP and BOPE-LLD as well as BOPE-HD*

hours of changeover time, because the materials are quite similar in extrusion and stretching parameters.

“BOPET is a different polymer family, so an interchange to BOPE is not possible,” Ruhland says. “Besides this, existing BOPP lines have the potential to be upgraded for BOPE, not to the full extent like a hybrid line, but at least to recover the output situation to approximately 70-80 per cent of the nameplate capacity. As soon as BOPE film demand reaches a significant volume, we expect to see dedicated BOPE lines with almost no changeovers.”

Speaking about the challenges involved during development, Ruhland cites the biaxial stretchability of PE as a new requirement. As a result, it was necessary to build up know-how in the design of the chemical structure of the polymers and test them on Brückner’s pilot line as well as on production lines. Unfortunately, this was a rather time-consuming procedure, he admits, even though the wider market is in a hurry to have new new PE-based packaging solutions.

### The BOPP won’t stop

Polypropylene is a legacy material used in many biaxially oriented films and applications today. However, the combination of bold sustainability commitments made by brand owners and the attractiveness of monomaterial packaging for enhanced recyclability, have elevated the profile of BOPE in many organisations.

Many packaging applications require multiple materials to provide the required performance, unless they utilise an all-PE structure, especially given the outstanding seal properties of PE. In addition, PP is harder to recycle due

to a lack of infrastructure in some regions of the world, including much of North America.

“Challenges in developing BOPE include maximising output rates, as BOPP/PP are well-established technologies that have been thoroughly optimised over the years,” explains Eric Vignola, Nova Chemicals’ food packaging market manager. “Continued improvement in optical properties and output rates will be achieved through a combination of novel PE resin architecture and equipment optimisation.

“BOPE-HD may not be a good fit for all BOPP applications, but there is growing interest in the former to replace BOPP or BOPET print webs in a range of applications, including metallised films, stand-up pouches, flow-wrap, pillow packs and labels.”

“Three- and five-layer designs will become commonplace in the production of 20-25 micron, or possibly thinner, biaxially-oriented films,” adds Lightbody. “One common finished film will contain a BOPE-HD print web laminated to a blown film sealant web.”

For Brückner’s Ruhland, this could extend across a thickness range of 15-50 micron, in order to fulfil all of the requirements of a stiff, printable base film.

Any new film structure or material substitution requires a rigorous qualification process, and as BOPE represents a challenge to the status quo, collaboration across the value chain is required to build understanding, confidence and, ultimately, widespread adoption of the material.

It is a point emphasised by Ruhland: “It sounds easy substituting existing film structures, but it’s not. Changing packaging structures is a time-consuming process since it immediately affects the functionality of the ▶





*Nova Chemicals calls BOPE a transformative technology*

packaging itself, packaging speeds, processability on older packaging lines, and even acceptability to the end-user. Any change requires extensive tests and confirmation by small batch tests."

Evaluations of Nova Chemicals' HDPE resin technology have been completed on commercial scale lines in Europe as well as North America now, and more were planned for July, having been postponed due to the pandemic.

One of the converter partners is Toray Plastics (America) (TPA), which has had a sustainability programme in place for many years and has active projects including thinner films, post-consumer recycle, bio-based resins, and biodegradable films.

Chris Nothnagle, senior director of corporate marketing at TPA, anticipates that the first BOPE-HD products on the market will be a sealable web for clear applications, as metallisation will need to be approved for in-store drop-off collection.

TPA itself has a history in the area of HDPE improvement, and an online search records a 2016 patent for OHDPE single-grade HDPE with nucleating agent in the core. This is just one step of many that the development team has taken to advance this technology, Nothnagle tells *Plastics in Packaging*.

For him, the requests for BOPE films appear to be fuelled by the lure of in-store drop-off for used flexible packaging in the US, as only PE is accepted at the store. No other plastics flexible packaging materials have a collection system in place.

"Most brands are committed to reusable, recyclable or biodegradable packaging by 2025, and BOPE may help in some cases if in-store drop-off continues and the downstream market remains healthy," he believes. "Vertical and horizontal form-fill-seal and pouch applications are the most common outlets for BOPE-HD. It is a challenging material to produce, as a true HDPE resin has very different processing characteristics, and extrusion and orientation are both difficult.

"BOPP has a 50-year head-start, and with low cost and very high performance, it will be challenging to replace. Mechanical properties at the elevated temperatures that would be seen in printing and laminating are a challenge. Nobody wants elongation and loss of print registration, or the use of simpler graphics to compensate. Barrier, sealability and appearance are all taken into consideration.

"There is a great diversity of BOPP films in the market and we expect many different variants of BOPE, if it catches on. The market demands best performance for the lowest cost, for every application."

Monomaterial LDPE structures help to improve the added value of recycle applications, he adds, as they strongly benefit both mechanical recycling output, as well as requiring less energy for chemical recycling processes. Chemically recycled grades of PE are already available for films.

Polivouga has also pioneered recyclable and biodegradable plastics technology called BioXpand, which Barros says will have a solution for BOPE-HD in the next two years. This

technology imparts a pre-determined service life to a film.

The company also has Zaphir BOPP BioXpand sealable films on the market commercially for fresh produce applications. These are between 20 and 35 microns. Barros confirms that the company has extended trials of this technology to LDPE films for apple bags.

## Next steps

The first challenge was proving that HDPE is suitable for the biax film process, so initial work has centred on non-barrier applications. Now that Nova Chemicals has confidence in producing BOPE-HD, the focus has turned to optimisation of the converting processes. These include metallisation to achieve barrier, or lamination to a blown-film partner web that provides different types of barrier performance.

"BOPE-HD can be part of a recipe to create an all-PE moisture barrier, or moisture-plus-oxygen barrier package, depending on the design of the finished laminate," explains Nova Chemicals' Lightbody.

To improve the barrier for oxygen and also water vapour, regular aluminium or aluminium oxide metallisation is possible, explains Brückner's Ruhland, preferably after inline coating with a primer between machine direction and transverse film orientation.

"By doing so, the oxygen transmission rate can be improved to values of around ten," he says. "EVOH could also be an option in the future, but this is an R&D topic."

BOPE-HD in its current guise can be used as base film for all kinds of flexible packaging,

with the focus on PE monomaterial structures. With a co-extruded sealing layer it could also be used as a PE lidding film.

“There is also white voided BOPE-HD film available, which is suitable for snack food and chocolate packaging, as well as label film,” adds Ruhland. “BOPE-LLD film can be used for frozen food packaging, rice packaging, and for single-use portions of cookies.

“We’re currently in the phase of providing films to converters in order to realise different packaging examples and product trials. Since we are a machine builder, we try to assist and promote the film as much as possible.”

The key is to have more and more BOPE film producers on the market, so that converting companies achieve more confidence in the resin technology.

“We have a confidentiality agreement with Toray but I can disclose that Polivouga has two existing BOPP lines in Portugal and has recently invested in an 8.7m BOPE/BOPP hybrid line,” he continues. A hybrid line will have a typical five-layer configuration.

“Besides the sequential film process, we are also evaluating and developing simultaneous BOPE film stretching. We are seeing promising film results, whereas a LISIM [linear simultaneous stretching] packaging film line is something really special.”

Diogo Barros, process and development engineer for the PE and PP business at Polivouga, says that the hybrid line has capacity for 54,000 tonnes and will start producing BOPE and BOPP materials from the start of 2022.

“Polivouga started converting PE films on cast and blown film extrusion, and only started producing BOPP in 2015, so in my perspective I think there is market for both materials as they are easy to recycle and reuse during extrusion,” says Barros. “BOPE-HD mechanical properties are really good due to the high stretching ratio and the material combination we used. However, our next target is to get similar optical properties as BOPP or BOPET.

“We have several structures with five-layers for BOPE. A stiff formulation with high temperature resistance is one of them, passing to a formulation with low initial sealing temperature.”

## The time is now

Machinery manufacturers like Brückner will tell you that discussions with converters these days inevitably end up focusing on 100 per cent PE as a way of fulfilling recyclability targets. Consequently, demand for BOPE films is surging, and this has already led to the sale of



*BOPE-HD can be used as base film for all kinds of flexible packaging*

three hybrid lines by the German manufacturer. Two more are close to a signature.

With additional BOPE capacities coming on-stream, converting companies will have greater flexibility in film supply and delivery.

Significant recycling capacities are available in Europe and North America for PE, and this latest resin technology taps into those opportunities.

“Even if those recycled films are not suitable for food-contact again, it can be brought into a lot of different applications in what is by far the biggest polymer market,” explains Ruhland.

When it comes to recycling, the US market has strongly backed in-store drop-off. TPA is a member of How2Recycle (H2R) and would therefore work to get the films approved.

“I’m not clear that the value proposition is as great internationally,” admits TPA’s Nothnagle. “If a new stream needs to be created then it could be done with all-OPP structures, as many already exist in Europe.”

In Portugal, for example, there has been little to no incentive to invest in recycling technology in recent decades, explains Polivouga’s Diogo Barros. This, he says, was justifiable until 2015 as there was little demand for low contamination premium recycled grades suitable for technical film extrusion applications.

“In 2019, Polivouga Group converted more than 7,000 tonnes of rLDPE PCR, incorporating between 50-80 per cent – sometimes more –

recycled content in some products,” says Barros. “We have several ongoing circular economy projects that have led us to take the investment decision on an organically developed post-consumer film residues recycling site equipped with infrared sensors, which combined with aerodynamic air injectors grant the possibility to separate washed film residues by density. This leads to higher rLDPE film quality. Production in this new recycling unit started in July.”

As very few BO films are recycled, Nothnagle agrees that this will require a huge paradigm shift for the consumer. He adds that not very many PE grocery bags are ever returned to stores, as this requires clean bags, with no other types of plastics mixed in.

Nova Chemicals’ Eric Vignola agrees: “We anticipate that all-PE structures produced with BOPE-HD will qualify for the H2R in-store drop-off label. However, each structure has to be tested according to the Association of Plastics Recyclers test protocol adopted by H2R for recyclability assessment. Europe has the RecyClass Recyclability Evaluation Protocol, which again most all-PE film structures will meet. In areas with kerbside recycling, the material can be collected directly from households in accordance with local recycling programmes.”

The H2R label is seen as an incredibly important way of telling consumers how to get flexible packaging into the correct recycling stream, or not to recycle in the case of mixed material and other non-recyclable formats.

So what else can be done to get the message across that plastics are sustainable and recyclable? Nothnagle explains that it takes effort, adding: “The adaptability and performance of flexible plastics packaging have made it incredibly inexpensive and high-performing. Progress has been made with rigid plastics – PET bottles – with help from standardisation and legislation.”

Flexible packaging will need the same help to level the playing field and restructure the market, build infrastructure and change habits.

Changing packaging in pursuit of sustainability targets is a complex undertaking, whether it’s related to packaging recyclability, incorporation of recycate, or material substitution. Solutions are within reach, though, and companies are innovating faster than ever to meet their goals.

More information from:  
Brückner Maschinenbau  
Nova Chemicals  
Polivouga – Industry Plastics SA  
Toray Plastics (America)

brueckner.com  
novachem.com  
polivouga.pt/en  
toraytpa.com