



Whether it's bottles, caps, or even films, polyhydroxyalkanoates (PHAs) are finding new avenues into the packaging space. **Steven Pacitti** finds out if they are on the right road to success

# PHAased approach

**W**here there's blame, there's a claim – or so the saying goes. A recent report on global plastics pollution by financial think tank Planet Tracker accused the industry of shifting its focus away from limiting production and adopting alternative materials in favour of promoting recycling – in its view, effectively shifting the blame onto consumers.

But for Fred Pinczuk, the chief technical officer of US-based Beyond Plastic, an R&D facility and manufacturer of packaging made from biopolymers, the issue of plastics recycling – or plastics “wishcycling” as he calls it – is a moot one.

“Nobody checks if plastics packaging is, in fact, recycled,” he told delegates at a press event during NPE2024, held in Orlando, Florida, in May. “They just stick a logo on the bottom and call it done, whereas the biopolymer sector has to jump through hoops to prove its credentials.”

In a year when the US elects its 47th president, current incumbent Joe Biden has made a bold

play for bio-based polymers, approving an executive order that calls for the displacement of 90 per cent of today's petroleum-based plastics with recyclable-by-design bio-based polymers over the next 20 years.

All PP, HDPE and LDPE – which is 40 per cent of all plastics and represents 182 million tonnes of volume – could be replaced by polyhydroxyalkanoates (PHAs), according to Pinczuk, who adds that HDPE and PP caps are the fifth most common plastics “trash” collected on US shores, and fourth globally.

PHAs are a type of biodegradable polymer produced naturally by microorganisms through fermentation processes. They are naturally synthesised by bacteria as intracellular carbon and energy storage compounds, serving functions like those of conventional plastics but with the added benefit of being recyclable, compostable and biodegradable.

“Produced from renewable feedstocks such as plant sugars, vegetable oils, or even waste streams from agricultural or industrial processes, including biogas such



*CJ Biomaterials' Max Senechal (left) says his company's focus is on a full PHA solution combining two grades, while Fred Pinczuk wants to see a level playing field for biopolymers*

as methane and carbon dioxide, they can be processed on conventional plastics manufacturing equipment with small modifications,” explained Pinczuk, as he demonstrated a second-generation RCB (Recyclable, Compostable and Biodegradable) PHA bottle cap.



**Left and above:** Could PHAs replace PP, HDPE and LDPE in packaging applications?



**Above and above right:** PHA caps are said to offer comparable performance to regular caps, but with the advantage of being compostable



Presenting alongside partner CJ Biomaterials and polylactic acid (PLA) producer NatureWorks, Pinczuk detailed the three-year path to a PHA 38mm closure in conjunction with CJ Biomaterials and Tech-Long International.

“In October 2021, we looked at the direct replacement of an HDPE 38mm cap for a water brand,” he explained. “By January 2022, we had the first PHA single-cavity mould in test, and the rest of 2022 and first half of 2023 was spent revising 13 custom compounds, trialling three natural colours, and revising six mould designs. The first commercial filling-capping trials at Unix Packaging in California took place in September 2023, and delivery of 16-cavity injection moulding and ongoing work in delivering the first continuous compression moulding equipment ready to run PHA, is to be completed by the third quarter of 2024.”

The result is a PHA compound that can be injection moulded into a closure at a

sub 6-second cycle from a multi-cavity hot-runner tool. A PHA or HDPE cap can be made on the same machine. Supplied by Tech-Long, the machine has a capacity of between 30,000 and 100,000 caps an hour.

“Shrink-ratios are a variance of the PHA material blends, so they need to be measured with very high precision and tracked,” Pinczuk added. “While being a minor component in terms of average mass within the cap, CJ Biomaterials’ amorphous material plays a key role in ensuring the performance of the closure.”

Amorphous PHA is a softer, more rubbery version of PHA that offers different performance characteristics than the crystalline or semi-crystalline forms that currently dominate the PHA market. As such, its initial applications are likely to serve as a modifier to other compostable polymers and biopolymers, to improve functional and processing characteristics, and for enabling these

products to achieve faster rates of biodegradation or composting.

“We have two grades of PHA,” explained Max Senechal, chief commercial officer of CJ Biomaterials, which is a division of South Korea-based CJ CheilJedang. “One ▶

### NatureWorks’ capacity update

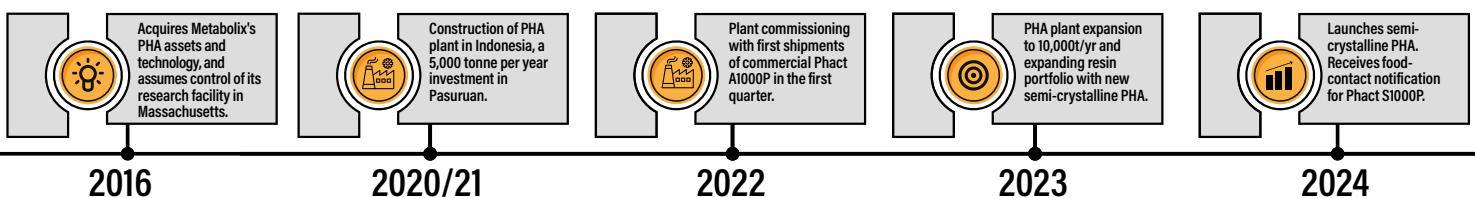
- The Blair, Nebraska plant has a 150,000-tonne nameplate capacity
- A 75,000t plant in Nakhon Sawan province, Thailand is under construction
- The new site is dedicated to Ingeo manufacturing with integrated lactic acid, lactide and polymer manufacturing sites
- Feedstock (sugarcane) will be sourced within a 50km radius
- Full production is anticipated in 2025

### Beyond Plastic: a timeline

- Company founded in 2021
- Lab construction completed in first quarter 2022
- Offers six commercial 100 per cent PHA TÜV marine-certified compounds for a range of applications, such as injection moulding, compression moulding, extrusion and extrusion blow moulding

## CJ Biomaterials: a timeline

The company’s centre of excellence in Woburn, Massachusetts, features a Collin blown film line, a Krauss-Maffei 50-tonne injection moulding machine, a Leistritz twin-screw 18mm 35:1 length-to-diameter extruder, and a Carver 15t compression moulding press.





**Left and middle:** CJ Biomaterials has two Phact PHA grades with versatile application ranges. **Right:** NatureWorks tied up with CJ Biomaterials to develop an Ingeo PLA and Phact PHA blend

amorphous, rubbery type called Phact A1000P, which is an enabler or modifier to other polymers, and one semi-crystalline, Phact S1000P, which is a new, general PHA with versatile properties for injection moulding, film and sheet. Our focus now is on a full PHA solution that combines the two grades we have.”

According to Raj Krishnaswamy, vice-president of R&D at CJ Biomaterials, A1000P could offer a greenhouse gas emissions advantage of around 70 per cent relative to conventional polymers, with the company’s objective to use it to enable easier processing and superior performance of PLA-based blown, cast or biax films.

“Early plastification of A1000P appears to promote faster solids-melt transition of PLA, which is confirmed by [extrusion equipment supplier] Davis-Standard,” said Krishnaswamy. “This translates to a 10-20 per cent higher output rate relative to PLA control.”

CA1270P is compounded product composed of PLA and amorphous PHA, specifically Phact A1000P, which makes clear film. The PLA used is Ingeo 4043D from NatureWorks.

“CA1240PF is 100 per cent bio-based at similar cost to Ecovio [by BASF] with a clear pathway to home composting,” explained Krishnaswamy. “Opportunities include snack food and produce packaging, frozen food bags, shopping bags, shrink wraps and labels.”

This April, on the eve of NPE, CJ Biomaterials introduced two Phact PHA and Ingeo PLA blended compounds for compostable packaging in blown, cast and machine-direction orientation film applications.

“Modifying PLA with amorphous PHA leads to improvements in mechanical

properties, such as toughness and ductility, while maintaining clarity,” stated NatureWorks global marketing and communications director Leah Ford. “The combination of Ingeo PLA and Phact PHA increases impact resistance for automated food packaging lines, while early assessments show that this new material has potential to meet the compostable criteria in California’s SB1335 statute requiring biodegradation within 60 days.”

CJ Biomaterials signed a collaboration agreement with NatureWorks in November 2022 to commercialise novel biopolymer solutions, and the latter introduced an Ingeo PLA and Phact PHA blend in April 2023 for improved softness and strength in bio-based nonwovens for hygiene applications.

Figures presented by Ford also suggest that a Phact PHA and Ingeo PLA blend has a lower global warming potential (kg carbon dioxide equivalent / kg polymer) than conventional plastics. PET, for example, comes in at 2.15, with LDPE at 1.87 and PP 1.63, while Phact PHA is 0.8 and Ingeo PLA is 0.62.

“PHA biopolymers will fully biodegrade in all environments,” added Senechal.

While PHA can be recycled, the infrastructure does not currently exist to enable it. Guaranteeing PHA as a clean waste stream, therefore, is a challenge, and Pinczuk admits that it’s not a priority for the US federal government, or for that matter, recyclers.

“The US recycling industry is fragmented, and PET and HDPE is the focus,” he said. “Recyclers have to step it up.”

One equipment supplier that might well be doing just that is Eagle Vizion Systems, which offers what Pinczuk calls “an inter-

esting” proposition.

“We’ve taught the Eagle Vizion sorter to recognise PHAs and PLAs and we’ll direct 5-10 per cent of our material during cap production back to the line, in order to demonstrate post-industrial regrind use,” he told delegates during a Q&A session. “Most materials recovery facilities in the US have near-infrared sorting, and sortation accuracy for PLA is now above 90 per cent. Composting is where recycling was years ago, so we have to ask ourselves how we ensure that we get clean streams to compost.”

During tests with Boston Labs’ sorting systems, Pinczuk says that Beyond Plastic reached 2 per cent saturation with HDPE without any problems, and 0.5 per cent PET cross-contamination.

While PHA promises much, when are we likely to reach the sweet spot when it comes to price? Pinczuk believes that its price parity with PLA will be reached in three-to-four years, which CJ Biomaterials’ Max Senechal called “an aggressive target”.

“Our scale is 15,000 tonnes today,” added Senechal. “We have come a long way in five years and are looking increasingly at new and lighter blends.”

Meanwhile, collaborations will continue to play an important role in growth, with new products emerging from partnerships with bio-firms, he noted.

“PHA starts with nature, and returns to nature,” Senechal concluded. And what’s not to like about that? EP

*More information from:*

- Beyond Plastic* [beyondplastic.com](https://beyondplastic.com)
- CJ Biomaterials* [cjbomaterials.com](https://cjbomaterials.com)
- NatureWorks* [natureworkslife.com](https://natureworkslife.com)