# JEC COMPOSITES MAGAZINE

SPECIAL ISSUE

# Composites for Sports, Health & Leisure


www.JECcomposites.com

November 2020



# Closed-loop recycling of epoxy composites

**Cobra and Aditya Birla Chemicals present a sustainable solution for closed-loop recycling of infused epoxy mould tools and thermoset epoxy RTM watersports fins for Starboard and MFC.**

**Paolo Cecchetti,**
*Chief Innovation Officer*
*Cobra*
**Amit Dixit,**
*Assistant Vice President*
*Aditya Birla*

Working with partners Aditya Birla, MFC and Starboard, Cobra is taking a massive leap forwards in sustainable development by incorporating recyclable epoxy thermoset systems into production. Using Aditya Birla's recyclable epoxy systems Epotec YDL5552-THR9351 to infuse watersports fin moulds and the recyclable epoxy RTM system Epotec YDL5540-THR9151 to produce components, Cobra and their partners initiated a sustainable closed-loop recycling process that will significantly reduce composite material waste volumes.

## Low-temperature recycling process

Aditya Birla's novel recyclable epoxy system of Epotec YDL5552 resin and Epotec THR9351 hardener based on proprietary Recyclamine® technology was used to infuse fin tooling, enabling recycling and recovery of the reinforcement and matrix at the end of the tool's life. Cobra CNC machined the fin tooling from infused fibreglass blocks.

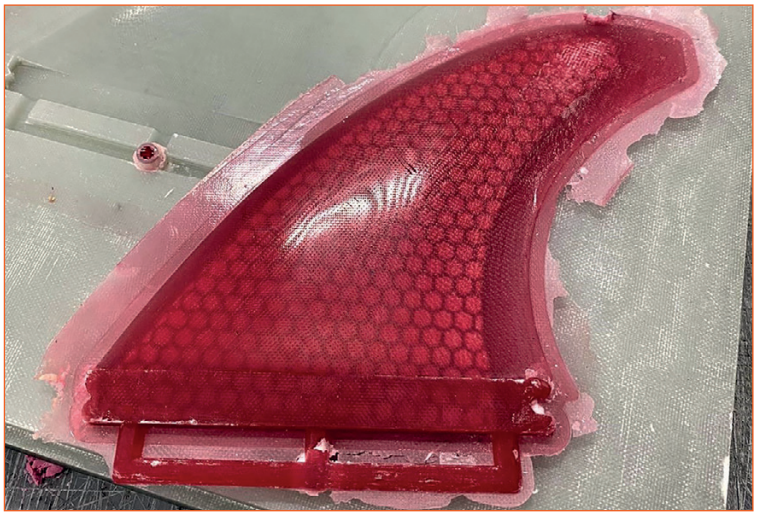
The mould consisted of two 25mm thick E-glass plates that were infused at 40°C, then cured at 60°C for three hours before a final post-cure at 80°C for eight hours. The laminate stack used 100 plies of 100gsm plain weave glass fabric at the part surface, backed up with 22 layers of 160gsm plain weave fabric and 16 layers of a 1200gsm stitched triaxial E-glass cloth. Cobra manufactured MFC and Starboard fins using this tooling and an RTM process using Aditya Birla's recyclable RTM system Epotec YDL5540-THR9151.

Typically, fins use woven glass and carbon fibre fabric preforms with some parts also using core materials.

The novel Aditya Birla resin technology enables the epoxy resin matrix in the composite to cleave using a low-temperature recycling process.

By conditioning the selected components or moulds in an acidic solution at around 80-90°C for two hours, a cleavage mechanism is triggered that breaks the cured thermoset bonds.

The reinforcements can be removed when the matrix is dissolved, then the resin solution is filtered and neutralized, allowing the reusable thermoplastic polymer to coagulate and be removed from the solution.



Recyclable Epoxy Fin and Mould

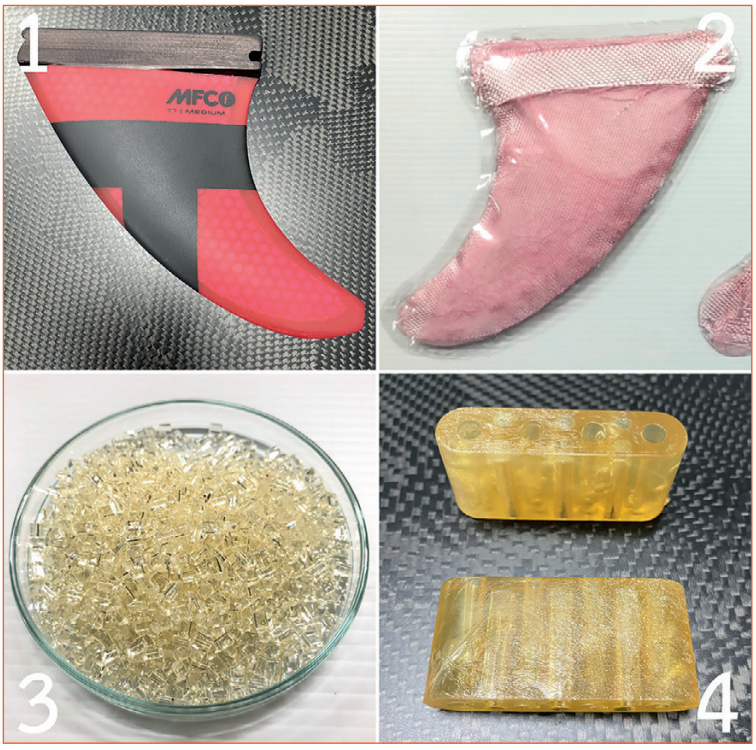
## Industrial-scale recycling

Epoxy thermosets are high-performance polymers with superior mechanical strength, very good chemical resistance and adhesion properties; they are thus used for many diverse composite applications. The volume of the epoxy thermoset market is currently around 2.7 million MT per year and is estimated to grow at a CAGR of 5.5% for the next eight years.

Unfortunately, dense three-dimensional crosslinking makes epoxy thermosets conventionally non-recyclable, posing a massive challenge to the disposal of parts or products at the end of their service life. According to the World Economic Forum, total plastic waste could reach 12 billion MT by 2050, with oceans containing more plastics than fish – clearly plastic production volumes must be reduced, and recycling needs to increase. Existing thermal, mechanical and chemical recycling technologies are often used to prevent waste from entering landfill or a water body.

However, these technologies have disadvantages and limitations including economic viability. The innovation presented in this paper allows the recovery and recycling of thermoset composites, unlike conventional thermoset plastics which are non-recyclable. Recycling uses a low-energy conditioning in an acetic acid solution for around 2-3 hours at 80-90°C.

The process has been validated for industrial-scale recycling and reuse of thermoset composites and Cobra demonstrated that recyclable raw materials can be used to replace existing materials without complex adjustments to equipment or processing methods. The recovered reinforcements can be reused for making new composite parts, rather than needing to be reprocessed into mats, chopped fibres or milled fibres.



The Recyclamine Process

The resin component, which is recovered as a thermoplastic polymer, can be used by itself or compounded with conventional thermoplastics to make objects for consumer or industrial applications.

## From lab scale to pilot and commercial scale

Aditya Birla Chemicals, who have been a technical partner with the inventors of the Recyclamine® amine building blocks since 2016, fully acquired their partner Connora Technology's business and technology in mid-2019.

During the initial development phase, the company worked on developing processes and technology to transition from lab scale to pilot and commercial scale.

Subsequently, they leveraged their technology platform to develop novel systems for composite applications and partnered with Cobra to develop sustainable closed-loop recycling of epoxy composites for sports and leisure applications.

## Massive potential in the thermoset composite market

The innovation has massive market potential, not just in the field of composites for sporting goods but also in the wider thermoset composite market.

The strengths that Aditya Birla and Cobra bring to this manufacturing development relate to their ability to reach industrial scale with the materials and production technology.

Previous work in this field has produced interesting components but the industrial capacity for raw material production via Aditya Birla and the series production lines at Cobra can now provide recyclable thermoset parts for true high-volume production. By

## Closed-loop recycling of epoxy composites

### Key advantages of the innovation

- Contributes to circular economy and a sustainable world
- Ground-breaking thermoset composite recycling solution
- End-of-life recycling and recovery of composite parts
- Closed-loop recycling process
- Production tooling recycled in house

offering resin systems that deliver equivalent performance to existing systems with no need for part redesign and that can be easily integrated into existing production lines with no major cost disadvantage, the innovation provides huge potential to reduce thermoset composite waste volumes.

### Contribution to the circular economy

The novel recyclable epoxy resin systems can be adapted to suit all typical composite manufacturing processes such as wet lay-up, resin infusion, RTM, prepreg, filament winding and pultrusion. Making the switch to recyclable thermosets is therefore made easier, with ease of use and ease of adoption removing key barriers for change.
The Cobra and Aditya Birla Chemicals innovation also presents significant opportunities to save energy, in terms of both the energy required for the recycling process itself and also by allowing the reuse of composite materials that have historically been discarded and new materials produced. The cleavage mechanism to break down the cured thermoset bonds with Aditya Birla's resin only requires approximately 2-3 hours conditioning in an acidic solution at 80-90°C, allowing the recovery of the reinforcement fabrics without the need for an energy- and capex-intensive furnace pyrolysis process. By recovering the reinforcements intact, this innovation allows manufacturers to keep these textiles in the manufacturing cycle without resorting to the use of new virgin fibre reinforcements.
The recyclable resin technology is expected to add tremendous value to PPP (people, plant and profit) and contribute to the circular economy by eliminating the greenhouse gas emissions during incineration of waste and lessen land filling and ocean dumping, by enabling recovery and recycling of waste.
In the sports and recreational composites segment, the usage of recyclable matrix systems for components made by labour-intensive processes will enable superior waste management at the shop floor. The recycling of the part at the end of service life will also allow the recovery and reuse of expensive inserts from the component.

### Positive environmental impact

The key environmental impacts created by the innovation relate to the recycling and reuse of a material type previously considered unrecyclable and also to $CO_2$ savings associated with not requiring composite materials for new components to be remanufactured. With reinforcements recovered intact, as opposed to requiring chopping or milling processes before they can be reused, many more reuse applications become available. Cobra and their customers are now able to recycle epoxy tooling blocks and re-purpose the recovered textiles for new parts or mould production as component designs evolve.
Smaller fin moulds are the first target with the company aiming at switching to recyclable epoxy moulds for their larger board moulds in the very near future. With industry figures indicating one ton of carbon fibre production emits approximately 20 tons of $CO_2$ and around one ton of $CO_2$ emissions resulting from the melting and production of one ton of fibreglass, the benefits are significant even before raw material freight is considered. In addition, the relatively low-capex recycling methodology demonstrated can be adopted by manufacturers on site without the requirements of an extensive collection network for waste, further improving the emissions reductions available.
By making the commitment to integrate Aditya Birla Chemicals' recyclable epoxy thermoset materials into a series production process at Cobra, the company and its customers MFC and Starboard are committed to a seismic shift in composite production technology.
Thermosets can now form part of a circular economy, improve their contribution to a more sustainable world and help to keep oceans cleaner for the generations to come. This exciting development has massive potential for the thermoset composite markets as a whole and Cobra and Aditya Birla Chemicals will be showing more details of their work, as well as fins, moulds and plastic components moulded from the recycled thermoplastic polymer during 2020. □

**More information:**
**www.cobrainter.com**