Reducing the carbon footprint of composites

Sustainable production processes and more climate-friendly products, based on low-CO_2 renewable raw materials, must play a key role if we have any chance of meeting the EU's goal of achieving a climate-neutral Europe by 2050. To help meet this challenge, Evonik developed the world's first sustainable isophorone products made from renewable acetone.

Authors I Michael Vogel, *Director Growth Projects, Epoxy Curing Agents,* **Dr. Sebastian Clermont,** *Manager Applied Technologies, Epoxy Curing Agents,* ***Evonik Operations GmbH***

Climate protection has become a central issue for society and politics across the globe, with many individual governments pledging to reduce greenhouse gas emissions and their reliance on fossil fuels. In Europe, with the "Green Deal," the European Parliament has set itself the goal of reducing greenhouse gas emissions to almost zero by the year 2050. This would make Europe the first continent to be fully climate neutral. The best-known greenhouse gas and the one that gets all the headlines is carbon dioxide (CO_2). Although there are several other greenhouse gases such as methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs), which also have a high global warming potential (GWP), CO_2 remains the most important one because it is released in very large quantities worldwide.

Ready for the challenges ahead

As an industry with a very high energy demand, the chemical sector faces major challenges on its road to climate neutrality. This is because – as one factor among many – in a greenhouse gas-neutral world, CO_2 emissions resulting from the carbon contained within products has also now become relevant and provides another way to reduce carbon. This is where the use of renewable materials will play a key role in the production process: greenhouse gas emissions from the use of virgin fossil resources as a source of raw materials need to be replaced by alternative, lower-CO_2 sources. Here, Evonik has achieved an important breakthrough for the chemical industry with its new form of isophorone and its derivatives made from 100%-renewable acetone. The new eCO series of products are part of the company's well-known VESTA brand family and are chemically identical to their standard virgin fossil-based equivalents, offering the same performance benefits, but with a reduced CO_2 footprint. The suffix eCO stands for "eliminate CO_2" and expresses Evonik's vision to become climate neutral.

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Alternative raw materials improve carbon footprint

Acetone is by far the most important base chemical in the production of isophorone (IP), isophorone diamine (IPD) and isophorone diisocyanate (IPDI). Standard acetone is based on petrochemical feedstocks and has the greatest impact on the carbon footprint of isophorone products. For example, with VESTASOL® IP, 80% of the global warming potential comes from acetone, for VESTAMIN® IPD 60% and for VESTANAT® IPDI it is still 30%. Using renewable acetone instead of traditionally derived petrochemical feedstocks can significantly improve the environmental footprint of these new VESTA eCO products.

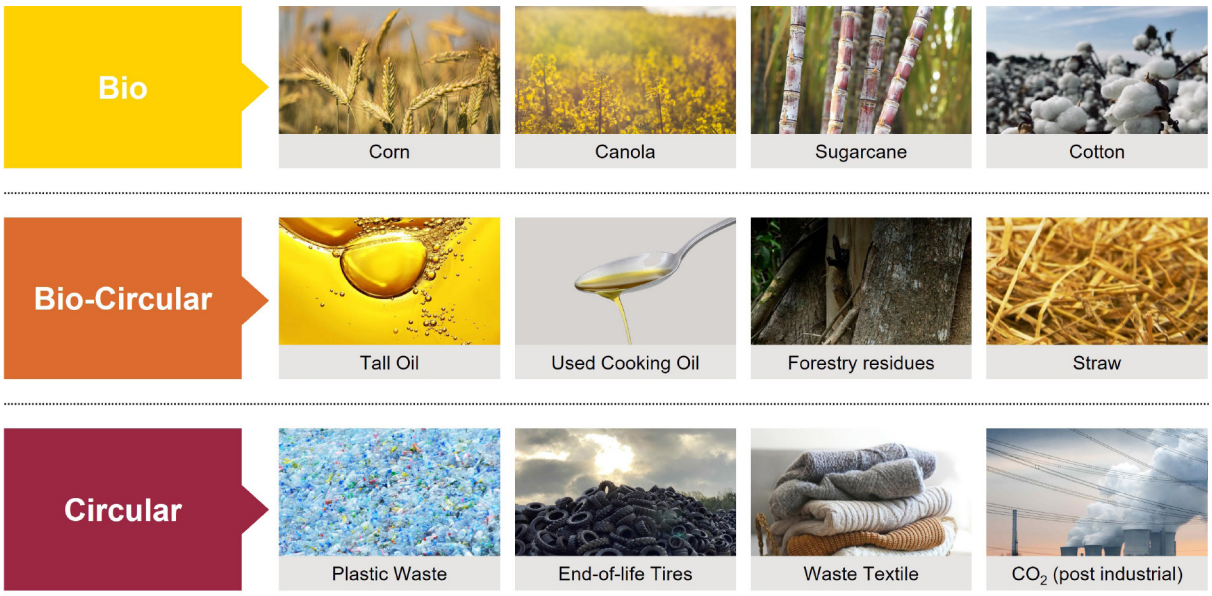

Fig. 1: Renewable acetone can be based on a variety of bio, bio-circular and circular materials

Renewable acetone includes all carbon sources (Figure 1) that avoid or replace the use of additional fossil carbon from the geosphere (coal, oil and natural gas), therefore it has a lower carbon footprint than conventional acetone. These include agricultural and forestry biomass (e.g., corn or straw), biogenic wastes and residues (e.g., tall oil and food waste), and recycled materials (e.g., plastics and textiles).

In addition to reducing the greenhouse gas potential, however, responsible procurement must also take more factors into account to arrive at a balanced purchasing decision. For sustainable isophorone production, Evonik only buys renewable acetone that is ISCC (International Sustainability & Carbon Certification) PLUS certified. ISCC PLUS stands for high sustainability principles such as social responsibility, high ecological standards, and strict compliance rules, and focuses on the sustainability of the entire value chain and its processes, not just the final product.

Mass balance accounting verifies sustainability data

Evonik produces the VESTA eCO series using the mass balance accounting approach (Figure 2). Renewable acetone and acetone from virgin fossil sources are mixed and processed together but strictly separated in book-keeping. Consequently, there is no chemical difference between the standard VESTA product and its more sustainable eCO counterpart, but the company makes sure that for every VESTA eCO product sold, the corresponding quantity of renewable acetone has been purchased upfront. So, every VESTA eCO customer knows that they are contributing to the increased use of renewable acetone in the industry.

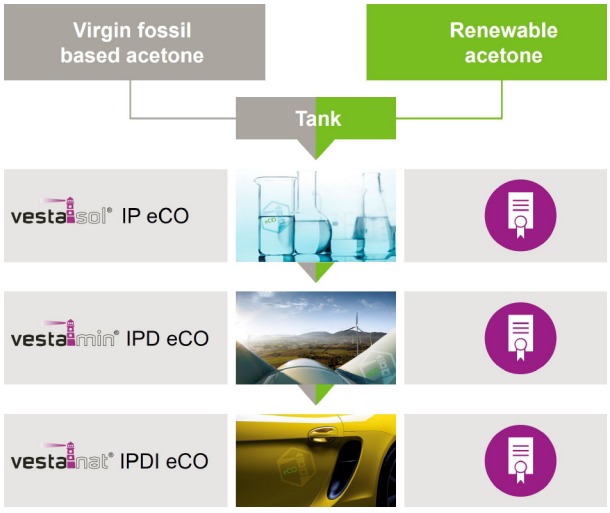

Fig. 2: The new VESTA eCO series is based on the mass balance approach

The mass balance approach is an important tool to drive the transition to climate neutrality as it gives the possibility to produce "drop-in" sustainable alternatives in a cost-effective way by using existing chemical plants jointly for standard products and their sustainable alternatives. The mass balance system is already well-established in several industries, such as fair-trade chocolate or coffee, but is also increasingly becoming the standard in the chemical industry's quest to provide cost-effective CO_2 reduced products.

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The entire process is audited and certified independently according to the internationally-recognized ISCC standards, a global sustainability certification system that supports the shift to a circular/bio-based economy and involves international associations, companies, research institutions and non-governmental organizations (NGOs) from around the world. Through rigorous record-keeping and external audits, the mass balance approach enables large-scale production of sustainable products, thereby providing cost-effective solutions for customers, with traceability of every renewable molecule used. At this stage, the total amount of renewable raw materials used via mass balance in a multi-million-ton chemical feedstock industry is still small but growing.

Drop-in solutions for climate-friendly composites

Chemically identical to their conventional predecessors, the new eCO products are drop-in solutions that offer the same exceptional performance as standard virgin fossil-based isophorone products, but with a significantly reduced global warming potential and carbon footprint.

The new eCO grades are designed for use as sustainable raw materials in the production of more sustainable solvents, composites and coatings due to their high mechanical strength, which provides excellent impact resistance, temperature resistance as well as resistance against chemicals and other forms of corrosion. For the composites industry, the new VESTAMIN® IPD eCO stands out here, as it is particularly suitable for two-component epoxy systems for wind turbine blades, pipes in chemical processing and marine applications, leaf springs, pump housings, boat hulls and other marine structures, sporting goods such as skis, tennis rackets and surfboards, automotive applications and printed circuit boards.

Let the wind blow – an example

With climate change and the growing scarcity of fossil resources, renewable energies are a very important topic. In Germany alone, electricity generation from wind power has increased sharply in just a few years, and in 2021, the wind turbines installed in Germany generated around 117.3 terawatt hours of electricity. This corresponds to a share of around 20% of the total gross electricity production. The current Renewable Energy Sources Act (EEG 2021) of the Federal Ministry of Justice aims to install 71 gigawatts (GW) of onshore wind energy in Germany by 2030.

High-performance solutions such as the new renewable acetone-based VESTAMIN® IPD eCO (90% renewable carbon via mass balance) will play a prominent role in the manufacture and operation of more durable and more ecological rotor blades for the (larger) wind turbines needed to meet these ambitious targets. Developed for improving curing and mechanical performance, IPD eCO makes the blades extremely robust and durable, while also providing the ecological benefits of a reduction in CO_2, thus making an important contribution to more environmentally-friendly energy generation around the world.

A complete toolbox of ecological epoxy curing agents

In addition to the new VESTAMIN® eCO series, Evonik's wide range of epoxy curing agents also helps customers to improve their ecological footprint in the production of composites and subsequent processes such as bonding. To address these needs, the company's versatile toolbox of solutions for epoxy-based applications made using building blocks from renewable sources helps to improve the sustainability of processes and can contribute to the development of more sustainable technologies.

These include the well-established technology platform of ANCAMIDE® amidoamine and polyamide epoxy curing agents based on up to 70% raw materials from renewable sources, which can be used in composite as well as bonding applications. While amidoamines, for example the ANCAMIDE® 500 series, are suitable for applications in both fields, polyamides such as ANCAMIDE® 3030 offer a cost-effective industry standard in adhesive formulations, predominantly for wind turbine rotor blade production. To address the trend for even larger rotor blades and the corresponding challenges of manufacturing them, Evonik extended its portfolio further with ANCAMIDE® 3130, an advanced version of ANCAMIDE® 3030 that offers a similar set of properties, but with a significantly extended gel time.

When it comes to bonding processes, which in the case of epoxy-based adhesives often involve elevated temperatures, an effective reduction of curing temperatures and curing times is an important step to improved sustainability. As an example, the modified aliphatic amines ANCAMINE® 2014AS & FG, along with ANCAMINE® 2441 & 2442 as well as ANCAMINE® 2337S, allow for a significant decrease of curing temperatures in 1K systems down to 80°C, which contributes to lower CO_2 emissions.

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These are just some examples of the many applications in which Evonik's latest range of versatile epoxy curing agents are helping customers enhance their ecological footprint.

Boosting e-mobility – an example

Addressing environmental protection and sustainability challenges, particularly the significant reduction of CO_2 emissions, has seen e-mobility emerge as one of the most important drivers in the automotive sector. Here, lightweight construction and high-performance battery technologies are essential development fields that will make a decisive contribution to increasing the efficiency of battery electric vehicles (BEV).

To address these technologies and support the expansion of the e-mobility sector, Evonik has developed VESTALITE® S, a series of amine-based epoxy curing agents specifically designed for high-performance epoxy Sheet Moulding Compound (SMC) applications. This series offers cost-effective alternatives to state-of-the-art unsaturated polyester (UP) and vinyl ester (VE) systems for high-volume production of composite parts. Due to their superior thermal and mechanical properties and very low emission profile, VESTALITE® S-based SMC parts, are not only a good fit for semi-structural and structural applications, but they also enable automotive customers to cope with more stringent VOC regulations for cabin air quality applications. Beyond that, VESTALITE® S epoxy curing agents also come with additional benefits such as low viscosity for better fibre impregnation to allow high fibre loadings, good processability and long storage stability, as well as low residual chemical shrinkage. This makes them an ideal fit for battery case applications by reducing weight and improving safety, as recently shown in Evonik's "Pure Performance Battery" case study.

Additionally, the company offers highly flexible, low-viscosity curing agents such as ANCAMIDE® 910 that provide an advanced tool to cope with the challenges of bonding dissimilar materials in lightweight construction. The curing agents enhance adhesion and peel strength on different materials, such as steel, aluminium or engineering plastics, and provide good flexibility and thermal shock resistance to corresponding joints. This is complemented by a low viscosity that allows the formulation of highly-filled adhesives such as thermal interface materials, for example, helping to improve the temperature management of battery packs.

Meeting the climate neutrality challenge in the future requires the full support of the chemical industry to find new, more ecological solutions. Through continuous innovation and the use of renewable and bio-based products, Evonik has taken the first steps on this journey and its versatile, low-CO_2 portfolio of products is already enabling its customers to reduce the ecological footprint of their processes and products in multiple different market applications.

More information: **https://crosslinkers.evonik.com/en/products/eco-grades**