Innovations in Sustainable Production & Circular Economy (Mar 2026 – May 2026)

Introduction

The last three months have seen **major global strides in sustainable production and circular economy innovations** – vital developments for chemical engineers and the broader process industries. These advancements, spanning **peer-reviewed research breakthroughs and real-world industrial initiatives**, focus on **new products and processes that enhance circularity and reduce environmental impact**. From **innovative green chemistry and biotechnology** to **waste-to-resource upcycling** and **policy measures**, diverse efforts are converging to help industries transition toward more sustainable production and consumption patterns. Below, we present key highlights (from March through May 2026) that chemical engineers and industry professionals can use to upskill and stay informed on the latest in circular economy innovations.

- **Green Chemistry & CCU Breakthroughs** – Researchers are developing **new catalysts and low-energy processes** to transform **waste carbon** – such as CO_2 and plastics – into **clean fuels and chemicals**[1] [2], offering novel routes for **circular carbon utilisation**.
- **Waste-to-Value Innovations** – **Agricultural and industrial wastes** are being **upcycled into high-value products** like **chemical feedstocks and advanced materials**[3] [4], reinforcing the **circular use of resources** in the process industries.
- **Industrial Circularity Initiatives** – **Leading companies** are implementing circular strategies at scale – from building **low-carbon production plants**[5] [6] to

[1]https://www.sciencedaily.com/releases/2026/03/260319044703.htm

[2]https://www.sciencedaily.com/releases/2026/05/260504023841.htm

[3]https://www.manchester.ac.uk/about/news/manchester-engineers-boost-sustainable-acrylic-acid-production-using-nextgeneration-membrane-reactor/

[4]https://newatlas.com/materials/coffee-grounds-insulation/

[5]https://www.fuelsandlubes.com/ineos-sandpiper-plan-low-carbon-methanol-plant-in-texas-city/

demonstrating **integrated recycling of plastics**[7] – drastically cutting waste and emissions in manufacturing.

- **Policy & Global Action – Governments and global forums** are driving sustainable production and consumption through new **policies and collaborations**. Examples include **landmark environmental regulations** – such as **the EU's Circular Economy Act** (to double circular material use by 2030)[8] – and **debates on chemical recycling regulations in the U.S.**[9] that could reshape industrial practices worldwide.

EU's Circular Material Use Target

24% by 2030

EU aims to **double** its circular use of materials to 24% by 2030 (from ~12% in 2023)

Pilot-Scale Bioprocessing

300 L

300 L pilot fermentation converts biodiesel byproduct glycerol into valuable chemical *1,3-propanediol*

Acrylic Acid Yield Boost

+10%

Membrane reactor improves **acrylic-acid yield by ~10%**, reaching 58.7% selectivity from waste glycerol feedstock

CO_2 Capture Efficiency

97%

New low-carbon methanol plant to capture **97%** of CO_2 emissions, aiding circular fuel production

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Breakthrough Sustainable Processes in Chemical Production

Catalysts turn waste carbon into fuels and chemicals: *Researchers worldwide have advanced novel ways to convert waste carbon emissions and plastics into valuable products.* In **Switzerland**, a team at ETH Zurich leveraged **single-atom catalysis** to dramatically improve the **conversion of carbon dioxide (CO_2) into methanol fuel**[10]. By anchoring **single atoms of indium** onto a specially designed hafnium-oxide support, the catalyst produces **methanol from CO_2 with greater efficiency and lower energy**

[7] https://www.devdiscourse.com/article/technology/3903932-innovative-chemical-recycling-vision-unveiled-at-ifat-munich-2026

[8] https://www.openaccessgovernment.org/europes-circular-economy-act-has-entered-the-implementation-phase/209680/

[9] https://phys.org/news/2026-04-epa-ease-chemical-plastic-recycling.pdf

[10] https://www.sciencedaily.com/releases/2026/03/260319044703.htm

input than traditional catalysts[11]. This breakthrough, published in *Nature Nanotechnology* (March 2026), demonstrates how **precious metal alternatives** can facilitate **clean fuel synthesis** while maximizing atom economy. *"If we can efficiently convert waste CO_2 into fuel, we address pollution and energy challenges together,"* notes lead researcher Javier Pérez-Ramírez, highlighting that such innovations offer **a pathway for carbon-capture-and-utilization (CCU) in the chemical sector**.

Meanwhile in **Australia**, scientists at Adelaide University unveiled **a sunlight-driven process to tap plastic waste as an energy resource**. By using **photocatalysts** activated by solar light, their system breaks down **discarded plastics** to produce **clean hydrogen fuel, syngas, and other chemicals**[12]. The technique, known as **solar photoreforming**, operates at mild conditions and *"can be more energy-efficient than water-splitting for H_2"* because waste plastics are easier to oxidize. Early results show high hydrogen yields and stable 100+ hour operation, converting plastic into H_2 gas and even diesel-range hydrocarbons. While challenges remain (like handling mixed plastic waste and ensuring robust, durable photocatalysts), this research – reported in *Chem Catalysis* (April 2026) – points to a **circular strategy** where **plastic pollution becomes feedstock for low-carbon energy**.

In **Japan**, materials scientists at Chiba University tackled another piece of the CO_2 puzzle: the high energy cost of **capturing CO_2 from industrial emissions**. They created a **new nitrogen-functionalised carbon material** that adsorbs CO_2 and then **releases it at < 60 °C – a significant reduction in heat requirement**[13]. By precisely arranging nitrogen groups in an "adjacent pairing" pattern, these **"viciazite" carbon materials** achieved efficient CO_2 uptake and **enabled efficient CO_2 desorption using only low-grade waste heat**. This **low-energy carbon capture** approach (published in *Carbon*, March 2026) could dramatically reduce the operating costs of capturing CO_2 from flue gases and thereby **improve the viability of carbon capture and reuse technologies**.

Turning Waste into High-Value Materials

Waste feedstocks to chemical building blocks: *Chemical engineers are increasingly finding ways to **upcycle waste biomass and by-products into useful chemicals***, reinforcing both sustainability and the circular use of resources. In one striking example from the **UK**, University of Manchester researchers developed **an intensified**

[11] https://www.sciencedaily.com/releases/2026/03/260319044703.htm

[12] https://www.sciencedaily.com/releases/2026/05/260504023841.htm

[13] https://www.sciencedaily.com/releases/2026/03/260328043549.htm

membrane reactor system to convert biodiesel waste (glycerol) into acrylic acid[14]. By gradually delivering oxygen through a porous ceramic membrane, the team **boosted acrylic-acid selectivity to ~59% (a 10% improvement over conventional reactors)**. The membrane-assisted process (published in *Chemical Engineering Journal*, April 2026) also **achieved up to 99% glycerol conversion** while diminishing hot spots and side reactions. This showcases how **process intensification** can transform a low-value **bio-waste** (glycerol is a plentiful by-product of biodiesel) into a **high-demand chemical** for paints and polymers, reducing reliance on petrochemical feedstocks and cutting emissions.

In **South Korea**, a biotechnology milestone was reached at pilot scale. The KAIST–Hanwha research partnership engineered **microbes to convert biodiesel-derived waste (glycerol) into *1,3-propanediol (1,3-PDO)* – a valuable monomer for plastics and cosmetics – in a **300 L industrial fermenter**[15]. By optimizing microbial metabolism (guided by computational gene modeling) and eliminating antibiotics from the process, the team maintained **high production rates in a 300 L pilot run**, demonstrating that **microbe-based chemical production can scale beyond the lab**. This breakthrough, published in *Nature Chemical Engineering* (May 2026), indicates that **bio-based processes can replace petrochemical routes** – here **turning waste glycerol into a circular feedstock** for polymer manufacturing. Industry partners praised the achievement as *“an important foundation for sustainable chemical production and industrial application in the future”*.

Upcycling waste into next-gen materials: Another innovative use of **biomass waste** comes from **China**, where scientists at Shenyang Agricultural University found a way to **transform spent coffee grounds into an eco-friendly insulation material**[16]. Typically, millions of tonnes of used coffee grounds are landfilled, releasing methane and CO_2 as they decompose. By converting the grounds into **porous biochar**, then formulating it with natural binders, the team created lightweight **panels with sixfold better thermal insulation than pure cellulose** – comparable to petroleum-based styrofoam. This “**coffee biochar foam**,” described in *Biochar* (April 2026), effectively trapped air (71% porosity vs 40% in raw grounds) and passed tests in solar panel installations. The researchers highlighted that **turning coffee waste into insulation not only improves material performance but also contributes to a circular economy by replacing plastic insulators**.

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[14] https://www.manchester.ac.uk/about/news/manchester-engineers-boost-sustainable-acrylic-acid-production-using-nextgeneration-membrane-reactor/

[15] https://techxplore.com/news/2026-05-microbes-biodiesel-plastic-ingredient-liter.pdf

[16] https://newatlas.com/materials/coffee-grounds-insulation/

Circular Economy in Industry: From Factories to Products

*Beyond the lab, **industrial leaders are increasingly deploying circular economy practices at scale***. In the **petrochemical sector**, a notable example is a **planned **1.1 million tonne/year** *"blue" methanol* plant in **Texas** – a collaboration between **INEOS** (UK) and **Sandpiper Chemicals** (USA). Announced in April 2026, this **USD 1.7 billion project** will use **natural gas with integrated carbon capture** to produce low-carbon methanol fuel and chemical feedstock[17]. The facility, slated for 2030, will incorporate **carbon capture and storage (CCS) to trap ~97% of CO_2 emissions** from the process. Up to 300,000 tonnes of the output are already earmarked for use in INEOS's acetic acid production, demonstrating **circular integration of captured carbon into chemical manufacturing**. Low-carbon methanol is seen as a crucial fuel for shipping and a way to decarbonise chemical processes, aligning with industry's efforts to reduce its carbon footprint.

In the **plastics recycling** arena, a major **chemical recycling partnership** spanning Europe and Asia emerged at the IFAT environmental technology fair in Munich (May 2026). **Germany's Evonik Industries** joined forces with China's **Vary Tech** to introduce a **full-process package for advanced plastic recycling**[18]. The initiative, which includes establishing **"Carbon Loop Systems" in Singapore** for demonstration projects, will convert mixed **waste plastics into petrochemical feedstocks (pyrolysis oil and circular naphtha)**. By leveraging state-of-the-art pyrolysis and upgrading technologies, the venture aims to produce **stable, high-quality recycled chemical inputs** – including sustainable fuels – and support Asia's transition toward a circular plastics economy. Such **cross-border industrial collaborations** signal how multinational companies are moving from pilot projects to large-scale deployment of circular economy principles, reducing waste and recirculating materials across global supply chains.

Designing products for circularity is another critical piece of the puzzle. In Asia's renewable energy sector, for instance, engineers recently unveiled **fully recyclable materials for infrastructure**, ensuring that the *"circular ethos" is built into products from the start*. One example is a new **building insulation foam made from **100% reused coffee waste** (as described above), which can replace fossil-based insulation with a biodegradable alternativeSimilarly, companies in Europe and China are

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[17]https://www.fuelsandlubes.com/ineos-sandpiper-plan-low-carbon-methanol-plant-in-texas-city/

[18]https://www.devdiscourse.com/article/technology/3903932-innovative-chemical-recycling-vision-unveiled-at-ifat-munich-2026

developing **biobased plastics from agricultural residues** (e.g. rice straw) and **wind turbine blades with 100% recyclable composites**, eliminating waste at the end of product life – themes that continue from earlier this year. These **product-focused innovations** demonstrate how rethinking material design and composition can make **long-lived industrial products fully recyclable or biodegradable**, further closing the loop in the manufacturing system.

Policy Drivers and Global Collaboration

Finally, **governments and international organizations are actively driving sustainable production and consumption** through new policies and partnerships. In **Europe**, decades of circular economy strategies are entering a decisive implementation phase. The **European Commission's planned Circular Economy Act**, expected in late 2026, is positioned as a key pillar of the EU's *Clean Industrial Strategy* to reduce dependency on virgin resources and create a single market for secondary materials[19] The EU's goal of **doubling its circular material use rate to 24% by 2030** (from ~11.8% today) is projected to **cut climate impacts of material production by *roughly 50%***. This dovetails with other EU measures like a **strengthened "Safe and Sustainable by Design"** framework (adopted March 2026) to guide industry in developing **toxic-free, circular materials from the earliest R&D stages**.

Across the **Atlantic**, the United States is grappling with how best to regulate **chemical plastic recycling**. In April 2026 the U.S. Environmental Protection Agency (EPA) proposed **loosening Clean Air Act rules that currently treat advanced plastic recycling (pyrolysis) facilities as waste incinerators**, potentially reclassifying them as manufacturing plants[20]. Industry groups like the American Chemistry Council have lobbied for this change to facilitate scale-up of chemical recycling, whereas environmental advocates warn it could weaken pollution controls and endanger communities. The debate highlights the tension between *promoting circular technologies* and *ensuring rigorous environmental safeguards*.

On the **global stage**, collaboration is seen as key to accelerating circular transition. At the **World Economic Forum's 2026 meetings**, circular economy was framed as **"an economic and industrial strategy that belongs in the boardroom"**, not just an

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[19] https://www.openaccessgovernment.org/europes-circular-economy-act-has-entered-the-implementation-phase/209680/

[20] https://phys.org/news/2026-04-epa-ease-chemical-plastic-recycling.pdf

environmental imperative[21]. A recent survey found **nearly 80% of manufacturing executives worldwide now consider circularity important to their organization** (up from 36% three years ago). To harness this momentum, the **G7 nations** have launched a three-year action plan (2025–2028) focusing on circular solutions for **plastics, textiles, and critical minerals**, aiming to cut waste and greenhouse gas footprints in these key sectors. These developments underscore how **sustainable production and circular consumption have become mainstream global priorities** – aligning economic resilience with environmental responsibility.

Appendix

Title & (Source)	Date	Region	Relevance to Sustainable Production & Circular Economy
Single-atom catalyst boosts CO_2-to-methanol conversion *(ScienceDaily – ETH Zurich/Nature Nanotechnology)*	20 Mar 2026	Switzerland (Global)	**CO_2 utilization breakthrough**: ETH researchers developed an *indium single-atom catalyst* that converts captured **CO_2 into methanol** more efficiently than conventional catalysts. This *photocatalyst* design lowers the energy input to produce clean fuel from a waste greenhouse gas, advancing **carbon capture and use (CCU)** in sustainable chemical manufacturing.
Sunlight turns plastic waste into hydrogen fuel *(ScienceDaily – Adelaide Univ./Chem Catalysis)*	4 May 2026	Australia (Global)	**Waste-to-fuel innovation**: University of Adelaide scientists use **solar-driven photocatalysis** to break down **plastic waste** into **hydrogen** and other fuels. This **low-energy "photoreforming"** approach treats plastic

[21] https://www.weforum.org/stories/2026/03/circular-economy-economic-industrial-strategy/

			trash as a feedstock, producing clean H_2 and chemicals with help from sunlight – tackling both plastic pollution and energy needs in a single circular process.
New carbon material cuts energy cost of carbon capture *(ScienceDaily – Chiba Univ./Carbon)*	28 Mar 2026	Japan	**Low-energy CO_2 capture**: Researchers created **"viciazite" carbon adsorbents** with carefully arranged nitrogen groups, enabling **CO_2 to be released at < 60 °C** (versus >100 °C for current methods). This **waste-heat-driven CO_2 capture** design can dramatically lower the energy costs of capturing and reusing carbon emissions, making industrial carbon capture and utilization more viable.
Membrane reactor converts biodiesel waste to acrylic acid *(Univ. of Manchester – Chem. Eng. Journal)*	23 Apr 2026	UK (Global)	**Process intensification & upcycling**: A new **membrane-assisted reactor** uses porous **ceramic oxygenation** to convert **glycerol waste (from biodiesel)** into **acrylic acid** with ~**59% selectivity** – a ~10% yield increase over conventional methods. The intensified process also runs stably with **94–99% glycerol conversion**, offering a scalable, low-emission alternative to petrochemical production of acrylic monomers.
Engineered microbes upcycle glycerol to polymer feedstock *(TechXplore –*	19 May 2026	South Korea (Global)	**Bioprocessing milestone**: KAIST and Hanwha researchers engineered **microbes** to produce **1,3-propanediol (PDO)** – a

KAIST/Nature Chem. Eng.)			valuable polymer building block – from **biodiesel glycerol waste**. The fermentation ran at *300-litre* pilot scale without performance loss, demonstrating **industrial-scale bio-manufacturing** of plastics precursors from waste feedstocks. This success indicates viable **biotechnological routes** for replacing fossil feedstocks with renewable wastes.
Coffee waste transformed into high-performance insulation *(New Atlas – Shenyang Agri. Univ./Biochar)*	12 Apr 2026	China	**Waste-to-material innovation**: Scientists converted **spent coffee grounds** into a **porous biochar composite** that works as **eco-friendly building insulation**. The resulting panels have **sixfold better insulation** than cellulose alone – matching polystyrene's performance – and are fully bio-based. This *waste-derived insulation* offers a circular alternative to synthetic foams and could significantly reduce landfill waste and carbon emissions in construction.
Evonik & Vary Tech partner on "Carbon Loop" plastics recycling *(Devdiscourse – IFAT Munich 2026)*	11 May 2026	Germany/Singapore	**Chemical recycling collaboration**: At IFAT 2026 in Munich, **Evonik (Germany)** and **Vary Tech (China)** unveiled a **full-chain process to recycle mixed waste plastics into new chemical feedstocks**. The partnership launched **Carbon Loop Systems** in Singapore to demonstrate integrated **pyrolysis-to-**

			naphtha technology , aiming to produce stable, reusable oils and **sustainable fuels** from plastic waste. The project illustrates **international industry cooperation** to scale circular plastic solutions in Asia and beyond.
INEOS to build $1.7Bn low-carbon methanol plant *(F&L Asia – INEOS press release)*	30 Apr 2026	USA (Global)	**Industrial circularity in chemicals**: INEOS (UK) and Sandpiper Chemicals (U.S.) announced a **1.1 million t/yr "blue methanol" plant in Texas**. Using **natural gas + carbon capture (97% CO_2 removal)**, it will produce low-carbon methanol for fuel and chemical use, supporting **circular carbon usage**. The 2030 facility is expected to **cut CO_2 emissions** and help decarbonize chemical and shipping sectors while reusing captured carbon in **acetic acid production**.
EPA may ease regulation of chemical plastic recycling *(Phys.org/AP – U.S. Policy)*	15 Apr 2026	USA	**Policy & regulation**: The U.S. **EPA** signalled it may **reclassify chemical plastic recycling (pyrolysis) plants** as manufacturing facilities rather than waste incinerators. **Industry groups** favour the change (to ease permitting of new **advanced recycling** plants), while **environmental advocates** warn it could weaken required pollution controls. The debate underscores the challenge of **balancing regulatory**

			flexibility with environmental protection in enabling circular technologies.