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Beauty & the Bioeconomy

Economic and Environmental Potential at the Nexus of Cosmetics and Bioeconomy

BBIA
CHAMPIONING THE INDUSTRIAL BIOECONOMY

COSMETICS
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01 Introduction

Beauty is Big Business — and It's Going Bio

The beauty industry has always been more than skin deep — it's a powerful economic engine that continues to grow at a rapid pace. The cosmetic industry is one of the biggest industries in the world. In 2022 the market size of the global cosmetics market was valued at $300 Billion and is expected to grow to $418 Billion by the year 2030[1].

In the UK, in 2023 alone, the UK beauty sector, encompassing everything from skincare and cosmetics to haircare services and wellness treatments, saw a striking 11% growth, pushing total sales to £27.2 billion[2]. But beyond the surface, a quiet transformation is underway: the fusion of beauty with biotechnology.

Globally, the bioeconomy — the sector focused on sustainably producing bio-based products using renewable biological resources—such as plants, algae, and microorganisms — is poised for a dramatic surge. This shift offers an enormous opportunity for UK innovators to lead the charge in developing sustainable, science-driven beauty solutions.

From lab-grown ingredients and microbial fermentation to plant-based alternatives replacing petrochemicals, biology is rewriting the future of beauty. As consumers demand products that are not only effective but also ethical and eco-conscious, the intersection of beauty and the bioeconomy is emerging as a dynamic and promising frontier.

By harnessing nature and biotechnology, the industry is advancing toward more sustainable solutions across skincare, haircare, makeup, and fragrance. This innovation is transforming how products are made, packaged, and delivered—creating alternatives to fossil-derived ingredients, developing bio-based and biodegradable packaging, and reducing waste throughout the product lifecycle—all in alignment with the values of today’s conscious consumers.

Beauty shouldn’t cost the planet

Against this demanding backdrop, the beauty and personal care sector is facing a series of operational sustainability challenges. This includes the need to reformulate products, innovate packaging to increase recyclability and identify the key energy intensive aspects of operations to minimise their environmental impact at all stages of the product lifecycle[1].

The beauty industry has come under increasing scrutiny for its environmental impact[3]. One major area of focus is the sourcing and use of ingredients. Traditionally, many cosmetic and skincare products have relied heavily on petrochemical-based chemicals, such as mineral oils, parabens, and ethylene derivatives, which are derived from fossil resources and contribute to 10% global greenhouse gas emissions[3], pollution and resource depletion. These substances don’t simply vanish after use; they accumulate in waterways and soil, harming marine ecosystems, contributing to coral bleaching, and introducing volatile organic compounds (VOCs) into the air[4].

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[1] Fortune Business Insights, 2022
[2] The-Value-of-Beauty-Report-2025.pdf
[3] Sustainable carbon ambition for the UK chemicals industry - Innovate UK Business Connect
[4] The Environmental Impacts of the Cosmetic Industry | Earth.Org

In response, brands are increasingly shifting toward sustainable alternatives derived from plants. There is significant opportunity to expand the Controlled Environment Agriculture (CEA) sector into the production of high-value plant-derived compounds. This high-tech cultivation method enables the growth of plants under precisely controlled conditions, ensuring consistent, year-round yields of high-quality material. CEA systems have the capability to grow a range of raw materials to provide a scalable supply of valuable phytochemicals for the beauty and cosmetic industry, including essential oils for natural fragrances, plant-based pigments, and bioactive compounds with health-promoting properties. This approach is particularly well-suited for the large-scale production of metabolites with intricate biosynthetic pathways—such as flavonoids and saponins—which are often difficult and cost-prohibitive to replicate using alternative biotechnological methods.

These bio-based, and sometimes biodegradable, ingredients not only lessen the environmental footprint during production and use but also reduce harm to aquatic ecosystems once they are washed down the drain.

Green biotechnology is also playing a transformative role in reshaping the beauty industry's environmental impact. Through advances in engineered biology, companies can now produce high-performance ingredients in labs via fermentation processes using microorganisms like yeast or algae. Moreover, lab-grown ingredients offer consistency in quality and a lower carbon footprint, making them a viable path toward large-scale sustainability. This innovation allows brands to deliver potent formulations without compromising the planet's biodiversity.

For example, Squalene, which is traditionally derived from shark liver oil, is now produced sustainably through fermentation of sugarcane or yeast. Hyaluronic acid, a key hydrating ingredient in skincare, can now be bioengineered using bacteria instead of animal-derived sources. And natural pigments derived from algae or engineered microorganisms are replacing synthetic dyes, offering vibrant colours without harmful fossil-based chemicals.

Packaging remains one of the most visible and pressing challenges in the beauty sector. The use of plastic—much of which is non-recyclable—has contributed significantly to landfill waste and ocean pollution. The beauty industry churns out an astonishing over 120 billion units of packaging each year—most of it single-use, complex, and unrecyclable. Shockingly, annually only about 9% of that plastic is recycled, while up to 95% ends up as waste— with much of it destined for landfills or oceans[5]. These figures underscore how deeply packaging pollution is embedded in beauty's DNA.

In response, companies are exploring eco-friendly packaging solutions that prioritise minimalism, reusability, and materials that are biodegradable, recyclable, or compostable, being derived from materials like corn-starch, sugarcane, or agricultural waste. Bio-based and certified biodegradable and compostable plastics are being used to create packaging.

The bioeconomy also encourages a shift toward circular beauty, where waste is transformed into valuable resources. For example, fruit peels, coffee grounds, and other food waste can be upcycled into exfoliants, fragrances, or active ingredients. This approach not only reduces waste but also aligns with the principles of the circular economy.

[5] Refillable beauty packaging statistics and trends - Devera

Case Study: Bio-based Surfactants for the cosmetics industry

Holiferm is a UK-based biotech company that has emerged as a key innovator in the production of sustainable biosurfactants for the cosmetics industry. Leveraging a patented gravity-based fermentation process, Holiferm produces sophorolipids—mild, biodegradable surfactants derived from natural feedstocks such as rapeseed oil and glucose. These ingredients are particularly attractive for personal care applications due to their low irritation profile and compatibility with microbiome-friendly formulations. Holiferm's biosurfactants, are COSMOS-approved, EU Ecolabel certified, and recently achieved MyMicrobiome Standard certification for face and scalp applications. Holiferm's innovative approach is helping to accelerate the cosmetics industry's transition to cleaner, more sustainable ingredient systems.

Case Study: Engineering biology for performance beauty ingredients

Twig Bio, a UK-based biotech company founded in 2022, develops sustainable, high-performance ingredients for consumer goods, with a focus on cosmetics. Its AI- and automation-driven platform, twig:tech, rapidly designs and optimises microbial strains to produce cosmetic ingredients—like hyaluronic acid and acetone alternatives—via fermentation, avoiding petrochemical and animal-derived sources. This accelerates R&D, cuts costs, and enables scalable, eco-friendly production. For cosmetic brands, Twig offers cruelty-free, high-performance ingredients aligned with clean beauty and ESG goals. Backed by £3M in seed funding and top investors, Twig is emerging as a key innovation partner for future-focused cosmetics manufacturers.

Case Study: Pioneering Sustainable Beauty Packaging

Shellworks' flagship material, Vivomer, is a biodegradable, microplastic-free alternative to plastic, made from bacteria that ferment food waste. It mimics conventional plastic in appearance and feel but breaks down naturally in compost or the environment, leaving no toxic residue. This makes it ideal for beauty brands aiming for sustainable packaging without sacrificing design or function. By combining biotech with circular design, Shellworks is reshaping beauty packaging standards. Its work highlights a broader industry shift where sustainability is as vital as aesthetics and performance, positioning startups like Shellworks at the forefront of change.

02 Challenges for the Beauty Sector

For many years, the cosmetic ingredients industry has been using bio-based materials and biotechnological processes such as fermentation, enzymatic transformation, and biomass processing, to manufacture ingredients such as bio-actives, chassis and formulation aids. However, several challenges are faced when bringing these products to market.
On the consumer side, demand for sustainable products is growing rapidly. Shoppers are increasingly scrutinising ingredient lists, seeking out eco-friendly packaging, and supporting brands that prioritise ethical sourcing and sustainability. However, the commercialisation journey for bio-based cosmetics is not straightforward, with several challenges to be overcome.

Technological Challenges

- Production Efficiency: Scaling the production of bio-based ingredients, such as biopolymers or biotech-derived actives, requires optimised fermentation processes and downstream purification methods to achieve consistency and quality at scale.
- Supply Chain Complexity: Ensuring a reliable supply of raw materials (e.g., plant-based feedstocks) can be challenging, particularly if they compete with other industries or face seasonal availability.
- Formulation Compatibility: Incorporating bio-based ingredients into existing cosmetic formulations without compromising performance, shelf life, or sensory attributes can be technically demanding.
- Ingredient Continuity Risk: Reliance on single-source biotech ingredients can jeopardise long-term product viability if the supplier exits the market or scales back production.

Economic and Financial Constraints

- High Costs: Producing bio-based ingredients often involves higher costs compared to synthetic alternatives due to expensive feedstocks, R&D, and manufacturing processes.
- Investment Gaps: Scaling from pilot to commercial production requires significant capital investment, which can be challenging to secure without established market demand or government incentives.
- Market Competitiveness: Competing with well-established synthetic ingredients on price while offering superior or equivalent performance remains a major obstacle.

Infrastructure and Circular Economy Gaps

- Packaging Innovation: Bio-based and biodegradable packaging solutions need scalable recycling or composting infrastructure to ensure they achieve their sustainability potential.
- Waste Management Systems: Limited end-of-life infrastructure for compostable waste means products may not be fully recycled as they are intended to be.
- Integration into Circular Systems: Establishing robust systems for upcycling cosmetic waste and by-products into valuable feedstocks is still in its infancy.

Market and Consumer Challenges

- Consumer Education: Educating consumers on the benefits of bio-based cosmetics and distinguishing these from "natural" or "organic" products requires targeted campaigns to overcome misconceptions.
- Demand Uncertainty: While interest in sustainable products is growing, it is uneven across demographics, and willingness to pay a premium for bio-based cosmetics is not universal.
- Brand Risk: Introducing bio-based alternatives involves a degree of uncertainty and potential risk for established brands, especially if performance or aesthetics deviate from consumer expectations.

Investment and Risk Capital Constraints

The biotech sector, particularly SMEs and start-ups, suffers from limited access to risk-tolerant capital and fragmented innovation support. This issue is especially acute for cosmetic ingredient developers, who are often excluded from biotech investment schemes due to sectorial biases toward pharma or agri-food applications.

Fragmentation of Biotech clusters and underutilised capacity

The fragmentation of biotech efforts across the UK leads to inefficiencies and underperformance in the UK's biotechnology value chain. This is especially true for bio based cosmetic ingredients, where duplicated or disconnected regional clusters often fail to translate R&D into market ready solutions at scale.

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However, the industry faces challenges in fully integrating the bioeconomy into its operations, due to evolving regulatory landscapes, which aim to balance consumer safety, environmental sustainability, and market competitiveness. The complexity and divergence of regulatory frameworks hinder the growth and competitiveness of biotech-based innovation, particularly for SMEs and sectors like the cosmetic industry.

- **Lack of Established Frameworks for Novel Ingredients**: Regulatory frameworks have not kept pace with biologically engineered ingredients, leading to uncertainty that slows innovation and market entry.
- **Complex Safety Assessments**: Evaluating allergenicity, immunogenicity, and long-term effects of biotech ingredients demands innovative methods like advanced toxicology and -omics technologies. While essential, these approaches can delay approvals.
- **Blurring Lines Between Cosmetics and Therapeutics**: Ambiguity in regulatory definitions and claim language creates confusion among manufacturers, testing labs, and consumers regarding product classification.
- **Evolving Testing Methods**: New Approach Methodologies (NAMs) offer robust, ethical alternatives to animal testing, enabling more reliable data and moving beyond anecdotal product claims.
- **Public Perception and Consumer Trust**: Transparent communication about the safety, benefits, and sustainability of biotech ingredients is critical to overcoming misconceptions and building consumer confidence.
- **Redundant Safety Reviews Across Sectors**: The same biotech-derived substances, such as those from microbial fermentation, often undergo duplicative safety assessments when used in both food and cosmetics.
- **Inconsistent Ingredient Classification**: Diverging definitions and criteria for biotech ingredients hinder cross-sector harmonisation and market access.
- **Disproportionate Impact on SMEs**: Small and medium enterprises face greater regulatory burdens, including higher compliance costs and delayed time to market.

[6] Fortune Business Insights, 2022

04 Priorities for the Beauty Industry Moving Forward

Cosmetic ingredients represent an agile, innovative-driven application area with a short development cycle and high consumer acceptance, making them ideal candidates to pilot streamlined biotech approval pathways. To navigate these challenges and unlock the potential of the bioeconomy, the beauty industry must prioritise:

- Developing robust regulatory frameworks for novel bio-based ingredients.
- Investing in scalable and innovative safety assessment methodologies.
- Enhancing consumer education to build awareness and trust.

Recommendations:

1. **Enable Risk-Based, Cross-Sector Regulatory Alignment**: Align regulations across sectors for well-characterised biotech systems (e.g., microbial fermentation) to reduce redundancy and improve efficiency.
2. **Establish Clear, Updated Guidance for Biotech Ingredients**: Provide predictable regulatory pathways for cosmetics, including ingredients from fermentation, enzymatic synthesis, and GMO-based platforms, including ingredients from raw plant material, fermentation.
3. **Avoid Sectoral and Technological Bias**: Ensure cosmetic biotech is included in future streamlined regulations, avoiding exclusion due to narrow focus on food, pharma, or legacy chemical models.
4. **Support Science-Based Policy on GMOs**: Recognise the safety and sustainability of contained-use GMO platforms and avoid blanket exclusions that undermine industrial biotech capacity.
5. **Leverage Cosmetics as a Strategic Biotech Sector**:
    - Acts as a **fast-moving, consumer-facing market** with global demand.
    - Serves as an **early adopter and testbed**, de-risking new technologies.
    - Functions as a **bridge sector**, enabling scale-up of fermentation and synthetic biology.
    - Provides **diverse biotech applications**, from bioactives to chassis ingredients.
    - Supports **pilot-scale validation** for broader industrial use.
6. **Increase Supply Chain Visibility:** Establish collaborative communication between cosmetic companies, formulation experts, and bioeconomy ingredient suppliers — including CEA growers—to facilitate challenge-driven sustainable innovation.
7. **Ensure Equitable Access to Funding**: Include cosmetic biotech in national biotech funding, IPCEIs, and strategic tech platforms.
8. **Promote Public-Private Innovation Models**: Use cosmetics as scalable entry points for biomanufacturing, supported by pilot funding schemes.
9. **Accommodate Diverse, Evolving Production Pathways**: Recognise hybrid chemical-biological processes and sustainable feedstocks like agri-residues and marine biomass.
10. **Position Cosmetics as a Demand Anchor**: Harness the sector's constant need for innovation and sustainability to drive scale-up across UK biotech.

About the BBIA

The BBIA exists to champion the industrial bioeconomy to accelerate the development and adoption of bio-based and biodegradable materials and products through advocacy, collaboration, and education. Our vision is for a more sustainable future, where the UK is a global leader in developing, manufacturing, using and exporting bio-based and biodegradable solutions.
www.bbia.org.uk

About the Cosmetics Cluster UK

Founded in 2020, Cosmetics Cluster UK (CCUK) is a membership-based networking association and the only cluster for the cosmetics sector in the UK. Our purpose is *'connecting the beauty industry supply chain'* and we are united under our Beauty & The Bioeconomy pillar by a mission to integrate bio-based ingredients into the UK beauty supply chain.
https://www.cosmeticsclusteruk.com/

About the Beauty and the Bioeconomy Taskforce

Led by the Bio-based and Biodegradable Industries Association (BBIA), and the Cosmetics Cluster UK (CCUK) the Beauty & the Bioeconomy Taskforce has been launched to collaboratively identify and address the challenges faced by innovators in the beauty sector. This cross-sector initiative brings together a dynamic steering committee of stakeholders committed to advancing sustainable innovation. Steering committee members include (Chairs in bold): **BBIA, CCUK, Twig Bio, Holiferm**, Warden Agri, SOAS, Algisys, UK AgriTech Centre, Scott Bader, UKRI-BC, Potter Clarkson, UK-CPI, Saraco-Industries, and THG Labs.