

Biotechnology:

personal care market report



Introduction

Within the global chemicals industry, the personal care sector is a bright spot when it comes to switching from fossil fuels to bio-based ingredients. Aside from food, personal care has the highest bio-renewable raw material intake of any chemicals-using sector. In many ways it is a pioneer of the move towards a more innovative approach to the sustainable extraction, manufacturing, and use of chemicals.

There are numerous positive benefits to personal care products – not least hygiene, health, and mental wellbeing – so in this market, positive perception and reputation are everything. Innovation and sustainability are priorities for maintaining both. That is largely driven by the demands of consumers. People are increasingly looking for products that align with their values so they can live them through every aspect of their lives.

This is why a growing percentage of people buying personal care products want them to be high-performing, novel, and based on sustainable ingredients that are ethically sourced. And they want a detailed understanding of the product origins – all whilst requiring products to match their sensorial and cosmetic expectations. They also want to know that the products they buy are safe. The choice available to consumers is so vast that the more a product can fit these needs, the more chance it has of attracting and retaining their attention. This is particularly the case with younger ‘Gen Z’ customers who are incredibly purpose-led and interested in brands that meet their own values.

That matters because even in such a forward-thinking innovative industry, bio-based raw material still only account for around 45% of the total feedstock used¹. The majority of ingredients are compounds derived from non-biological sources – specifically petrochemicals. It suggests that products are not as natural as perhaps consumers believe. But it also shows that plenty of bandwidth remains for high-performing bio-based ingredients to expand their role, many of which could be derived

using innovative biotechnology processes.

For some ingredients, including some higher-volume items, the move to bio-based is challenging, but there are plenty of others where it may be possible. Some of those could occur naturally but may still run the risk of endangering biodiversity. It is therefore more likely that a more innovative approach using biotechnology will be the preferred way to derive the specific characteristics required by different products.

That is not going to be easy. Whilst biotechnology capabilities have continued to grow and develop, the approach still remains niche in its abilities and subject to various challenges including performance, cost, production at scale, and sustainability.

What is clear is that if these barriers can be reduced or overcome, personal care companies will be able to find smarter ways to meet the growing performance and sustainability requirements of their consumers, either through brand new biotechnology-derived ingredients or equally effective biotechnology-derived replacements for those already in use.

This report will explore where biotechnology already plays a significant role in the personal care industry; its potential to become the innovative new toolset of choice that helps companies address the expectations of consumers; the barriers currently preventing that from happening at sufficient scale; and recommendations for how those barriers can be reduced or removed. Our hope is that this document begins a different conversation about the crossover between personal care and biotechnology – one which seeks to maximise the potential that this completely different set of innovative tools and techniques can offer.

¹RoadToBio Strategy Report: Current Status and Drive for Bio-Based Chemicals/Products in nine Product Groups in the EU Chemical Industry - 2019.

What is biotechnology?

For the purposes of this report, we define biotechnology as the use of non-animal living organisms' cellular and biomolecular processes to develop products for industrial use. Biotechnology takes advantage of the ability of certain living organisms to take in a substance or substances and, via their inbuilt biological processes, convert them into useful industrial products.

It opens the possibility for a wide range of new ingredients to be derived from biological feedstocks, that could replace ones that require chemical manufacturing processes or are derived from petrochemical feedstocks.

Whilst there is a variety of terminology in use across the personal care sector, for the purposes of this report we will be using two main key terms:

Bio-based products/ingredients – products/ingredients derived from non-animal living and renewable materials such as crops. The means by which these raw materials produce products/ingredients include both chemical and non-chemical processes.

Biotechnology-derived products/ingredients – these are also derived from non-animal living raw materials but are converted into products/ingredients solely through biotechnology processing.



Biotechnology in personal care

What do malaria treatments and skin cream have in common? Answer - they can both contain Squalene oil, a highly effective moisturizer that occurs naturally in human skin. It is a highly prized and hugely effective ingredient. It can help save lives when being used as part of a treatment for a disease that kills more than 600,000 people a year². And it can also help improve the efficacy of other ingredients it is paired with in beauty products, making it significant for the skin care sector.

Until recently, obtaining some Squalene oil involved harvesting shark liver – an unsustainable and expensive practice. But today biotechnology can be used to create Squalene oil using molecules derived from sugarcane using fermentation. More than two million sharks have already been spared in the production of cosmetics as a result of this innovative approach.

The use of biotechnology for personal care products is by no means a new development or restricted to niche players. Japanese skincare giant Shiseido was an early adopter of biotechnology in the 1980s. Notably, it was the first to create bio-hyaluronic acid at a time when competitors were extracting it from roosters' combs. Estée Lauder Companies recently embarked on a partnership to explore new anti-ageing molecules using biotechnology. And L'Oréal has signed a licensing agreement with a biotech firm specialising in

bacteria, to utilise their expertise for innovative product development related to the skin's microbiome. Even the development of peptides and ceramides in the 1970s that have revolutionised the industry, stem from biotechnology.

Over the past thirty years, blending advanced technology with natural raw materials has become more common and is now a regular source of new and replacement ingredients in the personal care industry. As standards of beauty have changed, so have the technology and innovation capacities we can leverage in their pursuit. At the same time, the boundaries between biotechnology and health care have started to erode and the technologies and approaches familiar for developing biopharmaceuticals have spilled over into other industries, including cosmetics. Here this has led to the establishment of 'cosmeceuticals' – which blend the two fields together and blur the lines between cosmetics and pharmaceuticals.

This is all enabling personal care companies to use biotechnology as a new toolset to discover bio-based ingredients that perform equally or better (offering new unique performance) than their petrochemical-derived alternatives, all whilst being more sustainable. This includes some game-changing anti-ageing products such as resveratrol and plant extracts.

² World Health Organisation Malaria Factsheet – 2022



Bio-based vs biotech?

It is a reason why personal care products now contain more bio-based ingredients. Current estimates suggest that bio-based products could now account for up to 40% of the personal care ingredient list⁴. And whilst it is challenging to replace petrochemical-derived ingredients entirely, bio-based options are gaining ground. For example, petroleum-derived preservatives such as parabens and formaldehyde donors are starting to be phased out due to safety concerns and regulatory requirements. The industry is now actively looking for bio-based substitutes – albeit as small volume additives in this case.

However, harvesting organic raw materials to create bio-based alternatives to petrochemicals is not the only way to find new ingredients. Many of these bio-based ingredients could potentially be derived from a number of novel processes, and biotechnology is a field containing many of the most important. Likewise, many existing petrochemical-derived ingredients that have failed to find bio-based alternatives may yet find answers in biotechnology.

This is important for an industry where the drivers for changes in consumer demand for bio-based products may be better-addressed by taking a new route rather than relying on existing ones. That puts pressure on personal care companies to continuously seek out new suppliers with biotechnology capabilities, or to invest in their own.

Either way, whilst the shift from petrochemical-derived ingredients to bio-based ingredients is recognised and established, the scale at which biotechnology can play a role in that change remains uncertain. Answering that question is fast becoming essential as the industry seeks out new ways to achieve the necessary but delicate balance between performance and sustainability through innovation.

⁴RoadToBio Strategy Report: Current Status and Drive for Bio-Based Chemicals/Products in nine Product Groups in the EU Chemical Industry - 2019

Biotechnology drivers and opportunities in personal care

The driving force behind product development decisions in personal care is consumer buying patterns. Unusually, these are shaped less by cost than just about any other variable⁵. Drivers considered more influential than product pricing are product performance and product sustainability.

Advances in these areas not only create appetite for new products but strong brand reputations too. This is vital because choice is considerable so competition is high and in the digital age the negative impact of a single ingredient can destroy market share in a matter of hours. The impact of reports in early 2022 that hair product Olaplex No.3 contained butylphenyl methylpropional, banned in the EU due to its potential effect on fertility, are testament to the damage a single viral video from an uninformed influencer can impart. So maintaining a

positive external reputation in these areas is critical for players this market.

The good news is that bio-based ingredients have the potential to enhance both of these consumer priorities, which is why company marketing strategies continually leverage the renewable nature and performance of novel bio-based options. But whilst these ingredients can be equally or even more effective, and certainly more sustainable than those derived from petrochemicals, many of the approaches used to extract ingredients from living raw materials can still require more trade-offs than using biotechnology. This is why this report considers product innovation, performance and sustainability not just as drivers for the use of bio-based ingredients, but for using biotechnology as a way to produce them too.

⁵Cosmetics Europe 2017 – Consumer Insights 2017



Innovation

Whilst biotechnology is not new it remains one of the most innovative ways in which to create novel personal care products whilst addressing sustainability concerns. Companies have been using bio-based ingredients within their products for decades, but they have been limited by the boundaries of what traditional chemistry can create. Biotechnology changes that significantly in two ways.

Firstly, it provides a completely different toolkit with which to explore the molecules that can be obtained from existing living organisms. We know that traditional chemistry already provides a way to produce certain ingredients, but it can require the use of catalysts, solvents, and raw materials that are not sustainable. The number of those ingredients that

can be produced through biotechnology processes instead, such as fermentation and bioprocessing, is growing. There is considerable potential for more bio-based alternatives to be produced than ever before and biotechnology is the key to finding them.

Secondly, it provides a way to discover bio-based ingredients from new and existing natural feedstocks. The use of biotechnology to replace existing petrochemical-derived ingredients is only half of the story. In an industry that constantly needs to innovate and improve product performance, the opportunity biotechnology provides to answer questions that the sector has never been able to solve through chemistry alone is huge.

This is largely because biotechnology expands the number of living raw materials that could be the starting point for brand new ingredients with new capabilities. With so many species of flora on land and in the sea, and such a variety of microorganisms available for use in biotechnology processes, the potential for this approach to uncover replacements for fossil-fuel based ingredients, or develop novel molecules that enable entirely new product properties, is significant.

Biotechnology also has the potential to change the entire manufacturing process – making it faster, more powerful, and considerably more sustainable. Some companies are already powering some of their own manufacturing sites using

the gas created by enzymes used in their biotechnology processes.

Another advantage of biotechnology-derived bio-based molecules is that they can be adapted to be more potent and therefore more effective. One of the most recent bio-hyaluronic acids now dissolves in both water and oil, so it penetrates better through oily skin and is absorbed deeper for more intense hydration. This was achieved purely through laboratory research and development to tailor ingredients at the molecular level. Similar processes can be used to allow new product delivery systems to be created, by tailoring ingredients with specific functions in mind – for example, growth factors or peptides for anti-ageing.



Sustainability

Deriving ingredients from biological feedstocks rather than petrochemicals is often a more sustainable option. But the source of those biological raw materials and the way in which they are processed into useful ingredients still has a significant bearing on how they affect people, society, and the environment. That is why biotechnology's ability to create bio-based ingredients without endangering biodiversity is attractive. For example, plant cell culture can be used to extract cells from one plant and use them to produce larger amounts of specific ingredient, rather than potentially having to harvest huge amounts of crops to achieve the same outcome.

Biotechnology processes such as fermentation and plant cell culture take place in sterile and confined environments. The ingredients that emerge provide the best way of sourcing new bio-based products with a lower environmental impact.

Sustainability does not start and end with environmental impact though. Consumer attitudes and concerns around

sustainability are evolving and now span a much wider definition, encompassing ethical supply chains; diversity and inclusion; gender equality; and the equitable sharing of benefits.

Today's consumers are far more interested in learning about what goes into making their products than previous generations, leading to a growing demand for better safety and transparency and much closer interrogation of upstream raw materials. Where once the question was "is this ingredient plant based?" it is now frequently "where does that plant-based raw material come from? Which country? Which region? How is it sourced? What impact does it have on biodiversity? Is there an equitable sharing of benefit in the supply chain through which you receive it?"

As a result, personal care companies now have industry-leading sustainability programmes that cover all these areas and more, but they constantly need to remain relevant to changing consumer demands. Biotechnology can help maintain and even enhance their credibility. The use of controlled processes limits the complexity of the supply chain

and the number of points where threats to sustainability and equality could materialise. So, as the demand for greater transparency grows, greater control over the source of raw materials and the processes by which they become bio-based ingredients will be

vital as companies fight for market share. Biotechnology is a way in which that control can be increased.

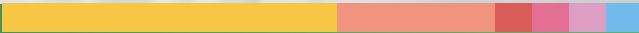


Performance

The natural world is not a controlled environment geared towards supporting the production of precise molecules performing predetermined functions. Sterile environments such as laboratories are, and they can guarantee the quality and enhance the performance of the ingredients they produce.

Subtle changes in growing conditions can cause issues with naturally sourced ingredients and lead to fluctuations in crop volumes and how much can be extracted from each harvest. But because biotechnology processes use a controlled environment, the ingredients they produce have the advantage of not being subject to these uncontrollable variables. This means biotechnology can produce a more consistent product, and the resulting ingredients can be purer and deliver more stable potency, which is why they are usually stronger than those obtained through classical methods. For example, using cell cultures in a bioreactor can, in some cases, provide a concentration of molecules of interest that are up to 100 times higher than a typical natural extract.

Personal care companies now no longer need to settle for natural performance alone. Biotechnology's ability to tailor inputs and outputs means that the molecules produced can be fine-tuned for efficacy improvements. For example, tailored microbes can synthesise active ingredients with higher reliability and better quality control. Because they are grown in a controlled and sterile environment, R&D teams can engineer their growth and development to prevent the likelihood of impurities and irregularities—a common challenge among farmed, mined, and naturally sourced ingredients, which can compromise performance.



Barriers

Whilst the benefits of biotechnology are being more widely recognised, incorporating it into the personal care industry is not without its hurdles. There are some specific issues preventing companies from fully exploiting biotechnology's potential to improve innovation in this market.

This report highlights four that represent the most significant challenges hindering biotechnology's shift from a niche toolset to a fundamental component of progress in the move to bio-based ingredients. They are: industrialisation; specialised skilled workforce; confidence in feedstock supply; and personal care customer/end consumer understanding.

Industrialisation

An inability to industrialise is holding biotechnology back. Granting the personal care sector access to an entirely new set of innovative product capabilities requires biotechnology processes to be delivered on an industrial scale. Several approaches are showing credible promise, but none are available at the magnitude required to compete with alternative petrochemical routes.

This is due to a combination of cost and complexity. The process of moving from lab to production is extremely challenging and as volume increases it becomes harder to manufacture products this way. Even for the largest businesses, which have significant manufacturing experience, it can be very difficult to go past certain volume thresholds when it comes to some biotechnology-derived ingredients.

In addition, to support product scale-up and technology development, pilot/demonstration plant operation is often the most reliable way to generate the data needed to design equipment and scale it up. Once successfully trialled/modelled in laboratory conditions, the finances and expertise required to grow to industrial production are significant, limiting access to only the few larger companies with the resources to commit. It will naturally therefore limit the technology options selected, which will ultimately restrain levels of innovation in the sector.

Without sufficient support, particularly from governments, the challenges associated with moving biotechnology to an industrial scale will become significant barriers. They will limit the variety of innovative new ingredients for personal care companies, and the amounts of each that can be created.

Specialised skilled workforce

Biotechnology is a niche field of technology where the skills required to succeed are a complex blend of technical and non-technical expertise. That makes it a difficult environment in which to hire the right people and build the right teams. While biotechnology has always been highly specialised, more recent innovations in technology, methodologies, as well as in related disciplines such as gene editing, pharmacogenetics or immune-biotechnology, have made the industry even more complex, with not enough talent in these nascent areas to go around.

This is being exacerbated by the growth of the sector itself. In 2018, biotech startups raised just shy of \$29 billion globally according to Crunchbase data, up from \$19 billion in 2017. This cash infusion is fuelling biotech expansion across the world and emboldening startups to scale much more aggressively than ever. Hiring has therefore expanded and accelerated making it a more competitive market for those trying to find the right talent.

And it isn't only a tug-of-war within the core biotechnology industry.

Successful biotechnology programmes clearly require some specific technical skills – such as tissue culture; gel electrophoresis; and mass spectrometry, as well as knowledge of a raft of different organisms, genus, and families.

Some of the skills needed go beyond science, especially when it comes to the manufacturing expertise which is highly specialised when taking concepts from lab to production; and upper management positions, which require that candidates know how to work with partners around the world, manage and mentor people and please investors as well as corporate boards.

Biotechnology companies also need technology skills; commercial skills; and marketing skills to fully capitalise on the growth of the sector. They are now competing with more than just biotechnology businesses for talent. In the technology space for example, the adoption of artificial intelligence and big data analytics means biotechnology employers are now in direct competition with companies like Apple and Google for talent, which is a battle that can be difficult to win.

Confidence in feedstock supply

Having the infrastructure to put bio-based feedstocks through biotechnology processes is one part of the challenge. Having sufficient feedstocks to fuel the demand is another. Today, the majority of raw materials used in biotechnology processes are crops. And most of the world's crops are grown for food. A tiny percentage are grown to produce chemicals and an even smaller amount of those are used in the personal care market. Unsurprisingly, the global demand for food far outstrips the global demand for biotechnology-derived products. Crops to feed people and

animals must take priority. This means the security of crop availability for biotechnology processes will always be in question, reducing confidence in the ability of biotechnology to perpetually meet demand.

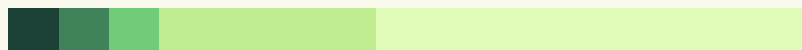
Although most biotechnology-derived products are currently used in very small amounts in personal care products, often as active ingredients rather than larger volume commodity or chassis ingredients, this remains an issue for biotechnology's wider adoption as a new toolset to stimulate innovation.

Consumer understanding

The manner in which the public perceive any new technology will have important influence on the timing and direction of innovation, and the rate of uptake.

We have already highlighted how consumer demand for more innovative yet sustainable products is driving the growth of biotechnology in personal care. Yet whilst conscious consumerism is on the rise, the understanding of biotechnology may not be keeping pace. One of the big hurdles today is the erroneous perception that biotechnology is bad, largely driven by poor communication around genetic modification in agriculture many years ago.

The very term 'Biotechnology' elicits a range of emotions, from wonder and awe to fear and hostility. These emotions indicate just how poorly understood the field is and the need for more accurate, dispassionate information in the public sphere to allow a rational public debate on the actual, as opposed to the perceived, risks and benefits. Put simply, most consumers do not understand what biotechnology is and what it is not. That needs to change if companies want to use more biotechnology-derived ingredients in their beauty products moving forward.





Recommendations

In any innovation-driven environment there will be barriers. Many of them can be overcome. In this section we propose a series of recommendations for changes that could release the full potential of biotechnology to drive greater innovation in the personal care industry.

FMCG manufacturer partnerships

The growth of biotechnology-derived ingredients must be underpinned by a tighter partnership between businesses on both sides of the commercial contract, and in academia, where open innovation can thrive.

Those creating and supplying novel ingredients must work hand in glove with personal care companies to ensure that introducing more biotechnology processes to the sector is driven by market demand.

For some time, specialist biotechnology businesses have been developing exciting new compounds and opening them up for market application. That needs to be switched around if biotechnology's role in innovative product design is to be fully explored within this sector. It must be driven by market demand and this requires greater engagement from personal care manufacturers at the design stage to ensure consumer expectations filter through to innovation processes in sufficient detail to underpin the next wave of

biotechnology-derived products.

This report recommends that an independent biotechnology and personal care working group be established, designed to bring together FMCG manufacturers and suppliers to exchange information in a more structured way. Businesses with biotechnology capabilities can share their latest science and technology innovations in the field, whilst personal care companies can share the latest consumer trends. Whilst this could become a forum for catalysing commercial relationships it would actually be designed to be something very different – a safe space where competitors and partners alike can share information and ideas collegiately without the threat of losing competitive advantage. Government representation in this working group would help make sure any public investment in, or strategy for, biotechnology is directed primarily by industry growth and economic return.

A national strategy backed with sufficient public investment

The current reliance on larger companies to fund the development of biotechnology infrastructure suggests that public sector support could play a part in the coming 5-10 years. There is no doubt that the challenges associated with scaling the sector are holding biotechnology back. This is why public investment is needed at a national level. This is not just about funding sustainability gains. Biotechnology processes were in use long before the advent of conscious consumerism and the drive for a more sustainable way of life. It is about funding a huge source of future innovation. More than any other outcome from the rapid growth of this industry, it is

biotechnology's ability to offer a new toolset with which to design, create, and produce new products and services that make it so important.

The argument for central funding, therefore, is that biotechnology represents huge potential for any economy and as an underpin for industry innovation. That will require a coordinated strategy that all parties can get behind and participate in. It would bring greater coherence and focus to a fragmented industry, and greater clarity about the outcomes of a mature world-leading biotechnology sector for any world economy.

Reduce reliance on food crops

As growth in the demand for biotechnology-derived products increases, so will the demand for bio-based feedstocks. Sourcing the majority from food crops can only be part of the long-term plan, because feeding people will always take priority over finding new cosmetic products and there are simply not enough food crops available to cover both. Bio-based feedstocks therefore need to be primarily sourced from areas that do not interfere with food production.

Thankfully, food crops are not the only source of bio-based feedstocks that can be used in biotechnology processes. Many microorganisms and plants other than food crops have the potential to produce biotechnology-derived products but remain largely unexplored. Diversifying into these areas could unlock an enormous variety of new products. Access to renewable aquatic biological organisms to make products is a particular area of opportunity that is already being explored but requires greater attention. Mankind now has the underwater technology to explore the sea and undertake DNA sequencing to analyse its life. More exploration of the sea biodiversity could enable us to develop new ingredients or industrial enzymes.

And why restrict feedstocks to fresh organic materials? Alternative options may become available if research into using waste streams such as waste cooking oil, waste water from industrial processes, or food waste continues to gather pace. Unfortunately these 'second generation feedstocks' are still at an embryonic stage, and the majority of activity is within academic

circles rather than industrial ones. And there are significant barriers to success. Waste oil tends to be a mix of different types of oil, making it necessary to filter and purify before a workable product can be delivered; food waste is seasonal – the volume of strawberries consumed in summer is likely to outstrip that in winter, reducing consistency of supply; and waste water will usually contain many contaminants that could inhibit growth and production. But the potential benefits are still considerable. second generation feedstocks are incredibly sustainable as their carbon footprint is near zero. They would reduce cost as reusing and recycling is often cheaper than starting from scratch. And they would stimulate yet more innovation – this time focussed on the process of purifying and filtering waste through new or adapted biotechnology processes that deliver high quality end products.

This report makes two recommendations to supplement the use of food crops. First, it recommends that industry, academia and government collaborate (potentially through the biotechnology and personal care working group outlined above) to support and accelerate research into 2nd generation biotechnology feedstocks. Secondly, and to support the first recommendation, it suggests that any integrated strategy created to support the growth of biotechnology, should incorporate a drive towards feedstock diversification. This will provide a political impetus for this fragmented industry to rally around a common barrier to success.

Scaled by design

If the most promising demonstrations of delivering biotechnology processes at an industrial scale are from large companies, then partnering with them makes sense for the array of smaller biotechnology businesses seeking to gain access to the personal care market.

This has the potential to offer a win-win for both parties. Large personal care companies get exclusive or early access to new ingredients they can offer to consumers,

and specialist biotechnology firms get to overcome the barrier of scaled production at a fraction of the cost of building their own infrastructure. Done correctly, businesses at both ends of the chain could build 'scaling up' into the design process and benefit hugely.

Both sides should be encouraged and incentivised to connect in this way by personal care companies seeking greater access to innovative ingredients. One proven model already exists in the defence

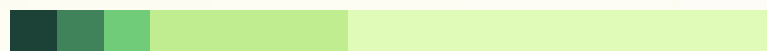
community, whereby a large customer (the MOD) incentivises its main suppliers to collaborate by giving preferential treatment to those that integrate SMEs into their equipment and services offerings. Likewise, personal care companies can prioritise working with large businesses that do the

same when it comes to biotechnology-derived ingredients. This would have a significant influence on the variety of products available, and the speed at which they can be offered to the market.

Build teams, don't hire people

The challenge of finding skilled individuals to support the growth of the sector is best tackled by not hiring individuals in silo, but by building multidisciplinary teams that function as a unit from day one. The complex mix of capabilities required to succeed in this sector means technical skills, marketing and communication skills, research skills, and management skills all need to be brought together to create high performing teams. Building those teams by hiring individuals and then trying to turn them into cohesive units is far harder than designing the right team to deliver successful biotechnology programmes, and then populating that team with talent.

The diverse spread of skills required also means that companies need to cast their nets wider and in more exciting ways to attract the right talent. This is a competitive landscape and building multidisciplinary teams means using a variety of methods to attract attention from a range of people with very different backgrounds and expectations. Hiring science graduates is very different from hiring data scientists or marketing managers. Yet each have their role to play in the successful development of biotechnology processes from research and development, to commercialisation and engaging FMCG customers.



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