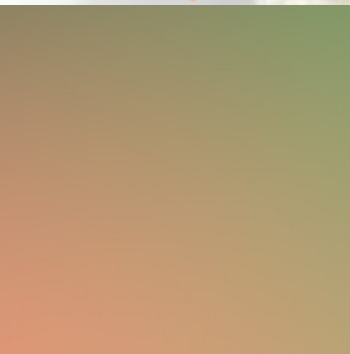
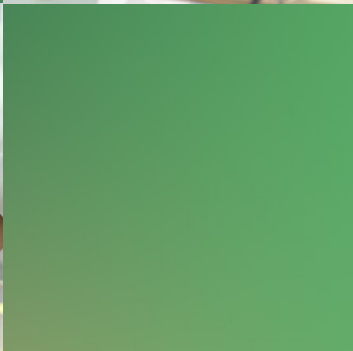


Biotechnology:

fragrances market report





Introduction

In the famous novel “Perfume”- a virtuoso fragrance maker dreams of concocting a fragrance so indescribably good that whoever smelled it would fall in love with him to the point of insanity. Fiction, of course but not that far off the mark. For though the medicinal powers of fragrances have fallen out of favour, the capabilities they have to alter moods and enhance wellbeing are still utilised by modern scent-makers for everything from fine perfumes to laundry detergents and floor cleaners. Many manufacturers run rigorous trials to gauge the emotions and memories inspired by their fragrances. Those that arouse fear and loathing are unlikely to become ingredients in best-sellers. The technology of odours is therefore big business.

Like any industry, consumers dictate the direction of travel when it comes to fragrances. Today, sustainability is growing rapidly on their agenda. So replacing petrochemical-based products with bio-based alternatives constitutes a growing percentage of research and development. Some can be found in nature but they can be hard to control and unpredictable to formulate with. Many will need to be sourced through more innovative approaches. This is fueling a greater interest in biotechnology as a potential route to achieving innovative new developments that satisfy both growing consumer demand and corporate objectives.

As a result, the fragrances sector has become one of the most promising areas for biotechnology innovation. What is a niche option for incremental sustainability gains today, is expected to be a fundamental toolset for future innovation as the search for bio-based ingredients that can match the performance and efficacy of those currently based on petrochemicals continues to gain momentum. In time

it is also hoped biotechnology will offer brand new ingredients that can extend the perfumers’ palette beyond that which traditional chemistry can provide.

Today, fragrances with ingredients derived through biotechnology only account for a small percentage of those available for use in product formulation. There are still many barriers that need to be overcome if their role is to grow, including cost; the ability to achieve production at scale; and overcoming the complexity of using them in the formulation process.

If these barriers can be reduced or overcome, we can expect to see a rise in the number of new fragrances built using biotechnology and designed to meet the growing sustainability and performance requirements of consumers.

This report will explore biotechnology’s opportunity in the fragrances industry; the potential it has to help companies address the product and reputational expectations of their customers; 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 contributes to the emerging conversation about the crossover between fragrances and biotechnology – one which recognizes the limits to what biotechnology can achieve in this space, but also seeks to maximise the potential that does exist.



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 home 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 drivers and opportunities in the fragrance industry

The grapefruit industry is suffering its biggest squeeze for decades. In Florida, a global centre for grapefruit harvests, figures from the US Department of Agriculture show the number of boxes produced is declining by millions each year. The production of grapefruit and other citrus is in peril because of temperature shifts, and extreme weather caused by climate change. Unfortunately, shoppers are now going to have to start paying more for their juice. But there is a wider impact to consider beyond the price of beverages. That is because unbeknownst to most consumers, oils and extracts from grapefruit peel also supply many industries with popular aroma chemicals such as nootkatone. And as produce volumes have declined, unfortunately the need for natural citrus fragrances has rocketed. To offset the growing gap between supply and demand, the grapefruit industry needs new innovations that can help it find alternative sources of natural citrus fragrances.

It is not alone. Many of the most potent and desirable fragrances have long used a variety of natural raw materials, much of which is either in natural decline from climate change or over-farming. At the same time, consumers are becoming wise to this. They are beginning to seek out more sustainable ingredients in the products they buy in all aspects of their lives, and fragrances are not immune. From fine fragrances to floor cleaner; and perfume to polish, they do not want the smells they enjoy to have a negative impact on the world around them. At the same time they won't tolerate products performing badly.

This has driven a growth in the burgeoning relationships between fragrance companies and biotechnology firms for the last couple of decades as biotechnology has started to become a novel toolkit for fragrance innovation with the potential to offer benefits beyond the limits of traditional chemistry. Biotechnology entrants are expanding the list of available molecules they can offer the sector. At the

same time, large chemicals and fragrance companies have all made acquisitions or invested significantly in-house to find ways of bulking up their fermentation knowledge and expertise. They want to create natural fragrances without negatively impacting people, plants or places; and craft scents that deliver an effective experience for consumers. For example, the first biotechnology-derived ingredient to replace naturally-harvested patchouli was released in 2014, with biotechnology derived molecules launched in 2020 in response to the unsustainable supply of santalol, sometimes obtained from endangered species of sandalwood trees.

These firms, and others around them, are betting that product brand owners will want to sidestep the challenges in their supply chains caused by poor weather, seasonality, and inconsistent harvest quality without having to turn to petrochemical based synthetic substitutes. And that they will be attracted to ingredients that help them avoid human-caused problems like political unrest, trade disputes, unsustainable harvesting, and mistreatment of small-holder farmers. But there are other drivers beyond the challenges of sustainability. Many are starting to engage more enthusiastically now that the costs associated with biotechnology itself are starting to come down.

Twenty years ago the technology was too expensive for the production of sustainable alternatives to traditional petrochemical ingredients that could deliver the same efficacy. Consumers did not want to pay more for the same or poorer performance. The picture is very different today. Biotechnology is far more accessible, either through in-house investment in people and technology; or through partnerships with specialist biotechnology firms. It is also highly compatible with 'Green' chemistry – the name synthetic producers have adopted for their efforts to reduce the environmental footprint of R&D activities – because it uses renewable materials; consumes very little energy; is highly efficient; produces little or no waste; and is completely safe for the technician and the environment. Fragrance firms and product manufacturers are now embracing this new toolkit with vigour, seeing it as a source of innovation today and in the future, very publicly.

All of this will delight consumers, who will embrace products if they know they also enable them to adhere to their core values. But the opportunity extends beyond sustainability alone. Consumers now want fragrances to be more than simply 'nice odours'. They want them to provide an experience, not just a smell. This is driving a move in the industry from fragrances to 'scents' and it embodies the desire by consumers to build more emotional connections to the products around them. The ability of a fragrance to make them think and feel something different; to recall a positive experience; or to influence their mood is fast becoming an essential part of product performance and desirability. Like producing more sustainable natural ingredients, engineering that kind of effect requires new ingredients. And that, in turn, requires a new toolkit. Again, biotechnology can help by providing greater control over the development of novel ingredients. Biochemists can now use fermentation-derived molecules as starting points to get exactly what they want. It means new scent profiles can be created to fit particular requirements that encourage specific emotions or feelings from consumers when they smell different products. They can also be designed so different notes can be emphasised in different combinations and their longevity can be increased to boost the length of time they hold an effect. That means products can be tailored to specific cultural requirements around the world. They can also be designed to achieve a specific perceived performance. If you wash your clothes in a detergent that makes your clothes smell like a summer meadow for longer, your perception will be that the clothes are cleaner for longer, when in fact it is just the scent that is lingering.

Biotechnology-derived ingredients for fragrances are also gaining interest because they make downstream product formulation easier and more predictable. Fragrances are compounds not single molecules so they can be more complex to work with. And natural ingredients can be unpredictable due to subtle changes from season to season and growing conditions. They are 'living ingredients' influenced by the environment. Weather, natural phenomena and climatic changes are all factors that can influence the composition and smell of essential oils used in perfumery. For example, a year of drought

can cause differences in oil composition which affect the olfactory profile of essential oils, making it very difficult to standardise fragrances that contain them. The use of natural oils from a controlled and sustainable production process is crucial if the perfumer is to have quality, stable and safe ingredients. At the same time, they have to find a balance in the use of synthetic and natural-origin ingredients. This all makes naturally-derived fragrances uniquely challenging when used in product formulations.

Biotechnology-derived molecules offer a way to address this. They can generate more effective formulations that are more certain because they are produced in a highly controlled environment. Not only does that help accelerate the creation of new products, it helps enable fragrances that are stable from one year to the next, making not only the scent stable, but the price and sustainability of the fragrance too. It also makes them highly traceable. Natural raw materials can come from hundreds of different farmers. Biotechnology-derived ingredients usually come from a single source.

Whilst the points above focus on the role biotechnology could play in the replacement of existing ingredients drawn from synthetic chemistry, one of its biggest innovation opportunities lies with the development of new ones. Biotechnology is being explored in many other industries, and in several of those it is already seeing considerable progress. In those sectors, new molecules derived from biotechnology processes can sometimes offer benefits and applications beyond those for which they were originally intended. Some molecules used in the fragrance industry also have skin active properties and can therefore have applications in personal care. This could work in the other direction too. Scanning new biotechnology-derived molecules in other industries for fragrance properties could aid the discovery of new ingredients for perfumers to use when blending unique fragrances. From agriculture, to pharmaceuticals and home care, every new biotechnology-derived molecule could have potential fragrance capabilities that could offer differentiation. This requires a much tighter connection between those that manufacture ingredients (where possible, for multiple industries) and those that blend and sell fragrances.



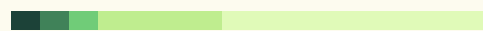


Barriers to faster more widespread adoption

Whilst the benefits of biotechnology are being more widely recognised, incorporating it into the fragrances 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 of 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 the cost of entry; the need for a specialised skilled workforce; the challenge of early-stage innovation; and the need for collaboration.

Cost of entry



Although costs have dropped in the past decade, biotechnology is often still perceived as an expensive approach. It can produce some materials for less than £10 per kilo but the capital cost of technology is still high and the time required creates significant overhead. Using biotechnology to create molecules for onward formulation is often hard. Using it to create the complex compounds required for fragrances can be even more taxing. Compounds, by their very nature are harder to control and formulating with them rather than individual molecules can require far more time.

They can also be harder to formulate with, increasing the downstream resources required to apply them as part of creating end products. All this keeps costs high and creates a barrier to entry for all but the most wealthy of manufacturers. Small specialists can still provide a route into biotechnology-derived molecules but not at the scale required to meet the demand from manufacturers.

Challenging skillset



Biotechnology is a niche field 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 and 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 start-ups 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. It means the mix of biology; chemistry, and formulation skills is challenging to identify and recruit.

But 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. 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 Qualcomm and NVIDIA for talent, which is a battle that can be difficult to win.

Early stage innovation



Whilst there is excitement about the prospects of biotechnology in the fragrances industry, this remains a very new area for the market and both manufacturers and perfumers rightly want to see proof of efficacy from biotechnology-derived compounds before they make manufacturing commitments. This is not simple as the industry remains in a phase of experimentation when it comes to biotechnology and a lot of exploration and testing is still required to get to that point. It is therefore taking time to convert new ideas to proven fragrances that can be used in product formulation. Until that process can be accelerated without compromising the quality of the findings biotechnology will remain an exciting horizon not an exciting reality.

Competitive advantage



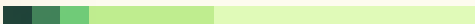
Accelerating progress depends on greater collaboration across the industry. An approach that is not in abundance today. The competitive nature of the fragrances market and its domination by a small number of large suppliers means examples where businesses share findings, ideas and failures is relatively scant. That includes both sides of the buying equation, and leaves the advancement of biotechnology adoption largely in the hands of those with the funds to invest in its growth and development. Until that changes, the whole sector will move at the pace set by the biggest firms.



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 unlock greater innovation and adoption in the fragrances industry

Greater cross-industry collaboration



A greater degree of information and skills sharing between biotechnology organisations and companies in the fragrance ecosystem; and between fragrance companies themselves, will deliver the blend of knowledge and expertise required

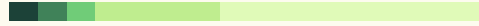
But the benefit of partnership is not limited to the supply side of the market. The growth of biotechnology-derived ingredients must also be underpinned by a tighter partnership between those developing them and those buying them. Creating tighter partnerships with brand manufacturers ensures a better link between the requirements for biotechnology-derived ingredients and the process of developing new ones. All whilst ensuring a greater mutual understanding of the benefits and greater opportunity to share the challenges of scale and cost.

This report recommends that an independent global biotechnology and fragrances working group be established, designed to bring together biotechnology specialists; brand manufacturers; and fragrance manufacturers to exchange information, ideas, and skills in a more structured way and in a non-competitive environment. 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.

This is not a unique concept - associations like IFRA are already working with several companies in this sector on common topics such as greenhouse gases – creating toolkits for smaller companies and helping larger companies to establish a common way to measure their emissions (scope 3 standards for instance).

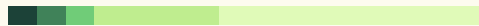
Greater inter-industry collaboration



Looking within the fragrances market alone, limits the potential for innovative progress. We have already established how other industries could offer a considerable opportunity for discovering new fragrance molecules by simply scanning the biotechnology-derived ones they create for their own endeavors. Achieving this is harder than it sounds. It requires much greater engagement with ingredient manufacturers in sectors

that may have limited experience in the fragrance market. This needs some facilitation so the scope of this group also needs to include inter-industry collaboration – working across markets to encourage the exploration of all biotechnology-derived molecules for potential use in the fragrance sector. Companies that both manufacture ingredients, and blend and sell them too, should be able to offer significant insight and guidance on this journey.

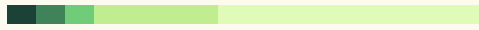
Find ways to demonstrate the mechanisms of biotechnology



One of the fastest ways to address the challenges of skepticism around very early stage innovation is to prove how biotechnology works and how it delivers the compounds required for bio-based ingredients for fragrances. Developing better investigation methods to demonstrate the mode of action of new biotechnology derived compounds

will make this easier. It should therefore become a priority for those that want biotechnology to get a stronger foothold in the fragrances market. Learning how other industries such as personal care are overcoming this barrier and establishing new ways of proving how biotechnology works in their market, is a good place to start.

Agree standards

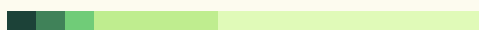


Proving how biotechnology delivers valuable outcomes can be further enhanced by ensuring predictable and repetitive outcomes from formulation with biotechnology-derived ingredients. This will build confidence with suppliers but requires established standards to be employed across the sector against which outcomes can be evaluated. That is a considerable undertaking given the scale of innovation underway and the new ground being broken annually. Biotechnology is still an emerging practice in the fragrances industry and it is somewhat premature to create standards for something evolving this rapidly. However, work on biotechnology standards for fragrances can at least begin, and where possible should be tied to recommendation 1) above – the establishment of a global working group to

connect the biotechnology and fragrances industry. Together with existing regulators, the pathway to standardisation can be mapped out and work begun to establish some core principles. That alone will build belief in biotechnology as a reliable source of sustainable ingredients for the future.

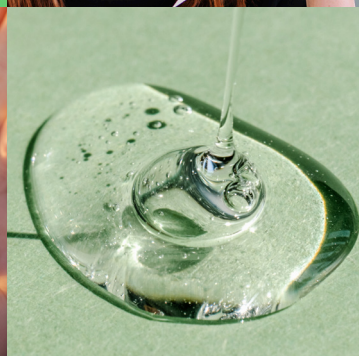
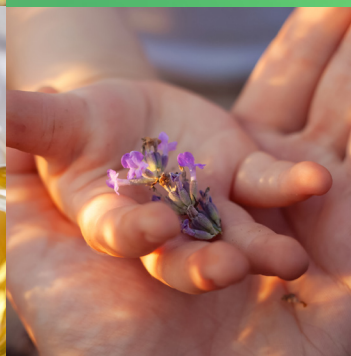
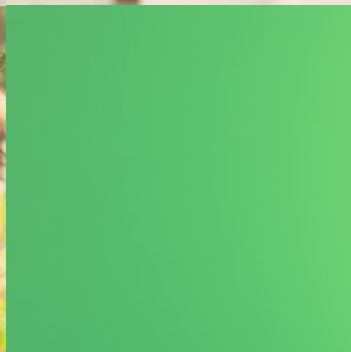
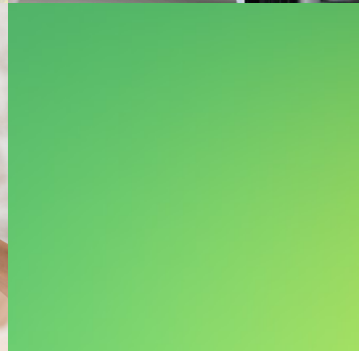
This is a well-trodden path in other industries. The technology sector, for example, has relied upon standardisation to drive growth for decades. Whether it is wi-fi (IEEE 802.11 standard); video (MPEG standard); or mobile connectivity (4G & 5G standards) – a consensus approach to standards has improved interoperability whilst retaining opportunities for differentiation; created new markets; expanded addressable ones; and allowed for cost efficiencies through economies of scale.

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 and engaging perfumers and brand manufacturers.



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