

Biotechnology:

home care market report





Introduction

The global pandemic has accelerated growth in the home care industry. Consumers are more aware of hygiene priorities and self-care than ever before, and their demand for products that improve both cleanliness and wellness at home, from laundry detergents to antibacterial cleaners, has rocketed. As product demand has grown, so has interest in product ingredients. Today's consumers are incredibly aware of the environmental impact of their choices and are expanding their desire to be more sustainable into areas of their lives that were previously untouched by such expectations. That means home care cannot avoid the trends other sectors have had to embrace. They must find ways to improve sustainability – from ingredients to manufacturing processes without reducing product performance. That is fueling a greater interest in biotechnology as a potential route to achieving innovative new developments that satisfy consumer demands.

As a result, the home care sector has become one of the most promising areas for biotechnology innovation within the broader chemicals industry. What is a niche option for incremental sustainability gains today, is expected to be a fundamental toolset for future innovation in the search for bio-based ingredients that can match the performance and efficacy of those currently based on petrochemicals. This has led to parallels frequently being drawn between the home care industry and the personal care industry, which displays some similarities, particularly when it comes to customer preferences and expectations around sustainability and performance. But whilst personal care is largely a discretionary sector, home care is based on commodity purchases. That matters because price can be a lower priority than efficacy for personal care customers. In home care

price is a significant variable for choices. And whilst new innovations are always exciting, they still need to fit the customer spend profile in this market. Biotechnology-derived ingredients can be expensive and do not always achieve this outcome.

This is one reason why they still only account for a small percentage of the total ingredients in this sector. But there are many others as well, including the ability to achieve production at scale, and the ability to be driven purely by customer demand rather than what effects available organisms/plants can offer.

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

This report will explore biotechnology's opportunity in the home care industry; what 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 begins a different conversation about the crossover between home care 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 in home care

The first sustainable home care products were hygiene products designed to be more environmentally friendly, which appeared on the professional market in the early 1990s. At the time, these technologies generally did not perform especially well and were not unanimously accepted by a marketplace that had yet to embrace the concepts of sustainability and environmental care. Since then, and with a more receptive audience, their demand has grown and reached a point where their use is mandated in many environments. At the same time, the list of chemical ingredients historically used in home care products and which are now considered undesirable, of concern, or are even banned, is continuing to grow. Their removal must be compensated using new substances or technologies. This has led to the innovation and development of several innovative new technologies that enable products to match efficacy with sustainability across the wider home care industry.

Biotechnology is one of the most important of these, and significant efforts have now made it possible to obtain as good, or even better levels of cleaning performance using biotechnological cleaning products. This has brought home care into a new stage of development. For example, while traditional chemical cleaners have the ability to solubilise or emulsify dirt, biotechnology-derived cleaning products that contain enzymes have the ability to 'break' and remove dirt through hydrolysis and biodegradation, making them more effective. This action also offers ongoing residual activity beyond the short period

of mechanical action applied during the actual cleaning activity. In short, biotechnology cleaning products do not simply make dirt and stains more soluble, so that you can mechanically wipe or wash them away; they break down the molecular components of dirt, and continue to work and clean long after they have been applied.

Today, due to their ability to match efficacy with sustainability, biotechnology features in a much broader range of home care products than ever before. In laundry detergents, enzymes break down stains like protein, starches, and fats, making clothes cleaner. Biosurfactants have started to replace chemical surfactants, offering the same outcomes but without affecting water quality or possibly irritating people's skin. Microbial cleaners (also known as probiotic cleaners) are growing rapidly in the market. And bacteriophages (viruses that kill bacteria), which have been used in the medical industry for more than a century, are now being considered for use in cleaning products that can disrupt and kill only harmful, targeted bacteria, without disrupting entire microbiomes.

Progress in this sector therefore has been effective but more is required. Demand remains high for new technologies and approaches that will provide effective and sustainable solutions for challenges that remain unsolved in the home care industry today. Biotechnology has made a significant impact and is expected to continue to offer innovative contributions in this field.



Biotechnology drivers and opportunities in home care

The driving force behind product development decisions in home care is consumer buying patterns. These have changed dramatically since the COVID-19 pandemic.

COVID affected consumer sentiment and purchase behaviour globally. Prior to the pandemic, consumer product preference was becoming increasingly focused on sustainability. As soon as the virus hit, consumers were quick to align their spending with products and services aimed at effective health protection. Staying safe and hygienic amplified the relevance of certain product claims. Consumers prioritized products that focused on killing germs, providing immunity, and overall health promotion above those with claims around naturalness, sustainability, and brand. COVID may not have made society happier but it has certainly made it cleaner. Furthermore, during the pandemic people had to stay home for long periods and therefore home care products became, and still are, a core element of people's daily lives.

That has had a significant impact on the home care industry – particularly the cleaning and hygiene sub-categories. Sales have increased dramatically as consumer spending on these products has rocketed. But since the pandemic began to recede, that laser focus on product performance has been rebalanced somewhat with sustainability concerns. Lingering concerns about the virus mean product efficacy in health and hygiene remains a key purchase driver across many home care product categories. Yet sustainability concerns over ingredients are rising once again, especially now that the overall volume of home care products people use is so high. As confirmed by Euromonitor, a global research firm

focusing on consumer insights, 'Consumer awareness [in 2022] of the importance of beneficial natural bacteria to their personal health is growing, and potential health issues linked to the use of chemical-based antibacterial cleaners in a domestic setting will be scrutinised more closely.'

This is one reason why home care products now contain more ingredients based on biological raw materials than ever before. Current estimates suggest that bio-based surfactants in home detergents now represent more than 40% of all surfactants in these products. And whilst it is challenging to replace petrochemical-derived ingredients entirely, a range of alternatives are gaining ground.

However, using biological raw materials to create bio-based alternatives to petrochemicals is not the only way to find new ingredients. Many could potentially be derived from novel biotechnology processes such as fermentation, which requires fewer trade-offs than using more traditional methods of extraction. This is important for an industry where consumers' demand for a better balance between performance and sustainability could be addressed by taking an innovative route rather than relying on convention. That is why home care companies are starting to seek out new suppliers with biotechnology capabilities or thinking about investing in their own. The growing trend of formulating with biosurfactants produced through fermentation, such as glycolipids, is an excellent example in practice.

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 this question is fast becoming essential as the home care industry seeks out new ways to achieve the necessary but delicate balance between product sustainability and performance through innovation. This report considers all three to be drivers for the use of biotechnology as the main way to produce bio-based ingredients for the sector.



Innovation

Whilst biotechnology is not brand new, it remains one of the most innovative ways in which to create novel home care ingredients 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. This matters because, as the past few years have demonstrated, the impact of volatility in our society and the increased focus on health and hygiene, means that companies are forced to constantly innovate to meet the new and often unpredictable challenges they face. Simply accepting something could not be achieved before isn't an option if they want to keep up with market needs and retain market share. They have to find a solution. Having a different toolkit with which to search for answers opens up new avenues to consider. Biotechnology addresses this in two ways.

Firstly, it provides a completely different set of processes and approaches 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 organic 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. For example, using biotechnology-derived ingredients such as CroBiotic™ 100, based on microbiology instead of traditional chemistry, has transformed the domestic cleaning market. Not only can they outperform petrochemical-based ingredients but they also offer significant sustainability gains. A win-win for customers and consumers alike. So whilst they can be more expensive, cleaning product manufacturers are developing ways to get novel probiotics into their formulations with strong efficacy and at a cost effective level so they can maintain consumer loyalty to their brands.

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. Probiotic cleaners use beneficial bacteria to colonise surfaces and break down soils and odours that are present. They offer a deeper longer-lasting clean, as engineered beneficial bacteria can get into the tiny imperfections and pores on a surface where dirt hides, degrading the dirt and preventing re-soiling. They also continue to work their magic for weeks, long after chemical cleaners have stopped being effective. For this reason, they are promoted as a way to reduce the level of traditional chemical cleaners in products by offering longer term cleaning.





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, fermentation can be used to produce large amounts of a specific ingredient from a single microorganism, rather than potentially having to harvest huge amounts of crops to achieve the same outcome.

Sustainability does not start and end with environmental impact though. The concept of a green home care product refers to those that have a lower and less harmful environmental impact than that of traditional ones. Although this is noble and desirable, the concept for an eco-responsible cleaning product uses a much broader concept that integrates environmental, societal and economic parameters. Consumer attitudes and concerns around sustainability are similarly 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 transparency and much closer interrogation of upstream raw materials. Where once the question was "Is this ingredient safe for the environment?" it is now frequently "Where do its core ingredients come from? Which country? How is it sourced? What impact does it have on biodiversity?"

Biotechnology can help maintain and even enhance home care companies'

capabilities here. 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.

Biotechnology can also enhance ingredients, reducing the amount of actives required to achieve the same outcome. In 2000 the first biotechnological neutral pH degreaser for kitchen floors was patented and then marketed. This contained less than 0.05% active ingredient and degreased a kitchen floor more efficiently than a traditional alkaline degreaser containing 25 times the amount of active ingredients. Using less is the most effective eco-friendly approach to home care because it has a knock-on effect in other parts of the supply chain. A high concentration of active ingredient makes it possible to reduce the transport costs associated with moving that ingredient from manufacturer to buyer and its high efficiency allows for very high dilution rates and therefore lower amounts of all the other ingredients used to make up the product. This simultaneously helps home care companies reduce packaging – an important part of helping customers cut down waste and their consumption of materials – something that has become a key demand since the drive to reduce the use of plastics has accelerated in the last five years. This translates to more refill bottles and concentrated versions of products on supermarket shelves – all driven by the ability to enhance the potency of ingredients through innovative new approaches, of which biotechnology is a major participant.



Performance

The natural world is not a controlled environment geared towards supporting the production of precise molecules performing predetermined functions. The sterile labs and facilities in which biotechnology processes take place are, so the ingredients they produce have the advantage of not being subject to uncontrollable variables. As a result, they can both guarantee and enhance the performance of the ingredients they produce.

This means biotechnology can produce a more consistent product, and the resulting ingredients can deliver more stable potency, which is why they are usually stronger than those obtained through classical methods. The example of CroBiotic™ 100 shows that biotechnology is not a threat to performance; it can be an innovative way to enhance it.

Furthermore, since bacterial cultures and enzymatic extracts are highly effective even at very low concentrations and

considering their residual and prolonged cleansing action, biotechnological cleaning products can be diluted at very high rates while providing outstanding cleaning performance. These high dilution rates lead to high-performance cleaning solutions that have a very low cost per litre.

And home care companies 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 naturally sourced ingredients, which can compromise performance.



Barriers

Whilst the benefits of biotechnology are being more widely recognised, incorporating it into the home 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 five 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: the cost/performance relationship; industrialisation; specialised skilled workforce; and home care customer understanding.

Cost vs performance



The home care market is far more price competitive than other markets where biotechnology is showing potential, such as personal care. There will always be speciality home care products for a small percentage of the most dedicated environmentalists but to be adopted on a wide scale, the cost of integrating biotechnology-derived ingredients needs to come down. At the same time, performance must be maintained. Consumers are not going to want to buy products that are more sustainable

but offer inferior results. If the cost/performance ratio becomes balanced, a rise in demand is predicted. The increase in sales for biopolymers in fabric conditioners is an example in practice. 20 years ago when first released, they were rarely purchased. Now that consumers demand more innovative and sustainable products, and manufacturers have found formulations that allow them to use them cost effectively without compromising performance, sales have increased.

Industrialisation



An inability to industrialise is holding biotechnology back. Granting the home 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. This is particularly significant in highly price-sensitive markets such as home care. The margins are tight so any investment in novel processes or ingredients must be price neutral. Anything that requires a jump in cost for the consumer is unacceptable.

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 home care companies, and the amounts of each that can be created.

Specialised skilled workforce



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, 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 start-ups 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.

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.

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.

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 a driver for biotechnology use in home 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 cleaning, fabric care, and hygiene products moving forward.

Regulations



Another barrier for the fast acceptance of biotechnology in these products is that existing guidelines for industrial cleaning are not up to speed when it comes to biotechnology. Organisations have to follow the regulations in place today.

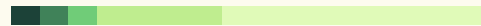
So unless these are adjusted to accommodate the progress of new technologies for home care products, they may end up restricting the adoption of biotechnology rather than advance it.



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 home care industry.

Scale through partnerships



Reducing cost not only comes from making processes quicker and easier, it is also a product of scaling up. Ramping up the scale of production will deliver larger volumes of active ingredients from raw materials at lower cost. Large chemical companies are already working on much bigger batch sizes of biotechnology-derived ingredients. That makes partnering with them sensible for the array of smaller biotechnology businesses seeking to gain access to the home care market.

This has the potential to offer a win-win for both parties. Large chemical companies get exclusive or early access to new ingredients they can offer to customers, 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 eradicate the cost-barrier together.

The cost benefit of partnership is not contained in the supply side. 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 home care companies ensures a better link between the requirements for bio-based 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 biotechnology and home care working group be established, designed to bring together home care companies and their ingredient 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 home 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. Regulator representation would increase the chances of updates that facilitate and indeed encourage the adoption of biotechnology-based products in industrial and commercial settings.

Simplification of process



For biotechnology to really achieve its potential in this market it needs to be cheaper without being less effective. Taking cost out of the process means simplifying it wherever that is possible. Today – making a sophorolipid (a surface-active glycolipid seeing growing application in consumer care markets) requires a nine-

stage process – that is time consuming and expensive. And that does not take account of the downstream work to get it to market in an effective formulation. There needs to be further research into simplifying the biotechnology process to reduce both the cost of that process, and the amount of downstream work required.

Increase the formulation skills pool



Having the ability to produce ingredients at scale is only one end of the challenge. The other is how they are used once produced. That requires an immense amount of manufacturing skills in the home care industry. A greater understanding of how to formulate with these products and the sustainable surfactants and other ingredients with which they can be

combined to deliver viable performance, will help develop new formulations that are efficacious using higher levels of these biotechnology-derived products at lower cost. Finding that talent is hard and with everyone looking for the same skills, a cross-sector collaborative intervention might be more effective than a 'land grab' for talent.

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.





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