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BIOCHEMISTRY START-UP TERPENOX: THE CASE FOR MENTHOL

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Abstract

We are presenting the business plan for TerpenOX, a ground-breaking biochemistry start-up developing a novel process for menthol synthesis based on a recent scientific breakthrough at the University of Vienna. TerpenOX provides a cutting-edge process, which consists in converting low-cost compounds such as citronella into menthol in a single step, instead of two. Moreover, our solution is faster, cheaper, and more sustainable which is exactly what is needed by the expanding industry of compounds. Finally, the market for menthol is expected to reach a value of approximately USD 1.05 billion by the end of 2023.

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Keywords

- Menthol
- Biotechnology
- Entrepreneurship
- Licensing

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1. TerpenOX

1.1. The idea behind TerpenOX

Menthol is one of the most popular organic compounds in the group of flavours and fragrances. It is classified as a monoterpenoid, and it owes much of its fame to the unique flavouring, fragrant, analgesic, and anaesthetic properties it possesses. Such attributes make applications for menthol immensely diverse and continuously expanding. Some use cases include non-prescription drugs, such as cough medicines and lip balms, prescription drugs like nasal inhalers, oral hygiene products (e.g., mouthwash, toothpaste, etc.), aftershave, fragrances, pesticides, and even certain food items. Furthermore, menthol promotes numerous health benefits which include relief of indigestion (Inamori et al. 2007), the alleviation of irritable bowel syndrome (IBS) symptoms (Cappello et al. 2007), the combat of cold symptoms (Eccles et al. 1990), lessening headache pain (Ali et al. 2015), boosting energy and exercise performance (Meamarbashi and Rajabi 2013), and fighting bacteria (Li et al. 2011). Additionally, menthol is known as a counterirritant, causing the skin to feel cold and then warm, which makes it a useful medication to treat minor aches and joint pains, such as arthritis and sprains (Barkin 2013). Consequently, all the positive attributes described above make menthol a very desired compound in different industries.

Today, menthol supply still lags behind the wide and ever-growing demand. This compound can be obtained naturally – from peppermint, corn mint, and other kinds of mint plants –, or synthetically (Ribeiro and Shapira 2019), while naturally extracted and synthetically produced menthol are practically indistinguishable. A great majority of the supply is still served by naturally extracted menthol, which is not as natural as one would assume at first, since some processing still occurs to transform mint into menthol. This naturally extracted menthol comes

mainly from developing countries. However, some socioeconomic issues persist in the plant-based production, such as many farmers working at subsistence levels, as well as the inefficient and prejudicial use of arable land (Lange 2015; Tiwari 2016). On the other hand, synthesised menthol has not yet proven itself as an optimal alternative to plant-derived menthol. Although more efficient than the natural process, the latter is expensive, requires harsh reactive conditions (high temperature and pressure), and uses heavy metals to serve as catalysts, which are present in the end-product despite intensive and costly decontamination processes. Heavy metals are well-known environmental pollutants due to their toxicity, persistence in the environment, and bio-accumulative nature. When entering the food chain, even in minor quantities, the toxins build up in individual's organisms and can cause numerus health issues and diseases including cancer.

The current issues regarding menthol production and its disconnection with global demand point out a necessity for innovative and more sustainable production and extraction methods.

Synthetic menthol is typically synthesized from a widely available terpene, more specifically a terpenoid, called citronellal, through a two-step process. Furthermore, the largest synthetic producers of synthetic menthol are the companies BASF and Takasago. Put simply, terpenes are a large group of compounds or molecules responsible for the way plants smell, and terpenoids consist of modified terpenes containing different functional groups. In this case, for example, citronellal is what gives citronella oil its lemon-like aroma.

Upon transforming citronellal into menthol, new carbon bonds are formed, changing the structure and properties of the molecule. In organic chemistry, such changes can be obtained through oxidation or reduction processes which, in an industrial environment, are often aided by the presence of catalysts, usually metals, and energy, to induce and accelerate the reaction.

In commercial state-of-the-art menthol synthesis, converting citronellal into menthol requires an oxidation step – cyclization –, followed by a reduction step – hydrogenation – plus a decontamination of the end-product from the undesired catalysts that were used throughout the process.

Further, we'll be mentioning the concept of *purity*, which fundamentally indicates the extent (as a percentage) to which the end-product is free of those catalysts, i.e., how efficient the decontamination process was in its function. Purity, however, does not correlate with the level of harmful or pollutant catalysts that were used in the process. In an extreme scenario, a company may be able to obtain a 100% pure menthol if its hydrogenation procedures are superb, therefore we cannot evaluate the quality and sustainability of the overall process solely by looking at the end-product's purity.

Recently, Professor Nuno Maulide and his research group at the University of Vienna discovered that fragrant compounds, such as citronellal, can be transformed into other terpenoids – namely more valuable ones – in a single step, instead of two. This single-step reaction does not only cut the required steps in the transformation in half, but at the same time addresses many of the flaws current synthetic production methods such as the use of heavy metals or high energy requirements. This astonishing scientific breakthrough is what inspired the idea behind our company TerpenOX and what we are basing our technology on. For now, menthol is the only compound being tested, given its large and mature market, but further opportunities, such as vanillin, already appear on the horizon. In this way, it will be possible for Terpenox to increase its portfolio of synthetic compounds produced, becoming more powerful in the market.

1.2. Company Overview

1.2.1. A Groundbreaking Start-up

TerpenOX is a Portugal-based biotechnology company pioneering novel chemical production methods. With ONESTEP we provide a cutting-edge process, that is able to convert low-cost compounds such as citronellal into menthol in a single step, instead of two. Moreover, our solution is faster, cheaper, and more sustainable, which is exactly what is needed by the industry to meet the expanding demand for compounds moving forward.

Our company is directly derived from a discovery of a novel process to produce menthol by Professor Nuno Maulide and his research team. This process is based on the concept of redox neutrality, which fundamentally consists of combining the oxidation and reduction phases during the conversion of one compound into another in a single step, which still occur separately in common industry practices. Despite current research focusing only on menthol synthesis, the technology has the potential to bring the same benefits mentioned earlier to the synthesis of many more compounds.

In a time of change and progressive global pressure to attain the UN's Sustainable Development Goals, we want to help large companies keep up with both societal and ecological demands. By doing so, in addition to the benefits related to more efficient production and cost reduction, we are helping our customers comply with increasingly strict regulations around environmental issues.

Our vision is to become the world's leading enabler of technologies that revolutionize the way compounds are produced.

On the other side, our company's mission is to make chemical industries more efficient, environmentally friendly, and able to generate products that do not endanger consumer health by developing innovative technologies for compounds manufacturing.

We intend to pursue our mission by developing knowledge and intellectual property around the production of terpene compounds – the compounds responsible for how plants smell –, and then licensing our technology or starting to manufacture a compound in-house, depending on what makes sense from a market perspective for a given compound. In fact, if a market is too concentrated, which is to say few players dominate it, the efforts required to penetrate it and conquer a relevant market share would be substantially higher, compared with a market that is more fragmented, meaning there are no clear market leaders, and it is largely split among the various players. In the latter, we are thus more willing to venture ourselves autonomously, since license agreements with smaller players are not as profitable, making the opportunity cost in those cases seem much larger. In addition, the profits we potentially generate by taking charge of all the value chain activities are significantly higher, and the risk is not as high as it would be in a largely concentrated market, because a smaller licensee in a fragmented market is theoretically more prone to fail when implementing our technology.

Menthol is, thus, the market we will enter first, through licensing, aiming to fund further R&D through the licensing income we receive. The fact that the patent we will obtain for this technology – not exclusively for menthol synthesis – will only be valid for 20 years, will bring a sense of urgency for us to add compounds other than menthol to our pipeline, in a way to maximize our licensing revenues throughout that period. Through the virtuous cycle that is generated by such a business model, we aim at strengthening our company's knowledge, which is crucial for TerpenOX to survive in the future. Our goal, then, is to constantly reinforce our patent portfolio, either by improving our current technology or discovering additional process

innovations, which will enable us to continuously license out new technologies. This might eventually allow us to launch ourselves onto more risky endeavours like starting autonomously manufacturing compounds with not as consolidated markets as menthol. By conquering a relevant market share of those markets, we can increase our high-growth potential.

Overall, our technologies will bring more efficiency to the production of compounds worldwide, leading to considerable improvements in the supply chain. This makes us directly tackle the UN's SDGs 3 (Good Health and Well-being), 9 (Industry, Innovation, and Infrastructure), 12 (Responsible Consumption and Production), and 13 (Climate Action).

1.3. The Team

Our founding team is composed of young and passionate entrepreneurs who are driven by the willingness to strive for the well-being of the world and future generations. We want to help large, global industries become more ecological. We aim to give our contribution to ongoing missions, especially pursuing the *2050 Carbon neutrality goal*, and the *Sustainable Development Goals*.

Especially, we are long-term thinkers whose goal, besides profitability, involves positive socioeconomical impact. Also, we are surrounded by our board of advisors, composed of professionals who have vast experience, technical knowledge, and expertise on the subject matter.

In addition, once TerpenOX will start producing menthol in Kilograms scale, eventually making tests to expand the production to tons, we will hire a junior chemist and a senior engineer. The latters are fundamentals human assets, who will bring experience and familiarity with the technological process. Also, this process will take between six to nine months according to João Seixas, member of the Advisory Board.

For the second year of the project, TerpenOX will start the experimental phase which will require a senior engineer, who will be responsible for setting up the facility and safety of the whole process and, another junior chemist that needs to operate in the laboratory doing benchwork and trying to optimize the findings of Professor Nuno Maulide in the University of Vienna.

1.3.1. Management Team

Pedro Dos Santos is a co-founder and CEO at TerpenOX. He is passionate about turning scientific discoveries into real economic value, which led him to be part of the founding team. As Chief Executive Officer, he is responsible for developing the company's strategy and inspiring the team to remain driven in pursuing it, for pitching the company externally and raising funds, and for other general issues that occasionally pop up. He holds both BSc and MSc in Management, and has professional experience in the telecommunications sector, where he worked for a year in risk management and compliance, as well as in the life sciences, having had a previous experience in a biotech start-up, where he worked alongside the company's CEO to support the latter on formulating licensing agreements terms, mainly by performing activities such as market research and financial modelling.

Alessandro Piccolo (CSO) joined TerpenOX as a Chief Sales Officer, with the responsibilities of studying the markets and establishing fundamental relationships with clients all over the world. In fact, he has excellent interpersonal skills which are fundamental to creating solid connections with all the stakeholders within and outside TerpenOX. Moreover, Alessandro has great exposure in the Private Equity and Real Estate industries, having started working in these fields at Deloitte in Luxembourg. After graduating from Cattolica University in Milan, and following a summer program in California at UCLA, he decided to pursue a Master's in

management with a major in Finance, where he has been exposed to an international environment.

Maria Margarida Ferreira considers that one of her biggest assets is to have an entrepreneur mindset. At TerpenOX she is one of the co-founders and CFO, leading the fundraising efforts, financial planning and is responsible for establishing/developing relations with external partners and stakeholders. Maria Margarida holds a MSc in Finance from Nova SBE, and a BSc in Business Management from Universidade Europeia. Prior to joining TerpenOX, she gained her first experience in a Corporate Venture Capital, in Lisbon, at Semapa Next and had several internships in start-ups or in areas related to entrepreneurship.

Maximilian Palige is one of TerpenOX's four co-founders and Chief Innovation Officer. With a strong passion for technology, he will coordinate the Research & Development team and be responsible for enabling our scientists and engineers to accomplish the company's ambitions. Growing up within a family business he got early exposure to what it means to be self-employed. After acquiring a BSc in Business Administration with a focus on International Management in Frankfurt am Main, Germany, as well as gaining international experience at the University of Technology Sydney, Dublin Business School as well as working in asset management in London he moved to Portugal to pursue a Master's in management degree at Nova SBE. At a fintech start-up in Hamburg, he gained first-hand experience in working with technical staff.

1.3.2. Advisory Board

João Seixas is one of the co-founders of both Spartax Chemicals (managing partner) and TargTex (CEO), a biotech start-up leveraging AI to treat brain cancer. João has by now extensive experience in the biotechnology field, having been part of successful ventures such

as Alfama, as well as big pharmaceutical companies like GlaxoSmithKline (GSK), and has frequently been involved in Chemistry research efforts. So far, João has been the main advisor to TerpenOX's founding team, especially on the licensing implications and strategy, as well as regarding the technology itself.

Nuno Maulide is one of the co-founders at Spartax Chemicals, a company also on the mission to develop new technologies for the production of added-value chemicals employing renewable starting materials, ultimately aiming at reducing downstream costs associated with their main asset-molecule – Sparteine. He is the main scientist behind the discovery of a novel process for menthol production at the University of Vienna, where he is currently a full-time professor of Organic Synthesis. Above all, Nuno can provide us with meaningful scientific support for our R&D efforts, since he is one of the most familiar people concerning our technology.

Manuel Barbosa is a Senior Investment Analyst at Semapa Next, a Venture Capital fund based in Lisbon. Even though the investment range at Semapa Next goes from Series A to late-stage funding, as a member of TerpenOX's Advisory Board, Manuel plays a critical role in providing access to Semapa's group and its international network partners in order to exploit prospects for business growth, technological pilots, and world-class knowledge in managing and expanding global enterprises.

Nuno Arantes-Oliveira is an entrepreneur, investor, and academic with a keen interest in turning scientific knowledge into economic and social value. He obtained a PhD in Genetics at the University of California San Francisco (UCSF). Since then, he has founded several companies and led successful exits and acquisitions. He has taken leading roles in national industry associations and has been a board member, advisor, and shareholder of innovative companies around the world, in fields including technology transfer, drug development, personalized medicine, aquaculture, and healthcare services. Currently, he is Chairman of the

Investment Committee of the 200M Fund, as well as Partner and Chairman of Clinical Research Ventures, a private investment fund based in Singapore and focused on clinical-stage biotech and MedTech companies. Nuno was also an invited professor of the MIT Portugal Program at IST, and is now an invited associate professor at Nova SBE, where he teaches Science-based Entrepreneurship and Innovation. That said, Nuno can provide great credibility to TerpenOX, facilitating connections with investors, and even potential licensees. Furthermore, his vast experience may also translate into advice on strategic and growth matters.

2. The Menthol Market

2.1. Market definition

The menthol market is driven by an increasing demand from the most important key end-user companies in many fields such as pharmaceutical, and food & beverages. The reason why the demand for this molecule is so high is that it finds applications, and therefore it is needed, in a wide range of products that are used every day, such as toothpaste or shampoos. Furthermore, menthol has increasingly been added to many products such as beverages, chewing gums, candies, and cough drops, causing demand to grow over the past few years. In addition, this organic compound is broadly utilized to treat several minor hurts such as pains and cramps. Therefore, it is clear the importance of menthol even for treating and curing painful injuries and relieving irritations.

What shows the potential of menthol worldwide is that, as per Statista, the global menthol market is supposed to reach a market valuation of approximately USD 1.05 billion by the end of 2023. Since the usage of this compound will face a relevant spike in the next years, the adoption of synthetic menthol is the most valuable solution that needs to be utilized for meeting the growing request. This is explained by the compound being obtained using a synthetic

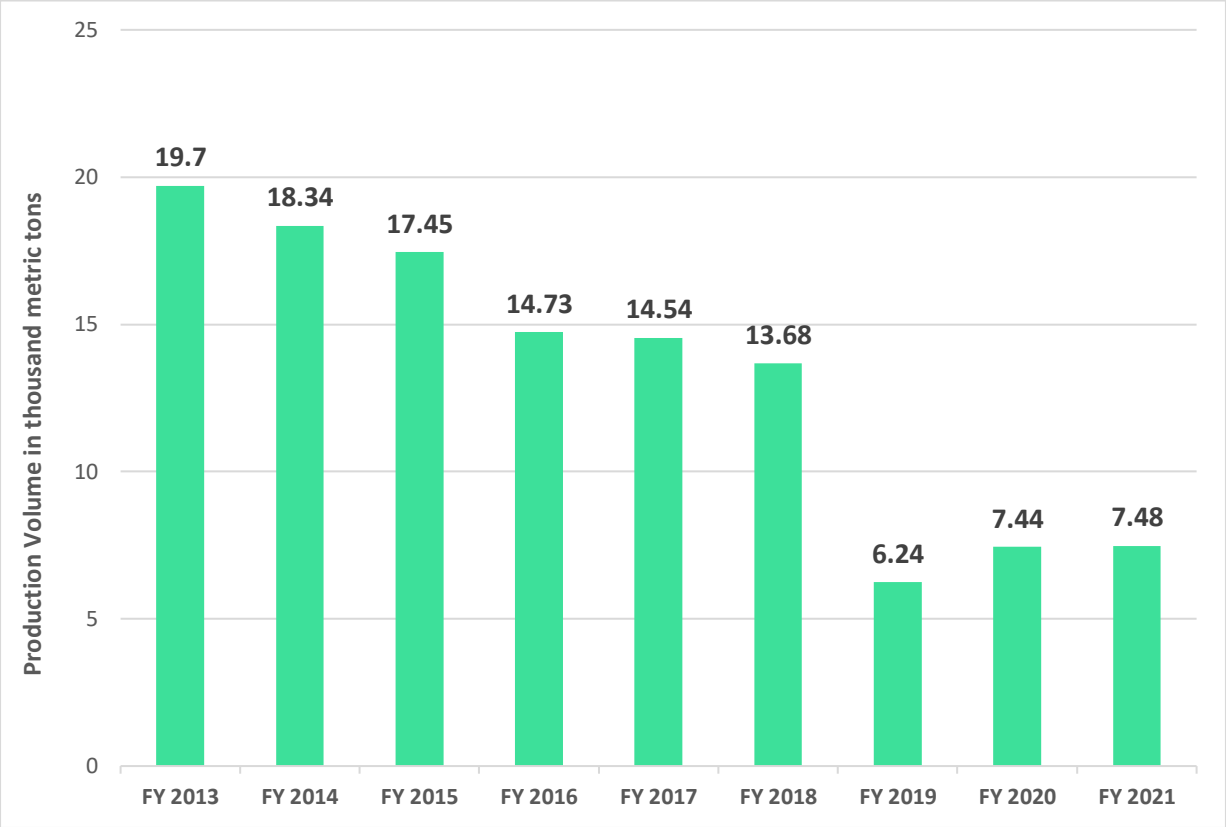
process which is more effective in terms of costs than natural menthol extraction. Furthermore, it has been reported that menthol has an overall global market request of approximately 30,000 tons every year, making it a necessity to be produced in the laboratory on a large scale (Kamatou et al. 2013). Moreover, in the last few years, the synthetic production of this compound has been steadily expanded due to the increasing request for menthol by many industries, and since menthol is created in the laboratory, the price is not as volatile as the natural menthol.

Moreover, using biosynthetic methods brings to dispose of a highly pure concentration of the compound, using a more efficient process than the several intensive steps necessary for the purification of it. One important aspect of the lab-based production of the compound utilizing microorganisms is that it avoids many issues concerning contamination in both synthetic and natural products.

When looking at all different fragrances, menthol is one of the most well-known and widely utilized flavors due to the massive volume demanded all over the world. In terms of production, it has been estimated in 2016 that approximately 70% of the total production of this compound is based on natural plants, therefore based on the farming industry. On the other side, the remaining 30% of the global offer is derived from both the synthetic and semi-synthetic methods used to produce the compound. However, already in 1998, the global synthetic supply of menthol accounted for 20% (Ribeiro and Shapira 2019). Additionally, nowadays, through an intense process of research and development, the production of menthol is largely switching to the laboratories, due to the relevant economic strength and sustainability of the process. The three main companies that are leading the market of synthetic menthol are Symrise, Takasago and, BASF.

Finally, the main consequence of this innovative transition (to the lab-based creation of the compound), is the enormous decline in menthol cultivation worldwide. Therefore, farmers have been reducing the cultivation of the aromatic herb due to a shrinking of the natural plant demand. Especially the Indian country, which is the main exporter worldwide, has experienced a massive decrease of almost two-thirds of tons produced, passing from 19,700 tons in 2013 to 7,480 tons in 2021.

Figure 1 *The menthol production volume in India from the financial year 2013 to 2021.*



Source: Statista 2022 (DCP India)

Finally, it is possible to make an estimation for the price of natural menthol, even though its rapid variability is an aspect that needs to be taken into account due to many changing factors such as climate conditions. The valuation of the cost on average of menthol is roughly USD 16.5 per kilogram.

2.2. Industry Analysis

The synthetic menthol industry can be divided into different regional outlooks: North America, Latin America, Europe, Asia, and Middle East & Africa.

Analysing the North American segment, the main factor that needs to be considered is the huge increase in cosmetic products. In fact, in this geographical segment it is quite common the habit of the massive usage of toothpaste and shampoos, which leads to a consistent boost in the menthol demand. Also, the exponential growth of the American chemicals industry is another important aspect that brings to a growing request for the compound.

Second, the Latin American countries are expected to require a substantive amount of menthol in the future due to the promising growth in both the pharmaceutical industry and the growing population. Further, this region is known as one of the largest users of medications such as cough syrups, and nasal sprays which require great amounts of menthol in order to be produced. Specifically, Brazil in the past was one of the most recognized global suppliers of menthol. However, around 1960 this market was not able to cope with the cheap prices of menthol and the strong competition of Indian corn mint production. In fact, the oil extracted by these plants make India the leader in the market, exporting it to both Brazil and Japan (Lawrence and Hopp 2007).

Considering the Asian market, India is the most important market player in the field of mint oil, surpassing even China, which was previously the dominant producer in the 1980s, with farmers growing corn mint in several regions of the East. Nowadays, India is responsible for cultivating and supplying about 80% of the global demand of menthol (Lange 2015; Tiwari 2016). However, even though India is deemed the prevalent exporter, its consumption of menthol counts for approximately 40% of the global utilization of it, succeeded by Chinese

consumers who account for around 20%, and the EU and US which count both for 15%. Analysing Europe, this continent shows the highest demand for the OTC (over-the-counter) medications such as several cold remedies. Also, the main countries with the highest level of import of menthol are Germany and the Netherlands.

Finally, the Middle East & African region has a high percentage of the young population because of the multiple births per family. Hence, this is the reason why there is an elevated request for personal care products that require intense usage of menthol, especially for kids who need a higher attention to hygiene.

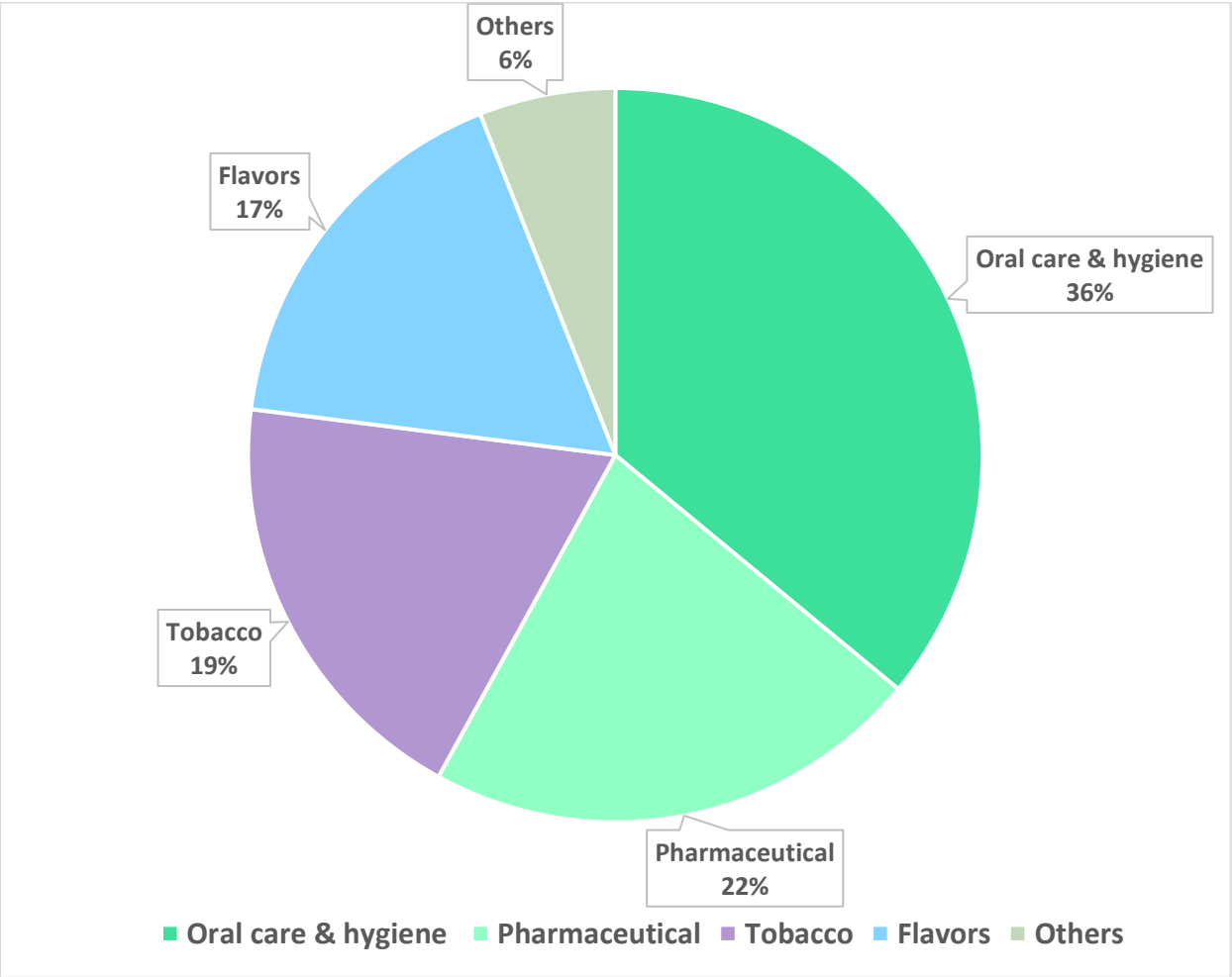
Therefore, some of the reasons why the transition to biosynthetic menthol has such a relevant superiority are economic stability, sustainable and efficient production. First, this turn in the lab-based industry of menthol will allow benefiting from a more reliable and stable source, which will not be affected by both the weather variability and political tensions among countries.

Further, the creation of synthetic menthol has been considered more sustainable due to the better environmental performance in terms of chemicals that are usually utilized, and the substantial contraction of pollution. In fact, switching from conventional ways of farming menthol to the production in the laboratory would greatly decrease the emissions of greenhouse gases, reducing sharply the length of the supply chain. In fact, this compound is usually grown due to the favourable temperature in the South countries and then transported to the ones in the North. Hence, producing synthetic menthol locally in a laboratory would allow countries which usually import it to produce the compound on site. In addition, avoiding the usual pathway for cultivating menthol would guarantee the elimination of many chemicals such as pesticides which is one of the main causes of global warming.

2.3. Market Segments

As shown in *Figure 2*, the estimated division for the market of menthol at the start of the 21st century is the following: 36% oral care and hygiene products, 22% pharmacy products, 19% tobacco products, 17% flavours, and 6% others (OECD 2003).

Figure 2 *The shares of different industries for the menthol market at the start of 21st century.*



Source: OECD 2003

Menthol belongs to the monoterpene category, and it is intensely utilized in several market segments. Also, menthol has been widely used more specifically as an antioxidant, anti-

inflammatory, and analgesic. Even though the cost of menthol does not reach the high impressive standard of the price of natural vanillin, it is increasingly being required internationally. In fact, throughout the last decades it reached an economic relevance close to that of vanillin and citrus (Kamatou et al. 2013). This is another reason why menthol has also become one focus of synthetic biology.

This compound is intensely used in oral care products such as toothpaste and mouthwash. As per Statista, the approximate dimension of the oral care market all over the world in 2019 was roughly USD 44.5 billion. In addition, the North American oral care market has been dominant in relation to the other countries. Instead, even if the population is by far greater in China, the revenue of the Asian country in this field follows in the second place, accounting for three USD billion less.

Since the oral care market has been growing fast in the last years, the projection for this market is to reach around USD 53.3 billion in 2025, which represents a relevant increase of almost 20% in six years.

The rapidly changing lifestyles and improper food consumed, such as sugar-based meals, and the material growth of consumption of both alcoholic beverages and tobacco, have caused many oral health issues all over the planet. In fact, the World Health Organization states that oral diseases are the principal cause of major problems worldwide. Also, the lack of oral hygiene affects many people during all the stages of their life, provoking suffering, discomfort, and in specific cases even death. Moreover, the Global Burden of Disease Study 2017 made an estimate which shows how oral issues such as caries of permanent teeth affect approximately half of the overall population, namely 3.5 billion people. These data are the clear proof that increasing purchases of oral healthcare are needed. Therefore, worldwide customers have been

starting to adopt preventive measures, which, therefore, has expanded the request for menthol products.

The oral care market is dominated by some crucial players such as Colgate-Palmolive and Procter & Gamble. The wide choice of different kinds of toothpaste, such as gels and pastes, offered by these principal companies give many options to the consumers, which also boosts the demand of the compound. In particular, the regional segment of Asia-Pacific has been prevalent in the market in 2020 reporting an overall share of 40.7%. In addition, the high predominance of dental problems in countries like India will stimulate the increase of menthol request in the Oriental market.

On the other hand, the personal hygiene market worldwide has been associated with an overall value of USD 508.5 billion in 2020. Also, it is forecasted to arrive at approximately USD 720 billion by 2030, recording a CAGR of almost 3.6% from 2021 to 2030 (Yahoo Finance 2021). The most important motivations why this sector has been becoming so popular is the general rise in disposable income, coupled with the spreading willingness to pay for these products.

Furthermore, the COVID-19 global pandemic situation has been a material factor that further strengthens the purchases of disinfection and sanitation products that are composed of menthol such as alcohol-based hand sanitizers. In fact, the two major companies that dominate the hygiene market, Unilever and Procter & Gamble, beat the expectations during the epidemic period, in the last quarter of 2020. The Financial Times reported a Unilever sales increase of roughly 4.5% which was far greater compared to the approximately 1% that was forecasted. Also, another element that needs to be taken into consideration is the development of emerging markets which creates lucrative opportunities for such key players in the hygiene sector.

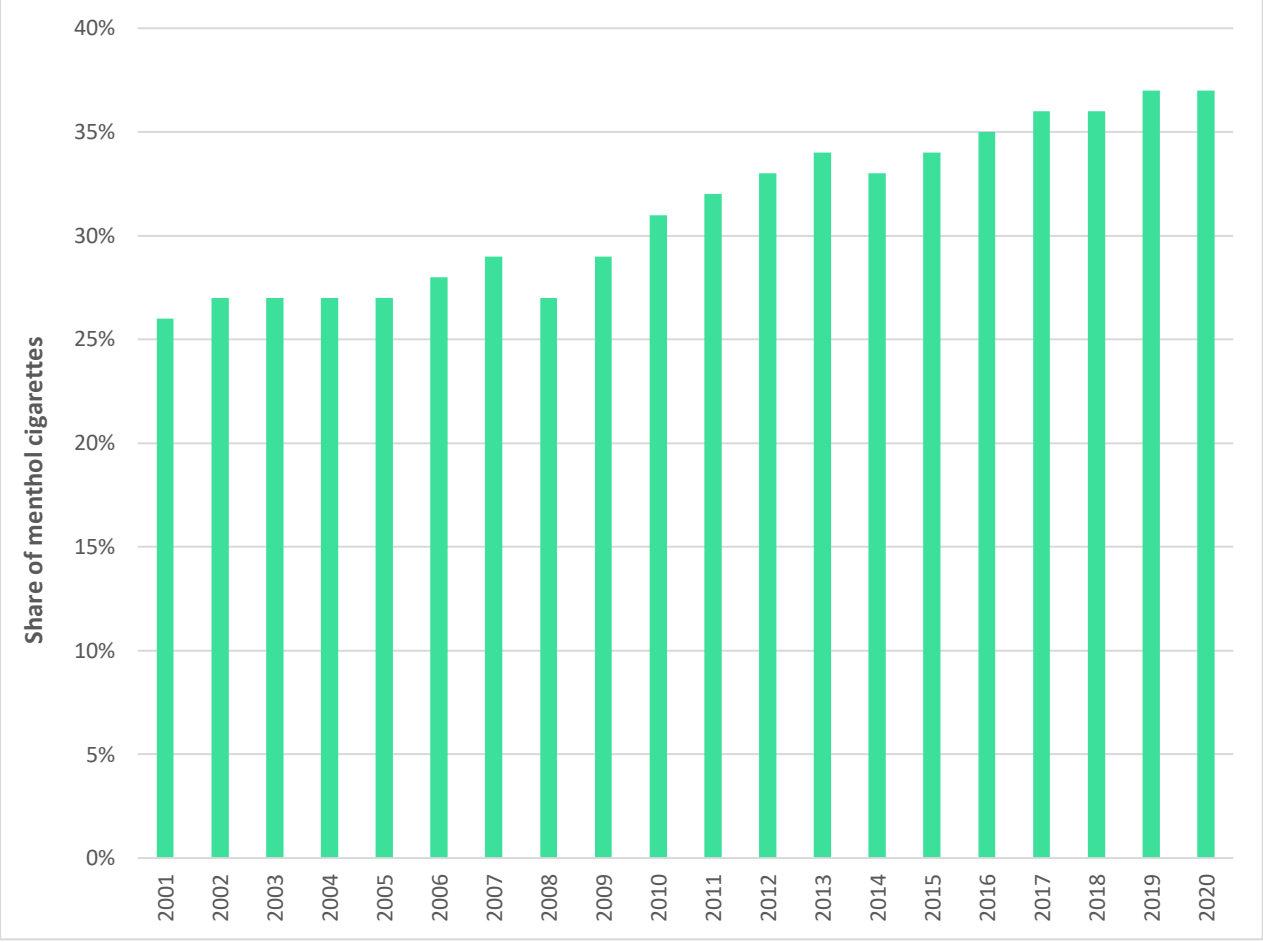
When looking at the pharmaceutical industry, it gives our company clearly one of the biggest opportunities for licensing the menthol process to one of the most expanded markets in terms of size among those considered. In fact, according to Statista the overall pharmaceutical market worldwide accounted for USD 1.27 trillion at the end of 2020. Also, the real potential of this industry can be understood if this number is compared to the rise of this sector, from the value of USD 390 billion in 2001. In addition, the American market has emerged as the most crucial one in the pharmaceutical sector. Two of the leading pharmaceutical companies in this sector are certainly Johnson & Johnson and Pfizer, which intensely use a high quantity of menthol for their products. Generally, many of the leading market players in this field are based in the United States, which therefore has the most important stake worldwide in the pharmaceutical segment. The second position in terms of revenues is recognized to Europe, which shows an intense development in the pharmaceutical industry with dominant competitors such as Novartis and Roche Holding AG.

The impact that TerpenOX would have in this field is cardinal, because of the recognized medicinal purpose of menthol. In fact, medications containing this compound are useful for a wide span of issues such as respiratory issues, gastrointestinal disorders, common cold, and muscle pain (Eccles, 1994; Patel et al., 2007). Also, the transition to synthetic menthol in the pharmaceutical industry would allow all the businesses to address the challenges related to high prices, providing customers with high-quality, less expensive, and more sustainable products.

Finally, the menthol tobacco industry gained in 2020 overall revenue worldwide of USD 87.2 billion. Also, the market forecasts are predicted to rise by a CAGR of 3.2% throughout the period 2021-2026. Further, when looking at the regional framework of this market, the Asia Pacific segment had the larger portion of the market in 2018, namely 64.2%. Also, this region is forecasted to experience the most relevant growth in the next years, with China being the

leading consumer of menthol, accounting for approximately 50% of the global demand. Moreover, the Central and South American region has experienced the second fast-expanding global menthol tobacco market, which is represented by a steady CAGR of around 3.2% from 2019 to 2025. Overall, a rising request from the tobacco and vaporizer industry is expected to drive a material expansion of the global menthol market in the next years.

Figure 3 *Menthol cigarettes market share between 2001 and 2020 in the United States*



Source: Statista 2022

In addition, a study conducted in 2020 which analyses the demand and purchases of tobacco in the last twenty years in the United States showed that the menthol cigarette market is becoming superior in the industry of tobacco, due to the increment of the menthol cigarette market

relevance (Figure 3). Moreover, the tobacco industry has continuously been supported by using many marketing channels to customers making cigarettes one of the main goods in the American Country. In fact, in 2019 the expenses used to sponsor this overall market exceeded USD 7.5 billion in 2019. Some of the well-known companies in the menthol tobacco industry are the top brands such as Newport as the most dominant, Marlboro, Camel in third position, and finally Pall Mall. The first one is specialized in menthol cigarettes and confirmed its premium position, with around 6.4% of market share growth from 2014 to 2019. Also, Marlboro was able to increase the market portion by approximately 18.0% from 2014 to 2019 keeping the second position in this industry. These market players promote the usage of menthol in cigarettes because of its perceived and sensory benefits. In fact, menthol cigarettes provide a cooling feeling, and a refreshing sensation, which helps to reduce the strong flavour of pure tobacco, increasing the demand even of young generations in other markets besides the menthol one.

2.4. Other Markets besides Menthol

Several organic compounds are selected by an increasing, international synthetic biology business which is based in the pharmacy and food industry.

Because of their flavours and fragrance properties, these compounds are intensely used in many fields. However, natural menthol tends to synthesise only a little percentage of these compounds, especially if we consider terpenoid products of a relevant value, which are constituted by less than 3% of the overall amount of dry weight of the plants (Roberts 2007). Also, alongside vanillin, menthol represents one of the most famous terpenoids, a wide group of more than 30,000 composites produced from herbs. In addition, terpenoids are included in crucial parts of the metabolism of plants, like photosynthesis and respiration (Aharoni et al. 2005).

Another aspect that needs to be considered, is the development of digitization and automatization. These factors have completely changed all the steps of the synthesis of the compounds, starting from the design of DNA constructs to the test of biosynthetic compounds utilizing efficient robotic programs. Further, the companies who are leading the biological synthetic market can raise considerable amounts of capital from dominant venture capitalists in order to fund their research and development in the first stage. Also, these investments are necessary to support the infrastructures such as computers, machinery, and robotic systems, which are necessary to optimize and make automatic the production process.

Apart from menthol, which is one of the most important compounds, there are many different types of elements like menthone, carvone, and linalool that can be made starting from mint oil (Verma et al. 2010). Given the market relevance of the fragrances field, a great variety of several compounds have been utilized for synthetic biology and for various research. Equally to trends noticed for menthol, vanillin has slowly changed its way of being produced, passing from natural fields to the synthesis of it. Nowadays, the price of synthetic vanillin is particularly lower than the plant-based alternative. In addition, this synthetic compound covers roughly 99% of the overall market of vanillin (Wilde et al. 2022). Compared to menthol, the statistic is completely diverse, since the natural production of this compound accounts for 70% of the global market. The overall market for vanilla is forecasted to increase at a CAGR of 5.8% during the period from 2021 to 2026. As the pandemic period characterized by COVID-19, the market for natural ingredients expanded due to the high request for organic products. This factor has been one of the consequences which brought to a relevant growth in the demand for the vanillin segment across the world, especially in the food and beverage sector (CBI 2021).

When looking at the South American geographical region, Mexico is one of the most relevant producers of vanillin. In fact, in 2016 this country was able to produce approximately 512.78

metric tons of vanilla, whereas in 2030 is projected to increase by almost 67%, reaching an overall offer of roughly 856.71 metric tons. However, the industrial demand for this compound is much greater than the total quantity of it extracted from the plants. This issue has led to the research of different modalities for creating vanillin such as the synthetic production.

Figure 4 *Production of vanilla in Mexico Between the years 2016 and 2030*

Source: Statista

A great part of the production of natural vanillin is consumed in the United States, that was the main importer from Mexico in 2016. In fact, as per Statista, based on the 30.82 metric tons of this compound exported from Mexico in 2016, more than 57% of it was delivered to the United States. The main reason is its intensive usage in the American food and beverage sector, namely in soft drinks, chocolate, and especially ice cream which requires almost 40% of the overall

import of vanillin in North America. Also, as per menthol, this compound is largely utilized in many sectors, and it has several relevant properties such as antioxidant, antimicrobial, and anti-inflammatory, that make this compound desirable. Therefore, this is another motivation why the United States, being the country with a major interest in the pharmaceutical sector, largely requires this compound to use it for the production of drugs.

On the other side, considering the Asia-Pacific region, it is the largest vanillin market all over the world. In addition, this geographical segment is projected to enlarge rapidly. In particular, China is considered both one of the main producers and consumers of vanillin, in accordance with the information provided by the UN Food & Agriculture Organization. Also, this country has been considered the most important exporter of vanilla in 2018. However, India has been recognized as one of the dominant markets of vanillin in the last decade, conforming to the ISS Institute Inc. The global offer of this compound is particularly small if compared to the large request which characterizes it across several markets. Since there are only a few countries that produce vanilla, and due to the considerable demand for it, the price fluctuates largely. In fact, a scarcity in 2017 provoked a crucial growth in vanillin prices, whereas prices were drastically reduced by one-third later in 2019.

When analysing the natural production of vanillin directly through the natural plant, it requires so much effort in terms of human work. As a consequence, from the high costs of the final product, fragrance companies decided to utilize the compound synthesis in order to reduce the raw material costs of vanilla beans, and therefore provide a cheaper price to customers.

In particular, the companies that work in the food and beverage industry need to cope with large expenses for natural vanillin. There are already many compounds that are available on the market, which are realized in laboratories through microbial cell factory methods by important market players like Amyris (US) and Evolva (Switzerland). Further this companies

are specialized in the development of sophisticated laboratory processes used to convert yeast, to generate orange, woody tastes and fragrances, and to make grapefruit extracts (Schempp et al. 2018).

These are the main motivation why the synthetic version of vanillin is becoming so popular and useful in several industries that require the usage of this compound. In fact, the latter is one of the most demanded compounds in the market because of the unique flavour and properties that it has. As a consequence, natural vanilla is responsible for only 1% of the production worldwide (Wilde et al. 2009), showing how fast the technologies utilized for realizing it have been rapidly evolved.

Finally, many bio-variations regarding the synthetic chemistry used for substituting the massive usage of fields for producing natural products. One of the many examples is the compound that is responsible for the fragrance of roses, which is produced starting from rose petals and oils. Furthermore, the process of producing it is focused on sustainability, cost reduction, and consumer acceptance (Fang et al. 2018). There are many other compounds that are important targets for synthetic biology as patchouli, saffron, cocoa butter, vetiver, orange, and grapefruit

3. Our Competition

As a chemical research start-up developing an innovative process for menthol synthesis, our competition are the conventional production methods currently in place. When looking at the processes for global l-menthol manufacturing we differentiate between plant-based, semi-synthetic and synthetic production methods. Currently about 70% of the global menthol supply is derived directly from mint plants. Roughly 30% of the world's supply is chemically derived, mainly by the three major producers Symrise AG, Takasago International Corporation and BASF SE (Ribeiro and Shapira 2018), that each developed their own unique production method. As we are going to find out, however, each of those production mechanisms comes with a set of flaws and limitations, which leaves us with a considerable opportunity for innovation.

To better understand how each of the different production methods to obtain menthol compares we have to briefly introduce a bit of science behind the molecule. Menthol exists naturally as a stereoisomer, meaning there are eight different possible forms of molecules. Each of those molecules is made up by the very same parts, yet the orientation of those parts differs among the distinctive forms (see Appendix, Figure 11). Levomenthol ((−)-menthol), commonly referred to as l-menthol, is the most common form of menthol found in nature such as in mint plants. This is the type of menthol that possesses local anaesthetic and counterirritant properties and is used by the industry in a large variety of products. At room temperature it is a flaky white, colourless substance that melts at around 41-44ºC (Oz et al. 2017). Whenever we refer to menthol in a general way, this is the type of menthol we are referring to. We might call it l-menthol or (-)-menthol depending on the context. D-menthol or ((+)-menthol)) on the other hand, presents different body reactions, causing skin irritation, and is therefore undesired.

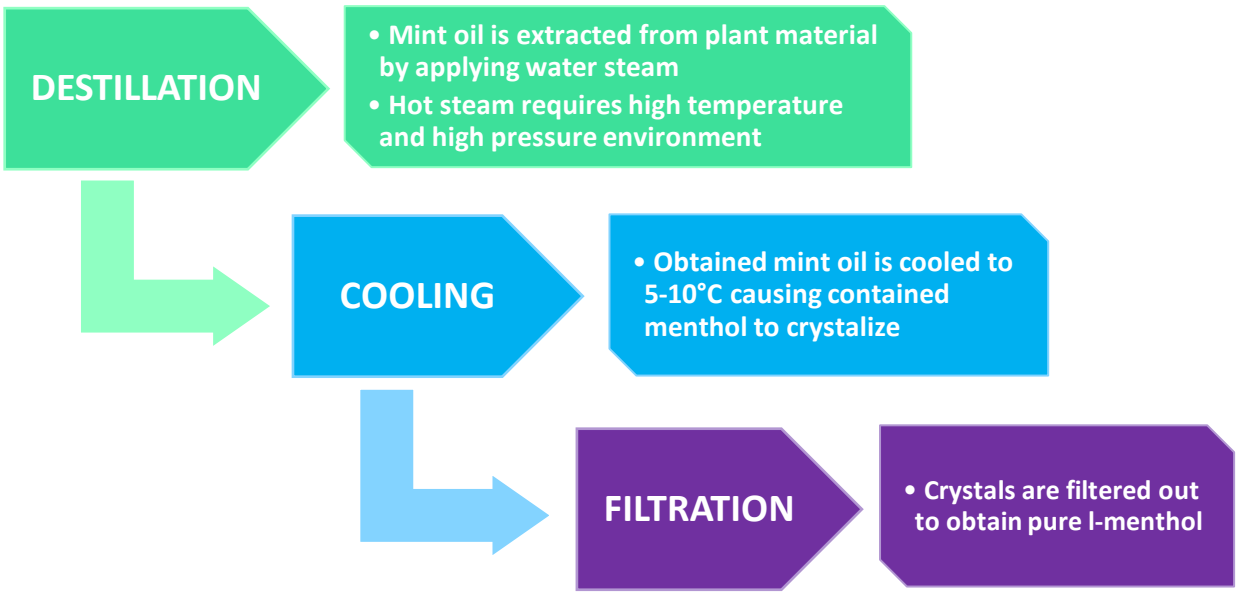
3.1. Natural Extraction (Plant-based Process)

The “Mentha arvensis” plant, which is also known as corn-mint, field mint or wild mint, is native to parts of Asia, Europe, Siberia, and North America (Tiwari 2016). The plant is first and foremost grown for the relatively high menthol concentration in its essential oils. With the help of genetic manipulation, there have been efforts in the past to increase menthol yield by developing and cultivating new superior variants of the plant that contain higher levels of menthol and are more resilient than their predecessors (Tiwari 2016). By far the largest producer of natural menthol is India, where most of *Mentha arvensis* is cultivated, followed by China (Lawrence 2006). Currently, India accounts for roughly 80-85% of the plant-based produced l-menthol globally (Ribeiro and Shapira 2018).

Plant-based menthol is created through natural extraction from plant material which consists of three steps:

1) First, a steam distillation process (see Appendix, Figure 12) is applied to the leaves of the “Mentha arvensis” plant. Thereby, the hot water steam is used to condense the plant material and to extract a mixture of mint oil and water.
2) After the mint oil has been separated from the water it is then cooled to a temperature between 5-10 degree Celsius. As the freezing point of menthol is above the remaining substances present in the oil, the contained l-menthol crystalizes first while the remaining contents stay in liquid form.
3) In a third and final step these menthol crystals are then isolated through a filtration process to obtain pure l-menthol.

Figure 5 *Natural menthol extraction process from mint*



3.1.1. Limitations of Natural Extraction

While chemically identical to its synthetic counterpart, menthol produced from natural sources, namely mint oil obtained from the *Mentha arvensis* plant, requires large portions of valuable farmland. In India alone roughly 1,630 square kilometres or 228,291 football fields are dedicated to mint farming (Tiwari 2016). With a growing world population, especially in countries like India and China, where most of the mint is currently grown, this soil could be used for food production instead. Even the land that is not suitable for cultivating food could be rewilded, thereby giving back valuable space to the ecosystem, flora and fauna which would greatly benefit biodiversity and contribute to combat climate change as CO2 will be stored in the trees and bushes of the rewilded areas. Besides taking up a lot of farmlands, growing mint for menthol also requires large quantities of water that tend to vary depending on different climate conditions.

Once the mint is harvested, the menthol still needs to be extracted from the plant. This process is quite energy-intensive as the steam distillation requires sufficient heat and pressure to extract the mint oil. On top of that, the obtained mint oil needs to be cooled down which further increases energy demand.

Despite environmental concerns, naturally produced menthol is susceptible to high levels of supply uncertainty. The price of plant-based menthol has proven to be very volatile as yields and therefore supply is largely dependent on environmental factors such as the condition of the soil as well as the amount of sunlight and rainfall. Prices as low as 5.00 EUR/kg for natural menthol, and as high as 16.50 EUR/kg, have been reported, which makes it difficult to accurately budget the cost of the raw material. Further, not only yield is affected by environmental factors but also menthol concentration on the mint plants and therefore quality (BASF 2012).

In addition, speculation by commodity traders contribute to shortages and unexpected price spikes of mint-based natural menthol. Lastly, mint-based menthol alone has not been able to keep up with global demand of roughly 25,000 to 30,000 tons per year and will not be sufficient going forward with a growing number of new products that contain menthol (BASF 2012).

Although our solution will be introduced in detail in the following chapter, we can already say that it is going to avoid the issues described above as menthol is obtained through a synthetic process that does not require any farmland. Therefore, it is not affected by any environmental conditions and able to produce a stable, consistent output in terms of quantity and quality. Also, our process works with low pressure and room temperatures, and therefore does not require energy-intensive heating or cooling. Additionally, it is adaptable to current market conditions, in contrast to mint farming, where output can no longer be upward or downward adjusted once the mint for the season has been planted. Finally, as our process is carried out in industrial

production plants, it is easily scalable and able to satisfy the growing demand for menthol in the future.

3.2. Takasago (Semi-synthetic Process)

Takasago International Corporation is a Tokyo-based manufacturer of aroma chemicals such as flavours and fragrances. Founded in 1920, the Japanese company is now present in 28 countries across the globe and was able to achieve a revenue of EUR 150 billion in 2021 (Takasago Int. Corp., 2022). Takasago started synthetically producing l-menthol in 1954 when citronella oil represented the basis for the starting product. Since then, they continuously adapted and refined the process, temporarily switching to petroleum-based chemicals until the company arrived at the so-called asymmetric synthesis in 1983 (Emura and Matsuda 2014). In the same year, the company constructed one of the largest asymmetric catalytic production plants globally. Despite further refinements, this process, which enabled them to become one of the leading producers of l-menthol, remains the current production method of choice for Takasago today (Takasago Int. Corp. 2022).

During the Takasago asymmetric process (see Appendix, Figure 13) l-menthol is synthesised from the aroma chemical myrcene. The pleasant-smelling terpene is organically sourced from gum rosin contained in pine resin but can also be found in other tree saps and wood chips (Emura and Matsuda 2014). During the four-step process, different catalysts are employed to carry out the reactions. Since a plant-based starting material is employed for the chemical synthesis, this process can be described as semi-synthetic. It works as follows:

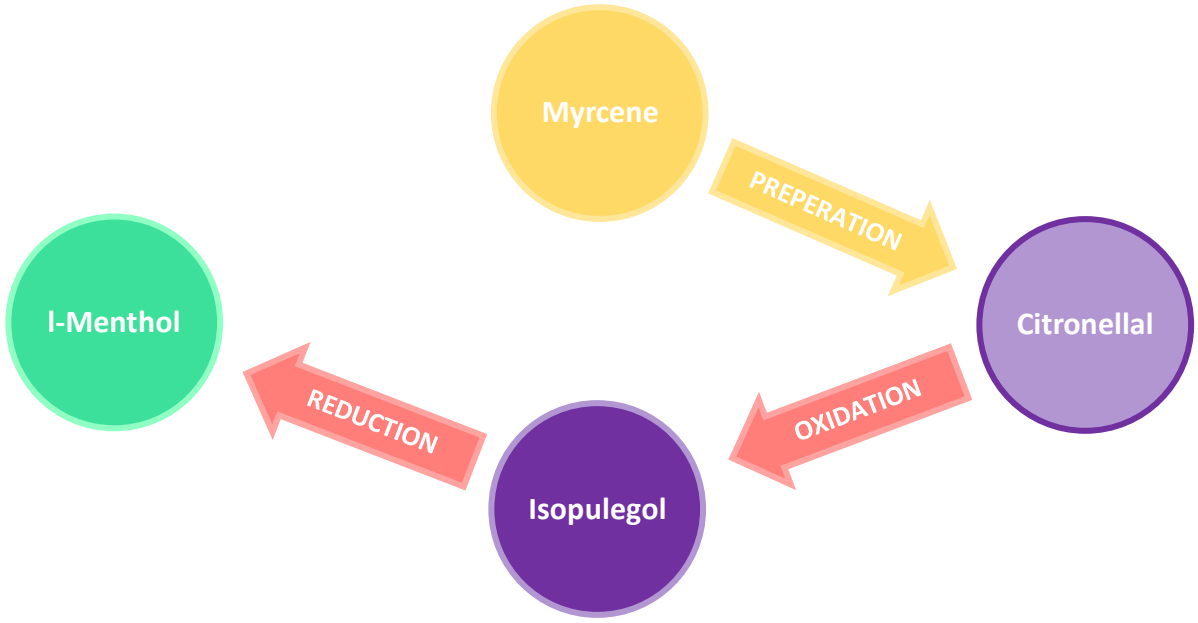
- The function of the first two preparation steps is to transform myrcene into citronellal, a fragrant molecule with a lemon aroma belonging to the so-called terpene class of molecules. During those two reactions, lithium amide and ruthenium as a catalyst (Rh-

BINAP (2,2'-bis(diphenylphosphino)-1,1'-binaphthyl)) are involved (Emura and Matsuda 2014).

The synthesised citronellal is then transformed in another two separate steps into menthol.

- First, by oxidation (cyclization), involving zinc bromide ($ZnBr_2$) as a catalyst, the citronellal is turned into isopulegol.
- Second, by reduction (hydrogenation) involving hydrogen and nickel, the intermediary is then finally turned into l-menthol (Emura and Matsuda 2014).

Figure 6 *Takasago process for menthol synthesis (simplified)*



3.2.1. Limitations linked to Takasago's production method

While Takasago's asymmetric synthesis (see Appendix, Figure 13) moved away from the reliance on mint, which is arguably more sustainable, it is still subject to the availability of organic compounds found in plants. Therefore, the semi-synthetic route may be impacted by several minor supply chain issues.

First, there might be a negative supply shock due to environmental factors such as climate change and pests that pine trees have shown to be very susceptible to. If large populations of

pine trees die because of draughts, fires or insects, pine resin as a starting material might be harder to come by and significantly increase in price. Although there are other ways of obtaining myrcene, the switch would certainly introduce additional costs. Besides potential supply shortages and fluctuating prices of raw materials, other risks include lack of available transportation, which comes with a longer and more complex supply chain linked with agricultural products as key ingredients.

The major negative effects of the semi-synthetic route, however, are caused by the final two steps of the synthesis. Here, the previously obtained citronellal is turned into l-menthol, which leads to a number of economic, environmental and safety issues by itself.

First, from an economic perspective, separately carrying out oxidation and reduction requires more time and equipment, which increase production cost. Additionally, energy demands are excessive as the distinct reaction steps involve both high temperature and high pressure, thereby further increasing the costs of goods sold. At this point in time, energy costs are particularly relevant since prices have been surging in the west because of introduced supply uncertainty since the Ukraine war. This is due to a strong dependency on Russian fossil fuels in the US and especially in Europe. Our solution mitigates this effect by significantly reducing energy requirements, while at the same time, replacing the two-step separate oxidation and reduction with a single-step process, thereby cutting the number of needed reactions in the transformation from citronellal to l-menthol in half.

From an environmental point of view, the high energy demands of the two-step separate oxidation and reduction within the Takasago process represent a major downside, since they are linked to increased CO_2 emissions that contribute to climate change. Further, the catalysts needed during the oxidation and reduction reactions involve so-called heavy metals which are known to be environmental pollutants due to their toxicity, perseverance, and bio-accumulative

nature. This is not only extremely harmful but also unnecessary, as the TerpenOX process will not require the use of heavy metals to operate at an equal or higher efficiency level.

Lastly, from a product safety point of view, it is inevitable that small traces of the toxic heavy metal catalysts will be found in the end-product, no matter how diligent the quality controls. Even the tiniest amounts of heavy metals can have detrimental effects on the health of human beings as well as animals, and can even be the cause of cancer and other diseases. With our solution, on the other hand, we will be able to produce clean menthol without these safety concerns.

3.3. BASF (Synthetic Process)

With about 111,000 employees globally and a revenue of EUR 78.6 billion in 2021, BASF SE is arguably the largest producer of chemicals in the world. The German company was founded in 1865 and has its headquarters in Ludwigshafen where its largest production facility is located as well (BASF 2021). Ludwigshafen is also where, according to BASF, the largest synthetic menthol production plant was built in 2012 (BASF 2012). The group got involved in the aroma chemical sector back in the 1980s when its first citral production plant was established at its German headquarter facility (BASF 2012).

The synthetic route to menthol that BASF employs (see Appendix, Figure 14) differs mainly from Takasago's process in that it is based on the terpene citral ($C_{10}H_{16}O$) as a raw ingredient instead of naturally obtained myrcene. The citral products geranial and neral are convenient raw materials for BASF as they are easily obtained from butene sourced from relatively cheap petroleum as a by-product through other chemical production lines within the company's operations (BASF 2012). The company claims a purity of minimum 99.7% for its final product. As the BASF process does not contain a naturally obtained raw ingredient such as myrcene, it

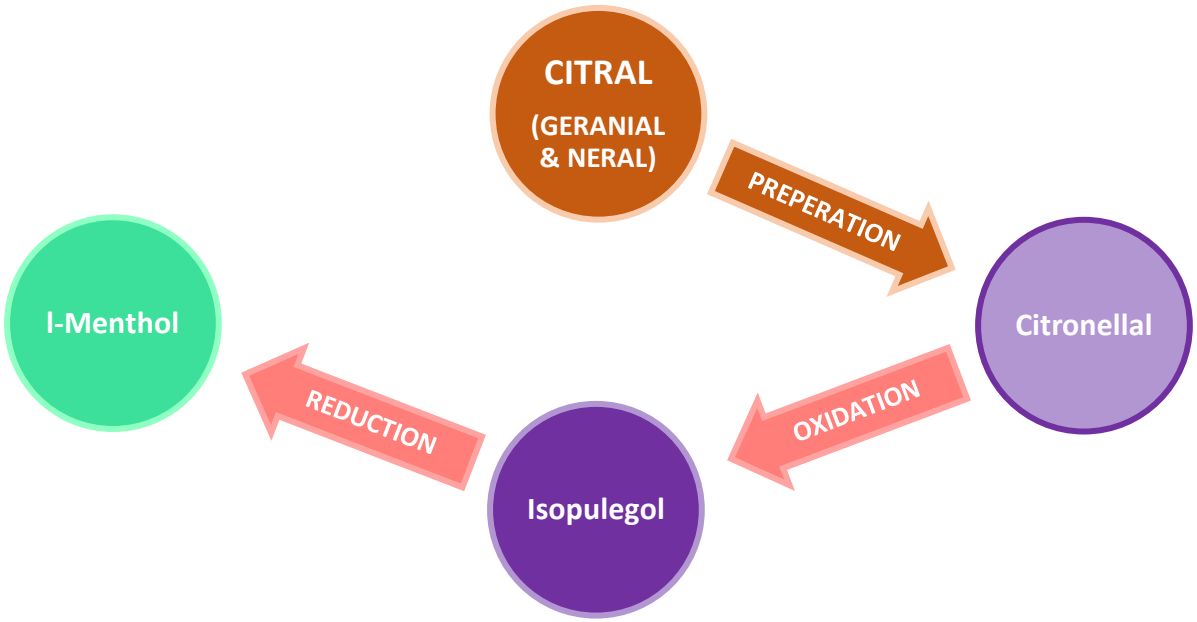
can be described as synthetic. The BASF process is outlined below according to a patent filed to the U.S. Patent and Trademark Office in 2010:

1) The citral products geranial and neral are transformed into citronellol ($C_{10}H_{20}O$) in the first of two preparation steps. In the second preparation step, the intermediary is then turned into citronellal ($C_{10}H_{18}O$), which contains two hydrogen atoms less than citronellol.

Just like with Takasago's route, the acquired citronellal is synthesised through two separate oxidation and reduction steps with the help of heavy metal catalysts:

2) First, it is oxidated into the intermediary chemical isopulegol (cyclization) with the help of heavy metal catalysts.
3) Finally, the obtained isopulegol is being reduced into l-menthol (Bergner et al., 2010).

Figure 7 *BASF process for menthol synthesis (simplified)*



3.3.1. Limitations linked to BASF's production method

The BASF process (see Appendix, Figure 14) can be viewed as building on top of the Takasago method. The key difference is that BASF eliminated organic myrcene as a starting material to obtain the intermediary compound citronellal and substituted it with geraniol and nerol sourced from petroleum through refining. Once the intermediary is created, the remaining synthesis into l-menthol looks very similar with both processes employing catalysts to separately oxidate citronellal into isopulegol followed by a reduction into l-menthol.

Using petrochemicals as a feedstock simplifies the supply chain as petroleum is widely available and already used throughout many of BASF's production lines. Potential downsides, however, might be the surging prices for oil all over the world upon the Ukraine war as well as the negative effects on the environment linked to the use of fossil fuels.

Yet, as the second half of the menthol synthesis from the intermediary citronellal is the same, the BASF process faces exactly the same economic, environmental, and safety issues linked to the separate oxidation and reduction steps as Takasago, described above, and which our process is going to tackle.

3.4. Symrise (Synthetic Process)

Symrise was created in 2003, when the two Holzminden-based German aroma and flavour producers Haarmann & Reimer and Dragoco merged into one, and thereby became the fourth largest aroma chemical company at the time. After both Hararmann & Reimer's and Dragoco's history in the aroma chemical sector dating back over a century, the newly formed Symrise went public in 2006 on the German stock exchange. Today Symrise AG has around 11,000 employees in over 100 locations around the globe, and achieved a revenue of roughly EUR 3.8 billion in 2021 (Symrise AG, 2021). Nowadays, the group's activities are divided into the two

main segments “Taste, Nutrition & Health”, as well as “Scent & Care”. The latter includes aroma molecule production such as menthol, which besides vanilla and citrus flavours, the company claims to be its core competency. After Symrise started synthesising menthol back in 1973, in Germany, a second production facility was introduced only a few years later in Bushy Park, South Carolina, United States. Since then, capacity in both locations has been continually increased to keep up with the growing demand for l-menthol over the years (Th. Geyer Ingredients 2015). In contrast to BASF, which sells menthol to external fragrant and flavour manufacturers, Symrise on the other hand uses most of its supply as an ingredient for its own flavour products (Halliday 2010).

Just like with BASF, the Symrise process (see Appendix Figure, 15), formerly known as Haarmann & Reimer process, relies on a petrochemical as its raw ingredient and can therefore be classified as synthetic. Petrochemicals are compounds that can be derived from petroleum through refining. However, instead of geranial and neral, Symrise uses m-cresol (3-methylphenol). Its process is described below:

1) M-cresol is first turned into thymol with the help of a catalyst.
2) The obtained thymol is then catalytically hydrogenated (enriched with hydrogen atoms) into a mix of the different possible menthol isomers menthol (+/-), neomenthol (+/-), isomenthol (+/-) and neoisomenthol (+/-) in equal quantities (see Appendix, Figure 11).
3) Through distillation the (+)-menthol and (-)-menthol molecules are separated from the remaining isomers which are going to be catalytically reacted (recycled) into a new mix of menthol isomers.
4) The separated 50/50 mix of (-)-menthol (l-menthol) and (+)-menthol is then esterified with a benzoic acid. Only the (-)-menthol benzoate molecules are crystallized, separated

and hydrolysed in order to obtain pure (-)-menthol (l-menthol) up to a 90% yield (Quoc Le n.d.).

5) The residual is recycled back into the process.

According to its product sheet, l-menthol produced by Symrise has a minimum purity of 99.7% (Symrise AG, 2021).

3.4.1. Limitations linked to Symrise's production method

Although Symrise relies on the relatively attainable m-cresol as a feedstock for its menthol production (see Appendix, Figure 4), there are a number of downsides to this process. Unlike the previously discussed production methods based on citronellal that Takasago, BASF, and TerpenOX employ, arguably the biggest issue is that not only l-menthol is synthesized, but rather all of the different possible isomers (see Appendix, Figure 11). As a result, the process demands an extensive procedure to separate the desired l-menthol from the remaining isomers, including selective crystallization followed by hydrolyzation just to isolate (-)-menthol (l-menthol) from (+)-menthol. While the undesired isomers can be recycled back into the process, indiscriminately creating all the possible isomers in the first place appears to be very inefficient. Therefore, from an economic perspective, the comparably long and complicated Symrise method introduces costs for additional time, equipment, and manpower to carry out the synthesis. Our ONESTEP solution, on the other hand, is discriminative, meaning only l-menthol is synthesized which eliminates the need for a lengthy and costly separation from the other isomers.

Additionally, Symrise is heavily dependent on the German chemical company LANXESS AG, which is the supplier of m-cresol and thymol. According to Symrise, the latest German capacity expansion in 2012 would not have been possible without the joint decision to increase

LANXESS's capacity as well (Halliday 2010). Relying completely on one single supplier introduces several risks and uncertainties. First of all, there is severe supply uncertainty since LANXESS could fail to produce enough quantity in time, decide to permanently lower production volume, or simply stop selling the required ingredients. Further, there is a strong price risk as LANXESS has effectively a monopoly on the raw material supply for Symrise. Should the partner company decide to increase its prices, Symrise has no alternative but to accept, thereby directly affecting the cost of Symrise produced menthol. Lastly, there is little decision autonomy as, for example, capacity increases to respond to higher demand for menthol can only be carried out after the partner agreed to a joint decision. In contrast, the TerpenOX process is based on citronellal as a starting material, which is not only off-patent but can be created from a large number of organic and fossil sources. With our solution, availability is consequently not an issue.

3.5. Problem Summary – Opportunity for Innovation

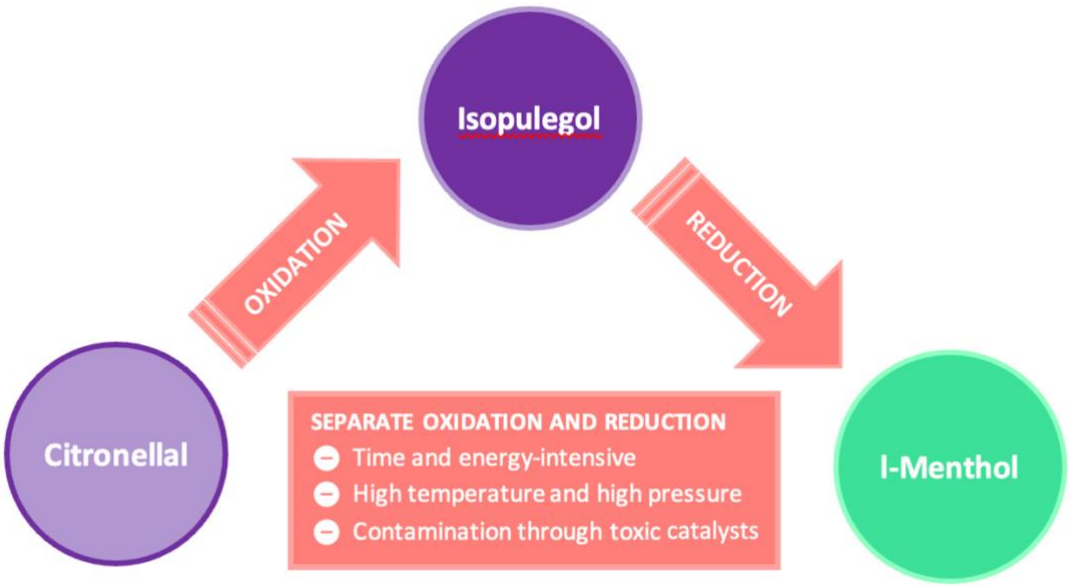
Although all of the four production mechanisms have their own specific advantages and limitations, some can be seen as superior to others. Growing natural mint alone brings along environmental concerns, as well as economic disadvantages, and is clearly unable to meet the world's growing demand for menthol in the various products the aroma chemical is used, therefore justifying the need for innovative chemical production processes.

Chemically producing menthol can be seen as superior, as it requires much less valuable land, and does not suffer from yield variability due to uncontrollable environmental factors.

Symrise was one of the first companies to commercially synthesise menthol, however, their process appears to be unnecessarily complex and inefficient, as not only the desired l-menthol is synthesised but also all the undesired isomers in equal amounts. On the other hand, both

Takasago and BASF developed a more elaborate process that can be viewed as superior, since only the desired l-menthol molecules are synthesised, eliminating the need for tedious recycling to achieve the desired yield as with Symrise. This is why it makes sense to focus innovation efforts on these two production mechanisms. The processes mainly differ in the way they obtain the intermediate substance citronellal; the semi-synthetic Takasago route relies on the plant-based compound myrcene, whereas BASF employs fossil fuel derived chemicals as a starting material. The choice of the raw materials comes with advantages and downsides described above, yet the majority of problems occur during the two-step transformation of citronellal into l-menthol which is similar for both production methods. Our novel solution is going to tackle the economic, environmental and product safety issues linked to separate oxidation and reduction through process innovation in order to create a healthier, less expensive, and more resource-efficient product.

Figure 8 *Separate oxidation and reduction during both the BASF and Takasago process*



4. Solution

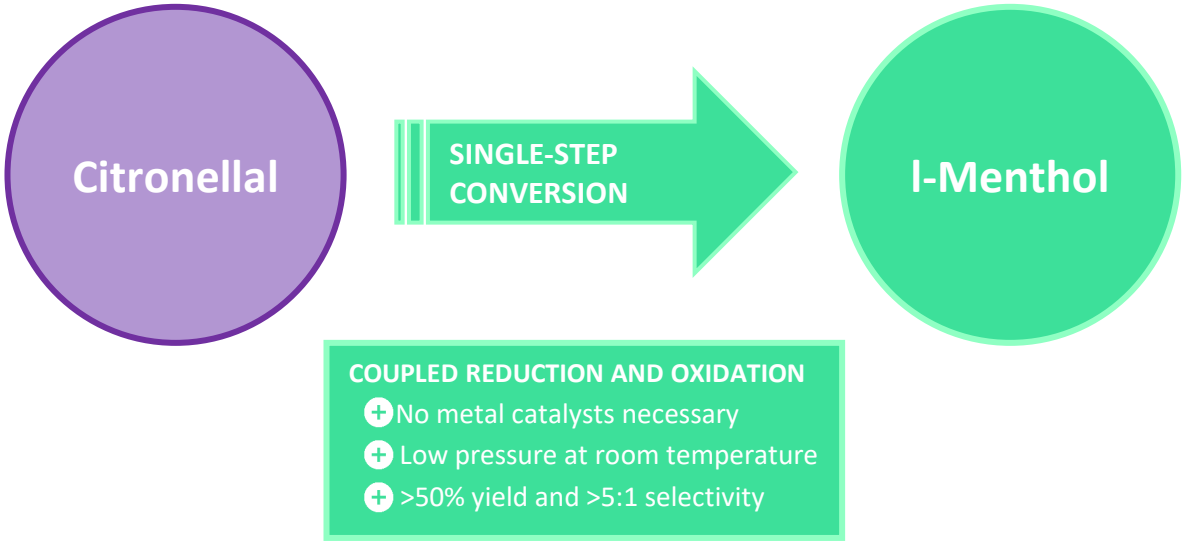
4.1. ONESTEP – Our Solution

Our solution is an ingenious chemical process innovation that is able to tackle all of the problems linked to the two-step oxidation and reduction by coupling the reactions into a single-step process which significantly reduces costs, lowers the environmental impact, and improves product safety. Put bluntly, it is a cheaper, faster, and overall better process that we call ONESTEP. While our efforts so far have been centred around l-menthol, as it is the most promising market in terms of size, by adapting the process to other terpenes, our innovation has the potential to become a platform technology for processes advancement in the production of a large number of valuable compounds, such as vanillin or cannabinoids like CBD.

TerpenOX's ONESTEP is based on the concept of *redox neutrality*. In contrast to separating oxidation and reduction in two steps, redox neutrality is a single-step process where oxidation and reduction happen at the same time, without the need for a catalyst. Although redox neutrality is not a new concept, so far it has not been suitable for applications such as menthol synthesis due to the nature of the reaction. During a redox neutral process, intermolecular hydrogen atoms (hydride) are transferred, thereby creating intermediates (carbocations). These intermediates are highly reactive, which causes them to form bonds spontaneously, unpredictably, and uncontrollably, resulting in a variety of random and undesired reaction products. Within the "NEUTRAMENTH" project, filed for the European Research Council's (ERC) Proof of Concept program (PoC), the team behind Prof. Nuno Maulide at the University of Vienna has now been able to control this bond formation which has been the critical challenge so far in order to create a desired reaction product. To capitalize on this scientific breakthrough TerpenOX is going to obtain the rights-of-use for commercialisation from the

University of Vienna to develop a process capable of utilizing single-step redox neutral reactions for menthol synthesis at an industrial scale.

Figure 9 *Single-step coupled oxidation and reduction as carried out during ERC POC NEUTRAMENTH project*



Source: Spartax Chemicals

Employing citronellal as a starting material has many advantages. First, it is already used during both BASF's and Takasago's production methods, and therefore compatible with the largest manufacturers of commercially available l-menthol. Second, it is easily available in large quantities and may be sourced from fossil or plant-based origins, whichever is more readily available and convenient at a given time. Third, citronellal production is off-patent, which allows its production to be vertically integrated into any company's operations for maximum supply security.

While ONESTEP relies on citronellal as well, our technology has several benefits compared to the current synthetic routes industry leaders Takasago and BASF employ. First, from an economic point of view, the technology lowers production costs because:

a) CAPEX requirements are reduced: The new single-step process replaces the current two-step process, therefore eliminating the need for two reaction chambers and reducing the footprint of the production line.
b) Variable costs are reduced: The previous two-step process demanded both harsh reaction conditions (high temperature & high pressure) as well as catalysts to carry out the reactions. In contrast, our new ONESTEP process is able to work at low temperatures and low pressures, thereby significantly reducing the energy demands. This is especially significant, as energy prices in the West and especially in Europe have recently surged upon the Ukraine war. Moreover, there is no need for additional catalysts which further decreases variable costs of the operation.
c) Production time is saved: As our technology cuts the number of redox reaction steps in half (from two to one), the new process is much faster as no intermediary isopulegol is created which needs to be processed further. Rather, the single-step reaction directly yields the desired l-menthol as a product, saving not only time but also required laboratory worker hours.

As efficiency gains proven in a laboratory environment cannot be directly transferred to a multitone industrial production scale, because of many unknown variables, further R&D is necessary to state precise performance gains figures. However, given the factors described above, we estimate a cost reduction from 20% up to 40%. For our financial forecasting and royalty estimates, we chose the lower boundary of 20% as a very conservative estimate. Despite cost benefits, ONESTEP is considerably more environmentally sustainable as:

d) Energy requirements are significantly reduced: Since our ONESTEP process does not require high temperature and pressure in contrast to the current redox process of Takasago and BASF, the demanded amount of energy is substantially lower. As

most of Europe's and North America's energy supply still relies heavily on fossil fuels or nuclear power, any improvement in energy efficiency is beneficial for the environment. Thus, ONESTEP contributes to reducing greenhouse gas emissions and the creation of toxic waste.

e) Use of harmful substances is avoided: Unlike with the separate two-step oxidation and reduction, our redox neutral process does not require any heavy metal catalysts that are widely known for their detrimental effect on nature due to their toxicity, persistence, and bio-accumulative nature.

Lastly, l-menthol produced with our process will be safer and healthier since:

f) Heavy metal contamination is prevented: So far, one of the downsides of synthetically producing menthol compared to natural extraction has been heavy metal contamination. When employing heavy metal catalysts, during the reactions, small particles of these elements and other metals will inevitably end up in the finished product. For example, according to its product sheet l-menthol produced by BASF contains contaminations of up to 10 mg/kg of heavy metals, up to 13 mg/kg of copper and up to 2.5 mg/kg of nickel. Since heavy metal toxins tend to bioaccumulate in the body over time, even the smallest amount of heavy metal exposure can be linked to health implications and diseases such as cancer when repeated over time. As our single-step process does not require heavy metal catalysts, there is no contamination risk, leading to improved consumer safety.

The table below helps to illustrate how our ONESTEP process compares to the other production methods discussed. In contrast to natural extraction and Symrise's method, TerpenOX ONESTEP delivers similar scalability as Takasago and BASF at a lower cost and with superior sustainability and product safety properties.

Table 1 *L-menthol production method competitive advantage comparison*

	Yield	Cost	Sustainability	Safety	Scalability
Plant-based process	44%	−	−	○	−
Symrise	90%	○	−	−	○
Takasago/ BASF	75%	○	−	−	+
TerpenOX ONESTEP	> 80%	+	+	+	+

Source: Spartax Chemicals

Additionally, with ONESTEP, we are able to contribute toward sustainable development according to the United Nations Sustainable Development framework. In 2015 the United Nations have established the so-called "2030 Agenda for Sustainable Development" that formulated 17 goals (SDGs) that countries all over the world should strive for in order to promote an ecologically, economically and socially sustainable future. Our technology is going to contribute toward the following goals:

- **Goal 3 - "Ensure healthy lives and promote well-being for all at all ages"**

  By improving product safety for menthol which is present in a large variety of products like foods, dental care and medicine and consumed by everyone from children to the elderly, we are contributing towards Goal 3 of the UN Goals for 2030.

- **Goal 9 - "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation"**

  With our innovative process that will help to transform the chemical sector into a more sustainable, less resource-demanding industry, combined with constant R&D efforts TerpenOX is going to contribute towards goal 9 of the UN SDG's.

- **Goal 12 - "Ensure sustainable consumption and production patterns"**

As ONESTEP is going to significantly save energy during menthol synthesis as well as avoid toxic heavy metal catalysts it is ensuring a sustainable menthol production pattern. Moreover, our technology has the potential to disrupt the entire chemical industry, as the concept might be transferred to solve sustainability challenges of other production lines besides menthol.

- **Goal 13 "Take urgent action to combat climate change and its impacts"**

  In the short term, while a large proportion of the energy supply in North America and Europe still comes from fossil fuels, a reduction in energy consumption is directly combatting climate change. As our process eliminates the requirement for high pressure and high-temperature reaction environments while cutting the number of redox reaction steps in half, the resulting substantial energy reduction supports goal 13.

4.2. Future Hirings

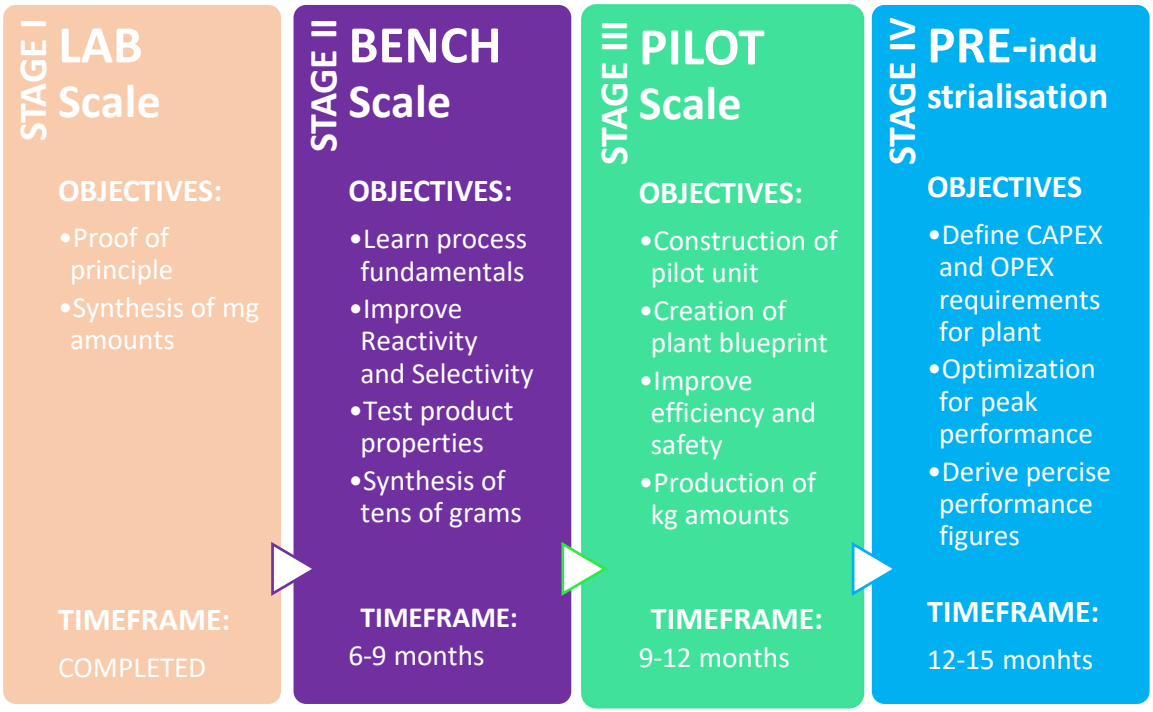
The first person we are going to hire will be a Chief Chemist to carry out TerpenOX's R&D efforts. Given the fact that our business model relies heavily on generating new chemical process advancements and intellectual property, we need to find a full-time scientist who is already acquainted with the bases for our technology. That is why acquiring an experienced chemist from Professor Maulide's research team is our strategy of choice, as they are very familiar with the progress achieved so far. In addition, we are also looking for a junior lab assistant which will support our senior chemist in his work. To fill this position, we are offering an internship possibility for MSc or PhD students. Around six months into the R&D process, we will add a senior engineer to the team who will start to plan a pilot unit that will be necessary at a later stage. Once planning is completed a few months later, we are going to hire a junior technician who will help the senior engineer assemble the unit. Furthermore, the relatively small team size, especially at the beginning, will imply that many of the employees are going to perform a rather broad set of tasks, given these are in their range of capabilities. This is

particularly the case for the founding team, composed mainly of people with management and finance backgrounds, who will have the responsibility of lending a hand in any business-related issue that requires attention.

4.3. Research & Development Roadmap

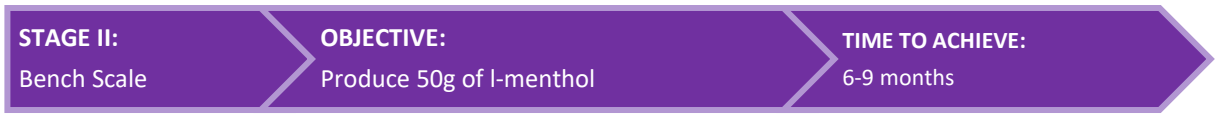
As upscaling chemical processes from laboratory scales to full-scale, multi-tone production is not trivial, but rather requires significant procedural adjustments in terms of safety and efficiency, we are outlining our Research & Development roadmap and milestones to arrive at a license-ready process that satisfies performance requirements for industrial production. As described above, the R&D team consists of two chemists, a senior scientist, and a junior laboratory assistant. Additionally, two engineers, a chief engineer and a junior technician, will be added at a later stage. Both the chemists and the engineers will be appointed by and report to our CINO who is responsible for achieving each of the milestones in a timely manner. The four milestones are illustrated in the diagram below:

Figure 10 *TerpenOX process development milestones including objectives to become investment-ready*



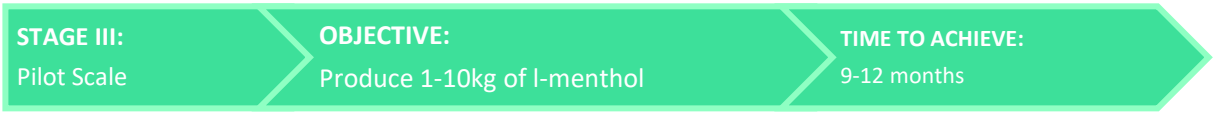
Throughout the whole R&D process, our patent lawyers will carry out activities in tandem to protect any scientific advancements and intellectual property discovered during the process.

Until now, Prof. Nuno Maulide and the team at the University of Vienna have been able to achieve the so-called "lab scale" (stage I), at which the proof-of-principle of the process has been established and milligrams of menthol were produced from citronellal in the laboratory. This is the starting point TerpenOX is going to base its single-step process on. Now, our chemists are going to take the findings obtained from this first synthesis, and built on top of it in order to upscale the process through the following stages.

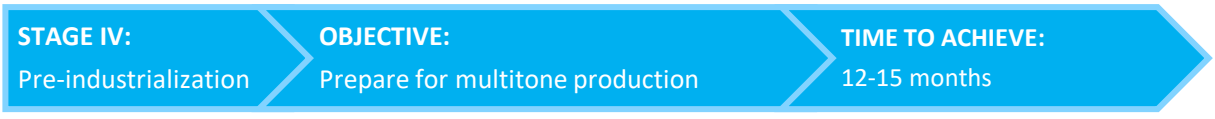


Currently, we are working on Stage II, the "bench scale", with the goal of synthesizing tens of grams, still in a laboratory environment. To accomplish this, further R&D efforts are necessary to improve the reactivity and selectivity of our process, which will be carried out by our senior scientist with the help of a laboratory assistant who will be hired immediately. By increasing reactivity, we will be able to achieve higher reaction speeds that will in turn reduce the required amount of time for the process to complete, and thereby lower the production costs. Selectivity, on the other hand, describes the distribution between the desired l-menthol and the undesired isomers (isomenthol, neomenthol, neoisomenthol) in the reaction product (see Appendix, Figure 11). So far, the University of Vienna was able to navigate the reaction towards l-menthol during Stage I (the pilot scale), but both reactivity and selectivity must be further improved for ONESTEP to be ready for industrial-scale (multi-tone) production, and to maximize

performance gains for our customers. In total, we can expect to accomplish these objectives within six to nine months' time, according to João Seixas from our Advisory Board. Towards the end of this stage, we will hire the senior engineer, as well as the junior technician, who will start the construction of a pilot unit.



Once our chemists were able to synthesise tens of grams using our process with the desired product properties, we will leave the laboratory to move on to the "pilot scale" (Stage III). Here, the goal is to produce kilogram amounts of l-menthol in a small-scale production environment. To accomplish this, we will rent a suitable facility and buy small-scale reaction tanks and supplementary equipment that is going to be assembled by our engineer and technician. At this stage, the senior engineer will create a plant blueprint and figure out issues like automation, heating, cooling, power, and space requirements as well as mechanical operations such as stirring for example. At the same time, process safety and efficiency will be closely monitored by the chemists to predict industrial performance before moving on to preparations for full-scale production. Realistically, we schedule between nine months up to one year for building and adapting the pilot unit, to advance the process as far as to conclude this stage.



As soon as we developed ONESTEP to a point where kilogram fabrication is possible in an effective manner, we enter the fourth and final stage of technology development which is pre-industrialization. During this last stage, the R&D team will prepare for multi-tone manufacturing levels by deriving concrete requirements for capital expenditure (CAPEX) and

operational expenses (OPEX) that help us to fulfil our unique value proposition with explicit and precise performance figures at an industrial-scale production. Additionally, we will consult artificial intelligence and machine learning specialists to run simulations, and who can help us to optimize the reaction environment for peak performance. To run all the necessary experiments, analyses, and apply optimizations we account for up to fifteen months. Once this final stage has been completed our technology will be investment-ready and the engineers can advise licensees in the implementation of the process at their facilities, while the chemists will move back to the laboratory to start experimenting with possibilities for different use cases.

All in all, we arrive at a timeframe of two to three years to complete R&D for our menthol technology from the point of obtaining funding. Given that we have enough capital at our disposal at the end, either from revenues earned through the successful commercialization of the single-step menthol process, or through additional investments into the company, and a final decision by the management team has been made on which market to focus next, the R&D team can start working on adapting our technology to for additional applications besides menthol. The next target will most likely be a process innovation for cannabidiol (CBD) synthesis to invent a production mechanism with similar economic, environmental and safety performance benefits as our menthol application. For this venture, and for any further adaptations, the scientists will follow the same four R&D steps outlined above, first demonstrating a proof of principle in the laboratory, refining the process to synthesize bench and pilot scale amounts, before planning industrial-sized applications. At the same time, all discoveries and scientific breakthroughs will be patented and added to our intellectual property portfolio.

5. Our Strategy

5.1. Market Entry Strategy

As with any other business enterprise, our ultimate goal is to become sustainably profitable. Put simply, we aim at being the technological leaders in the synthesis of terpene compounds, i.e. to establish our technology as the industry standard. On that front, it is worth emphasizing that the patents we will hold firstly are related to our novel process to synthesize compounds – the ONESTEP. That will be the basis for the patents we file for in the near term. Our technology allows for a faster, cheaper, and more sustainable manufacturing of compounds and, even though menthol is, for now, the first and only use case being studied, the process has the potential to synthesize other compounds. That said, our overall strategy to become sustainably profitable is to continuously put efforts into broadening our Intellectual Property (IP) portfolio, and subsequently exploiting its financial potential. In the short term, we are focusing on the exploitation of the ONESTEP technology in the menthol market, but in the medium to long term, we intend to update the technology, as well as adapting it to the production of other compounds which will ultimately allow us to preserve a vanguard position in this space.

The way in which we will monetize the knowledge – different patents – we generate over the years will differ regarding whether a market we intend to enter is concentrated – dominated by few players –, or rather fragmented, meaning there is no clear market leader, and market shares are split more evenly.

5.1.1. Concentrated Markets – Licensing

Market concentration measures the extent to which market shares are concentrated between different firms (OECD n.d.). Starting out with the concentrated markets, as is the case of the menthol one, the way through which we will penetrate them is by licensing our technologies

to dominant players. The reason for that derives from the factors implicit in such a market, as well as the benefits offered by the licensing model to counteract some of those factors.

In highly concentrated markets, most market sales are typically held by a few large firms, and as a result, these possess strong power over competitors, suppliers, and customers. Consequently, this imposes high entry barriers to new entrants, which may englobe high start-up costs, regulatory hurdles, patents protection, customer loyalty, and high customer switching costs. Naturally, this creates a vicious cycle in which incumbent are able to protect their revenues and profits, while keeping new entrants from competing for their market share (Hayes 2022). However, highly concentrated markets also present perverse effects on incumbents. Through the lower threat of new entrants, the former are able to preserve high operating margins and to control price, but in turn start to lose competitiveness, which is usually come under the form of high cost structures, inefficiencies, and lack of innovation.

Having said that, it would be a very risky endeavor for TerpenOX to enter a market like the one for menthol, in which BASF alone holds a market share of around 53% (Beroe, 2018), all by itself, i.e. performing all value chain activities, from in-house manufacturing to commercializing the compound. This leads us to opt for the licensing model, which comes across as the best way of guaranteeing that our technology generates revenue early on. This strategy presents some trade-offs, among which the shortened financial upside is the most noticeable, but we see it as the most rational option, given its significant certainty. Ultimately, this strategy results in benefits for both TerpenOX and its licensees.

Put simply, in a licensing agreement, we (TerpenOX) let other company (licensee) commercially use our patented technologies. Through this agreement, we receive financial compensation in the form of royalties, upfront payments, and milestone payments. Royalties in the Chemical industry tend to range from 2% to 5% (Gross 1998) of licensees' net revenues of a given compound, depending mainly on the factors below (Royalty Range 2019):

- Industry
- Market size
- Stage of technology development
- Exclusivity on agreement
- Market potential
- Upfront payments
- IP strength and novelty

Furthermore, licensing agreements can be exclusive, giving a licensee the sole right to exploit the patent rights, or non-exclusive, allowing us to simultaneously license a patent to more than one licensee. These agreements usually encompass terms such as:

- Subject of agreement: Refers to the patented process being licensed
- Scope of the license: Refers to the country or region where the license is valid
- Royalties to be paid: A percentage or fee – fixed or variable –, usually over net revenues
- License duration: States the period for which the agreement is valid, and may include renewal and/or early termination terms
- Restrictions: These depend on the patent at hand, but can include minimum annual royalties or a minimum percentage of cost savings to be obtained from a novel technology for a licensor (us) to be eligible to receive royalties
- Obligations and Warranties: Include the responsibility of protection, maintenance, and enforcement of patent rights

Licensing is simpler and less expensive than manufacturing in-house and commercializing the end-product, hence that is our preferred option for profiting from the technologies we patent since we avoid undertaking all the business-related tasks and costs included in manufacturing and marketing the product, while still getting significant revenues. However, to kickstart our licensing model, TerpenOX must properly protect over its intellectual property, otherwise no potential licensee will be willing to pay a meaningful price for the right to use it.

Some of the benefits we will derive from the licensing model consist of:

- Lower costs: The licensee takes care of all manufacturing and commercializing activities.
- Lower risk: By leveraging licensees' experience and value chain, the technology has a higher chance of surviving the competition and overcoming other market barriers.
- Faster financial upside: A licensee can get our technology to the market faster than we would by ourselves, thus allowing us to cash in sooner on the technology.
- Increased credibility: Provided the technology gets higher validation in the hands of the licensee, we enhance our reputation for future dealings with potential licensees, or upon an attempt to autonomously enter a new market.
- Keeping ownership of IP: Despite allowing licensees the right to use our technology and profit from it, we still retain the ownership and control of those rights until a patent expires.

On the other hand, some trade-offs inherent to licensing include:

- Lower potential returns: When licensing, the lower costs and risk come directly linked to a much lower revenue potential for us since licensees keep most of it so that the agreement remains beneficial for them.
- Lower control: Despite keeping ownership of the patent rights, we may risk losing control, partially and sometimes fully, over how our technology is used, even though some conditions can be set in the licensing agreement to prevent that.
- Effort to find a licensee: Even though licensing seems quite straightforward, finding companies willing to undertake the costs and risk may not prove as easy a task unless we leverage our relevant connections in the field.

- Information disclosure: Through licensing, we end up handing out some of our company's knowledge and confidential information to the licensee, who may become an effectively educated competitor in the future.
- Risk of licensee's failure: Even though much of the risk is mitigated when an established licensee takes over the rights for commercial use, some risk persists. The licensee may implement our technology poorly, deeming it as untrustworthy, and thus damaging our reputation. Also, the licensee might never put it to use, and we risk not only not getting any income from the agreement, but also being impeded to find new licensees if a protective clause to safeguard such cases is not included in the agreements we establish.

When licensing out a patent, we intend to limit the scope of the license to the minimum acceptable, to avoid giving the licensee unnecessary exclusivity, which would impair our ability to maximize revenue from a given technology. Additionally, we must tread lightly on our relationships with licensees. If conflict erupts, disputes may arise, translating into insurmountable legal costs for us. That said, prior due diligence on potential licensees will be an important first step to assess the suitability of an agreement.

5.1.2. Fragmented Markets – In-house Manufacturing & Marketing

When faced with more fragmented markets, although licensing is also possible, we will prioritize entering them independently, especially if the compound at hand is of high value and is needed in relatively small quantities. Such a scenario would not require a large production capacity, and would thus present itself as a good, and likely profitable, opportunity for us to start venturing ourselves autonomously. The main factor supporting this strategy is the fact that fragmented markets usually do not have clear and established market leaders with enough

power to force smaller competitors out of it, which makes it easier – less costly – for TerpenOX to enter and compete in these markets. For a fragmented market to be financially appealing to us, it must have either a meaningful size or promising growth projections, and ideally both. Notwithstanding, this path also means that competition among existing players will be fiercer, with new companies constantly entering the market, causing margins to shrink over time. Overall, pursuing this strategy entails a much greater complexity and risk than the licensing strategy, and to undertake it, we first have to gather the resources needed, namely capital and a robust and experienced team. For TerpenOX to venture itself in one of these markets will presumably take time. We want to prioritize the development of strategic partnerships with licensees in concentrated markets to further leverage these when entering fragmented ones.

From the moment this path is chosen, numerous challenges arise, such as having to figure out how to manufacture the compounds efficiently and sustainably, including the required plant capacity and capital to start operating, and how to market and distribute the end-product. The marketing strategy ranges from customer segmentation and targeting, to formulating a marketing mix, commonly known as the 4Ps (price, product, promotion, and place), with a special emphasis on distribution (place) – how the company will successfully deliver the product to its customers. In addition to all the internal planning, we further need to concern ourselves with how such a strategy can resist and thrive despite the level of competition in each of the markets we intend to enter. An example of a more fragmented market is the one for vanillin, with a projected CAGR of 9.7% from 2020 to 2025 (USD 308 million in absolute growth terms) (CBI 2021; Technavio 2021), thus presenting itself as a future target market for TerpenOX.

In short, the entry strategy to be used in more fragmented markets provides us with a far greater financial upside, while allowing us to maintain full control over our IP. Such benefits, in turn,

come at the expense of enormous investment needs, as well as a higher risk of failure, which may cause unforeseen distress to the company.

In this business plan, we will focus on the short-term strategy, i.e. the licensing model, since the approach for fragmented markets is not expected to take place in the near term, and may not even occur at all in the case that we are acquired before even having the chance to do it.

5.2. Intellectual Property Strategy

Our IP strategy starts by licensing the ONESTEP technology from the University of Vienna, which means that any further licensing agreement we establish is a sublicensing agreement. Given the technological basis of our company, IP is a core piece of our strategy. The sustainability of our competitive advantage will be largely dictated by our IP strategy. Intellectual Property is the basis for any licensing agreement, and thus we cannot pursue the licensing model without it. Our company's main asset is knowledge, which will mainly encompass Intellectual Property, and therefore the efforts we put into continuously strengthening it will determine for how long our business model remains self-sufficient. This brings a secondary benefit for us: with IP being part of TerpenOX's balance sheet, we become a much more appealing investment and partner for both investors and licensees, respectively. The generation of valuable knowledge requires huge investment, resulting in high losses accumulated in the first periods of activity – also known as the "valley of death" –, but that investment comes with the promise of large returns in the not-so-distant future.

Nonetheless, for IP to have value, it must be well assessed and designed, in a way that ensures maximum protection and prevents legal issues from arising. Activities around the generation of IP, which go from R&D to patent design and application, and then maintenance throughout its life, will be given special attention at every stage of our company. Having well-designed and robust patents is the most effective way to keep competition at bay. On this front, we will

rely heavily on an experienced patent attorney who can advise us on our IP strategy and help us avoid fatal mistakes. We talk more about patent attorneys in our ‘Key Partnerships’ section.

5.2.1. Our Technology

Succinctly, what we have is a novel process – ONESTEP – that can synthesize terpene compounds in a single step, as opposed to state-of-the-art technologies in the chemicals industry which do it in two separate steps. Since a more in-depth description of the technology can already be found in our ‘Solution’ section, we will not expand much about it here. For now, the technology is only being tested for the synthesis of l-menthol, but there is more potential to be tapped into. Adapting the ONESTEP process to new classes of terpenes opens significant new possibilities to make other valuable compounds and even novel, undiscovered ones. Using the same underlying principle, we can produce amines, such as methylamine – a molecule with potential pharmacological activity, but not widely explored, and which manufacturing is very complex. Extension to higher terpenes, such as cannabinoids or molecules for contraceptive pills, is also conceptually possible. These projections require further research, but serve to illustrate the enormous potential. That said, in the short term, we expect our patented IP to derive mostly from the process behind ONESTEP, but there are different ways to go about it.

5.2.2. Patent Portfolio Management

More often than not, one patent alone is insufficient to offer effective protection against imitators. A patent portfolio – a bundle of patents functioning together to provide higher protection (Austria Wirtschaftsservice 2017) – solves this, as it limits the opportunities for competitors to invent around our IP. Hence, we intend to maximize the efficacy of our IP strategy by patenting our technologies at different levels whenever possible.

Right now, the only patent we are filing for is the one for the ONESTEP synthesis process – *process patent* –, since it is not possible to patent it at different levels, but just the overall process, given that it only comprises one part of the whole synthesis of menthol, being that the conversion from citronellal into l-menthol. In the future, our goal is to develop either technologies that complement the ONESTEP process, making our IP for the synthesis of compounds more robust, or to discover novel compounds that can be produced using our technology, thus being able to further file for *compound patents*.

In addition, due to the widespread presence of the large players in the menthol market, as well as its high concentration, our patents must cover all the regions in which we intend to license our technology. As an example, Takasago has manufacturing locations in Japan, USA, China, India, Brazil, Mexico, Germany, Spain, France, Indonesia, and Singapore, which means that if we were to license to Takasago, we would need to file for a patent in all of these countries to prevent Takasago from implementing ONESTEP in locations that are not covered in the agreement, thereby going around the contract. That could lead to an eventual legal dispute against such a large player, which would quickly become unbearable for TerpenOX. Such a broad scope already indicates that the protection of our IP will bear significantly high costs. However, to reduce those, we can take advantage of the Patent Cooperation Treaty (PCT), which enables us to seek protection for our patents internationally. By filing an international patent application under the PCT, we can immediately protect ONESTEP in all of those countries (WIPO 2022), instead of having to file separate national or regional patent applications. Based on a few assumptions regarding patent terms, such as the number of pages and claims, we arrived at an estimate of EUR 80,000 (IP Coster n.d.) over around three years.

At every stage of our IP process, we are permanently tracking our relevant technology areas – Food Chemistry, Biotechnology, Chemical Engineering, and Organic Fine Chemistry – so that

we can identify new developments at their earliest stages. This process, known as “technology watch”, involves monitoring our competitors’ new publications and patents, as well as the legal status of our own patents. Put simply, we are constantly keeping an eye on emerging technologies that may act as substitutes to our solution, thereby threatening TerpenOX.

In the longer term, as we adapt our technology to the production of various compounds, our strategy centers around patenting those, and further licensing or producing and commercializing them in-house, having into account the respective market concentration.

5.3. Business Model

The way through which we will primarily make money is through licensing our Intellectual Property rights to strategic partners in concentrated markets, which enables us to become profitable and self-sufficient early on. Ultimately, our goal is to develop a virtuous cycle in which IP generates revenue, which further funds R&D to generate new knowledge, allowing to grow the business continually.

In Biotech and Life Sciences, there are fundamentally two bases for business models: the *tool model* – selling an innovative technology or service that supports other companies in developing their products –, and the *product model*, which is centered on developing multiple products. Another relevant distinction within the above categories is the one between *one-trick-pony* companies, which develop a single product, and *platform* companies, developing multiple products around a core competency or technology (Kolchinsky 2004).

That said, TerpenOX fits both the *tool* and *platform* company archetypes for the synthesis of various compounds. Primarily, our strategy focuses on licensing the rights of the patents we hold, at least in the near term, given that we are starting out by tackling the menthol market. As we grow our licensing income and gather the proper means, our goal is to progress onto a

blended model in which we launch ourselves into in-house manufacturing and marketing. In the end, our objective is to benefit from the best of both "worlds", i.e. business models.

Having in account the multitude of compounds this new technology can potentially synthesize, and the fact that patents only expire 20 years after being filed, the most rational way of monetizing it is to license it for as many applications as possible over that period. Such arrangement is possible, first and foremost, because a licensee can be given a non-exclusive license, rather than an exclusive one, and second, because there is the possibility of restricting the conditions – fields-of-use – under which the license can be used. Those restrictions may regard, for example, market segment, compound market, and market regions. This kind of license requires careful drafting to ensure the rights are clearly defined and delimited, but once done, it will put us in a comfortable position to leverage promising IP, such as the ONESTEP. The diversification that such non-exclusivity allows is a key factor in our business model, as it will help ensure that our patents are leveraged in multiple fields, which subsequently enables us to maximize our revenue. That said, in the short-term, our concrete strategy will consist of:

1) Developing and proving our technology's ability to mass-produce l-menthol
2) License the technology to dominant players in the l-menthol market
3) Invest licensing income in R&D for other compounds
4) Once successful in proving the same capabilities as those achieved for menthol, seek interested licensees in the markets for those compounds

In the long term, the only step that changes is step 4), in which we will not only consider licensing, but also in-house manufacturing and marketing in fragmented markets presenting a large size and/or growth potential.

The benefits to be derived from this strategy are clear. First, by licensing the patent, we can test the process at a much smaller cost and risk, compared to what we would face by undertaking everything in-house from the get-go. Second, if the licensee is indeed successful,

and provided the latter is an established player in a concentrated market, the licensing income we receive, via royalties and other payments, will likely suffice to trigger the funding of further R&D without diluting our company's ownership, which would happen if we had to raise capital externally. Third, by having our technology validated in our first case – the menthol market –, we will have stronger credibility in the eyes of potential licensees in adjacent markets, translating into a higher bargaining power on our side, and more favorable deals in future agreements. Additionally, once established in different markets, we will be better prepared to cope with the failure in a given market, hence diversified revenue streams beget lower risk.

Licensing will, without doubt, mean less overall control over our patents, since we will be disclosing them closely to large and powerful companies, but we see that as a reasonable price to pay for the benefits mentioned, more so if we indeed develop robust patents. In short, although we will only be capturing a small fraction of each market, we will be tackling multiple markets in the coming years, which we would not be able to do by venturing ourselves into the production and selling of compounds from the start.

5.3.1. Revenue Streams

Through the licensing model, our revenue comes primarily from three streams: royalties, upfront payments, and milestone payments. All these come from the companies to which we license our technology, and they will be counterbalanced differently among one another in each agreement we establish. That balance will depend on factors such as the market potential for a given compound, the market segment, region, and industry margins.

Fundamentally, royalties allow us to get income proportional to the sales licensees generate from the compounds produced through our technologies; upfront payments will serve to ensure us a comfortable financial situation early on, thereby fulfilling our company's basic needs and allowing us to keep our R&D operations running, as well as making it less appealing for

licensees to try contouring our patents; and milestone payments, which consist of payments made upon the achievement of certain metrics agreed when establishing the agreement, to align both TerpenOX's and licensees' efforts, ensuring the two parties keep collaborating and get their fair share of a technology's success. We talk about our revenue components with greater detail in our 'Financials' section.

5.3.2. Cost Structure

Developing Intellectual Property is a pre-requisite for us to be able to collect revenues from licensing agreements. Given the central role that IP plays in our business model, the costs and investment related to it will be rather significant, following the arguments exposed in our 'Intellectual Property' section. That said, most of our costs will derive mainly from Research & Development activities, as well as from the generation of IP. Furthermore, we will also have the more general operational costs inherent to most business models. We will go through each of these cost components in more detail in our 'Financials' section.

5.3.3. Key Partnerships

5.3.3.1. University of Vienna

Given the fact that the ONESTEP technology is a discovery made by scientists at the University of Vienna, our venture has a direct dependence on the former, with which we will maintain an official partnership throughout the life of our company. Fundamentally, we are licensing the technology from the university, demanding exclusivity, and sublicensing rights to carry out our licensing model. Universities do not often just pass the technology over, but rather ask for something in return. For this licensing to take place, we will have to pay for the licensing, which we can do using a mix of royalties, upfront, and milestone payments. We truly believe in the potential of ONESTEP, and we know the promising upside lies rather in the medium to

long term. Thus, we want to keep as much of that upside as we can. In that sense, we will be willing to pay a larger sum upfront to diminish the royalty rate due to the University of Vienna. By doing so, we will preserve most of the long-term income to be derived from future licensing agreements. The price to be paid to the university will also have to consider the effort already spent by it on the development of the technology. Essentially, the royalty rate to be paid to the university will be a percentage of the net revenue we get from our licensees. A study found that higher royalty rates for universities are directly linked to lower licensing incomes per faculty – a 10% increase in an inventor's royalty rate generates, on average, a 20-25% increase in total licensing income. The same study also shows that inventors' royalty shares in the Chemical sector tend to be about 16% lower than average (Lach and Schankerman 2004). This further supports our negotiation for a lower royalty rate to be given to the University of Vienna.

5.3.3.2. End-users of Compounds

To license our technology to the top players in the market, we need to demonstrate it can produce compounds that meet their customers' quality requirements. This implies having to validate the latter's interest in the compounds our technology can output, and if needed optimize it to further meet their needs.

Achieving such validation, we are then able to leverage it when negotiating with potential licensees. Forming good relationships with the end-users of compounds in the different markets will certainly be beneficial for us, and an important aspect to be used for business development purposes, as well as for getting feedback on how we could enhance our technology. In short, validating our technology with end-users will prove our product-market fit, which will be useful when raising funds from investors and negotiating with licensees. Moreover, after declaring their interest in what we are promising, these companies will likely be available to

test our compounds in their production, in order for us to demonstrate the benefits of our compounds over the ones they are currently being supplied.

A relevant player we will approach to gain validation is Givaudan, the Swiss manufacturer of flavours, fragrances, and cosmetics. Givaudan is the world's largest company in the flavours and fragrances market, and it maintains such a position by investing a significant amount of its revenues (10%) into innovation. Moreover, it drives its R&D and IP development according to its *FiveCarbon Path* program, which reflects its commitment to responsible innovation based on five measurable targets (Givaudan 2022):

1) Increase use of renewable carbon
2) Maximize use of biodegradable carbon
3) Increase carbon efficiency in synthesis
4) Increase the odor per carbon ratio
5) Maximize the use of upcycled carbon

That said, our technology is very much in line with their sustainability goals, which may be a favorable factor to consider when approaching them. Ultimately, they can even be seen as potential strategic buyers for TerpenOX, more so when, in 2020, they acquired Alderys (EUR 21 million for 80% of the company), a French biotechnology company developing innovative approaches to the biological engineering of profitable compounds from renewable plant resources (Alderys 2022).

5.3.3.3. Patent Attorney/Law Firm

Finding a good patent attorney early on is of utmost importance, since patents are the core of our company, more so in the beginning, when we have a rather narrow patent portfolio. In the earliest stages, committing a mistake on this front may greatly affect our competitive

advantage. In the short term, TerpenOX's business will depend mainly on the eventual patents to be filed and obtained around the ONESTEP technology, not the other way around, and in that sense, without Intellectual Property, there is no business. That said, it is important to be selective in who we hire to help us on patent-related matters, as well as on developing a proper IP strategy for the future, and providing general guidance. Specialized patent law firms we will approach include Patentree (Portugal), Mewburn Ellis (UK), and Vossius (Germany), which can be said to be in the mid-top tier among patent law firms in the Chemistry sector (Financial Times 2021). A good and experienced patent attorney will not be cheap, to say the least, but we must not try and save as much as we can in this regard. A "cheap" mentality on this topic can end up being a very costly mistake ahead. Again, and now through the words of one of Mewburn Ellis' partners, "in the absence of a tangible product, would-be investors consider the potential future commercial revenue if the product or treatment makes it to market. The decision of whether or not to invest, and the scale of any investment, is based on how well the technologies that form the core of a company have been protected" (Mewburn Ellis, 2018).

5.3.3.4. Advisory Board

We have already talked about the scientific and technical knowledge that we must gather as part of our company's staff for us to succeed in our mission. As important as the internal expertise we have are the people who can advise us on our strategic direction, and who have relevant experience as scientists, start-up founders, executives at large companies, investors, and sometimes even in more than one of these roles. By having people who can properly counsel us, we are more fit to overcome the difficult challenges we will inevitably encounter. Moreover, they can strengthen our decision-making over the multiple aspects that managing a company encompasses, and ultimately help TerpenOX succeed.

5.3.3.5. Network

Given the scarcity of resources – both financial and human – we will face during our first years of experience, one important factor we must leverage is our network. This consists of thought leaders in the biotech industry, universities, and industrial organizations who specialize in supporting biotech start-ups. Given the fact that TerpenOX is based in Portugal, which has a small but growing biotechnology scene, and that we include in our board of advisors important people in this field, we expect to connect and get the support of successful founders and biotech entrepreneurs, renowned professors, and institutions such as P-Bio (Portugal's Biotechnology Industry Organization). Portugal is a promising ecosystem when it comes to scientific knowledge, possessing a lot of talent, and in that sense, hiring can be eased if we manage to be attractive to surrounding talent. In short, we will rely heavily on our network to overcome the challenges that will inevitably arise.

5.3.4. Key Areas of Focus

5.3.4.1. Market Research

The importance of performing market research can often be neglected, but it will ultimately guide each step TerpenOX takes. To decide on which compounds or technology features are worth researching in the future, we will be better off by grasping their market potential before we invest any capital. Doing so will allow us to prioritize the largest market opportunities first, in a way to assure a comfortable financial situation early on, which can then free us to perform more strategic thinking. Market research involves estimating the market size and growth, analyzing the level of competition concentration, identifying the main segments, who the customers are, and where they are located. That said, R&D must always be preceded by market research to enable the most effective allocation of resources.

5.3.4.2. Fundraising

To have the ONESTEP technology achieve the licensing-ready status, we will seek external funding to proceed with our operations. Given our company's scientific base, as well as the sustainability and climate neutrality benefit inherent to our technology, we are able to hop on the mission to achieve the United Nations' Sustainable Development Goals. In turn, that will make us a proper candidate to receive funding from the European Commission's grants, such as the ones under the "Cluster 6: Food, Bioeconomy, Natural Resources, Agriculture and Environment" category of the Horizon Europe program. Even though grants can often be generous, we do not expect those to be able to fully cover our R&D and IP costs. That makes us pursue other sources of funding as well, namely venture capital. That said, we will also consider Planet A Ventures, MAZE Impact, and the European Innovation Council Fund, whose values align strongly with those of TerpenOX.

5.3.4.3. Research & Development

Research and Development is the core activity for TerpenOX, as it is what allows us to keep an edge over the competition. Without continuous R&D, TerpenOX would quickly cease to exist. As mentioned earlier, our current R&D plan encompasses three remaining phases to validate our technology in a first application (menthol) and increase its market readiness. After the first lab and bench-scale tests (already done), we intend to 1) improve the menthol synthesis process by optimizing reactivity and selectivity, and 2) validate our approach in a pilot unit. After such validation, we look to 3) more accurately define the environmental footprint of the process, predict the attainable industrial performance, and outline the requirements for industrial-scale production. Given that TerpenOX aims at being a successful platform company, we will have to constantly invest significant resources into R&D. In turn, that will

allow us to generate additional IP, which begets revenue, enabling the funding of more R&D while avoiding further dilution of our company's ownership.

5.4. Sales & Marketing

5.4.1. Becoming the Industry Standard

As stated before, our goal is to position our technology as the industry standard for the synthesis of terpene compounds. To achieve that, we are highly dependent on the establishment of an alliance with dominant players, through licensing agreements, in the different industries. In other words, our success is very much correlated with the adoption of our technology by large suppliers in the markets for the different compounds.

5.4.2. Our Customers

Regarding the menthol market, we are focusing on two target customers: BASF and Takasago. As of 2019, these hold market shares rounding 45% and 24%, respectively. There is still another dominant player in the industry, Symrise, but due to its synthesis process incompatibility with our technology, we are not targeting it.

That said, our top priority is to establish a licensing agreement with BASF. The five main arguments supporting this are its:

1. Large market share
2. Broad and diversified customer base
3. High proximity: BASF is headquartered in Germany
4. Broad portfolio of supplied compounds
5. High commitment to climate neutrality goals

First off, BASF's large market share is a good indicator with regards to the income we can potentially get. After all, the royalties we receive are directly correlated with our licensees' net

revenues coming from menthol sales. Second, the fact that BASF has such a broad and diverse customer base is also favorable to us in the sense that, by indirectly serving many end-users of menthol, our alliance is less reliant on any single customer that may weigh more heavily on our licensee's sales. Furthermore, BASF possesses long-term relationships with many of its relevant customers (e.g., Givaudan), which also provides more stability to our income in the future. Third, the fact that BASF is so close to TerpenOX geographically is not less important, as it may ease any logistic issues that may come up before and during the agreement. Fourth, by already supplying a multitude of compounds, establishing an alliance with BASF will be of great value once we can adapt our technology to the synthesis of those compounds. Additionally, and considering its high commitment to climate concerns, BASF is actively looking to replace its chemical processes with more innovative ones, since it recognizes that the first are not sustainable in the long term (BASF 2022), and thus our technology is able to help them fulfill that objective.

On the other hand, Takasago, also represents a very reasonable pie of the market, and cannot therefore be left out, especially considering our effort to diversify our licensing deals and keep opportunities as broad as possible in the future. Like BASF, Takasago too shows concerns about sustainability matters and places special emphasis on its mission towards "Green" Chemistry. Its focus lies mostly on the Japanese market (43% of Flavors and Fragrances sales), followed by the American (23%), with no minor portions from the European (17%) and Asian (17%) markets as well. The total flavors and fragrances sales amounted to YEN 132.3 billion (approx. EUR 964.5 million) (Takasago Int. Corp. 2022).

On this note, both firms could counter our non-exclusive proposal with one that would give them exclusivity, since they end up competing with one another in some of their targeted market segments and regions. If that happens, and given that these seem to be our only viable options, we will then be inclined to offer BASF an exclusive licensing agreement, which goes

against our risk diversification strategy. Nevertheless, given BASF's large capabilities and resources, the risk ends up not being that critical. This comes across as a rational option also due to the fact that BASF is a great potential acquirer of TerpenOX in the future.
Given the information above, we conclude that our USP, which is mentioned more in-depth in our 'Solution' section, presents an appealing match with our target licensees' objectives.

5.4.3. Approaching Target Licensees

Before we engage the big compound suppliers to which we intend to license our technology, we need to prove we have product-market fit. In order to do that, the first step we are taking is looking for validation from the end-users of the respective compounds – menthol in this case. That is to say that we must ensure that the menthol produced by our synthesis process meets the requirements of these end-users in the different segments – oral care, food & beverages, cosmetics, etc. Known examples of end-users include Givaudan, P&G, Johnson & Johnson, and Colgate-Palmolive. For one, Givaudan is one of BASF's main customers, collaborating for more than ten years now (BASF 2021), hence it is an excellent candidate for us to look for validation at a first stage. Givaudan has already declared their interest in testing our menthol in their products, through an interaction with one of our advisors. After these tests, and in case they show a preference for "our" menthol over the one they are currently being supplied, we will have a valuable argument to leverage during our negotiations with BASF.

Building relationships is what will ultimately allow us to sell our technology and establish licensing agreements, hence, when we get the validation from end-users of compounds, it is time to engage our potential licensees. The main ways through which we intend to connect with the latter include networking events and industry-specific conferences, where key employees from our targeted companies can usually be found, allowing us to sell our technology, or at least present it. Connecting with key employees from target companies –

internal champions – is one of the pillars of our selling strategy. Getting an internal champion – a point of contact in a target licensee – to willingly serve as an intermediary in selling our product at his company can be much more effective than if we approached the company directly ourselves. An internal champion will be willing to do it because he has personal and professional incentives for doing so, whether that is pressure to find innovative solutions to improve operational efficiency or to increase sustainability levels in the company, or simply foster personal recognition internally. Having a trusted intermediary pitch our technology in a target licensee will also make it more credible, as it implies the technology has passed the technical filtering of someone who has expertise in the subject. That said, they can "make or break" a deal for us. Given the nature of our technology, our primary target are technical people, say, engineers, rather than marketing people, for example, since the former are more capable of understanding the benefits our technology offers.

After this internal champion presents us to our target licensees, it is then time for negotiations to kick off between TerpenOX and the company at hand. This is the point at which we will leverage the validation we got from the end-users of compounds (e.g., Givaudan), which is of utmost importance to establish favorable agreement terms for us. The main terms that will be played with during negotiations include:

- Exclusivity
- Royalty rate
- Upfront payments
- Milestone payments
- Minimum royalties
- Fields-of-use
- Scope (geographical)

The main point here is that we are negotiating a whole package, not a single issue. In this sense, if, for example, a licensee demands a lower royalty rate to be paid to us, then that will have to be compensated by an increase in upfront and/or milestone payments. As stated in our section on strategy, our goal is to license our patents to multiple companies so that we mitigate the

impact associated with the failure in any given agreement, while maximizing revenue. In the menthol market, that may prove challenging to accomplish, due to the few existing licensing options, but the exclusivity term is a "no-deal" for us. While we can agree to offer BASF exclusivity on the menthol market, providing them with exclusivity on the overall patent is not acceptable, as it would impede us from monetizing our technology in the different markets we intend to expand to in the future.

5.4.4. Licensee Relationship Management

When it comes to licensing, it is important that we always keep a close, long-term-oriented relationship with our licensees, since this will help ensure continuous and incremental income throughout our company's life. Developing strong relationships with licensees includes providing them with excellent technical assistance, as well as constantly striving for mutual interests, whether these are financial, strategic, or operational. This may mean being flexible with some contract terms, if necessary, in a way to preserve profitable relationships. Maintaining these important relationships will also protect us from emerging technologies that can be seen as substitutes to ours. Once large companies adopt our technology, they will be less likely to shift to other solutions, mainly due to the switching costs involved. Furthermore, business development will be made easier for TerpenOX. As an example, BASF supplies compounds worldwide that go way beyond menthol, therefore by first licensing our menthol synthesis technology to them, we may further develop innovative technologies, or adapt ONESTEP, to the production of additional compounds they already supply. Such effort is also important because the slightest conflict with some large player in an industry can become highly damaging, namely by affecting our position and reputation in the eyes of other industry stakeholders, such as the end-users of the respective compounds. Additionally, since a strategic acquisition is our most likely exit scenario, a strong relationship between both parties can

ensure a frictionless and friendly deal. By having a good relationship with our counterparts, we will not have to worry so much about them trying to exploit us as much as they could due to their high power in the concentrated markets we described earlier. All in all, even if we were not able to strike an agreement with both large players in the menthol market, a close relationship with one of them would still bring advantages such as the security conferred by a stable relationship, and the freedom to concentrate our own strengths – R&D –, while relying on those of our licensee.

5.4.5. Online & Media

To grow awareness from external stakeholders to the company, namely potential licensees, having an online presence is essential. Having a website, and even a LinkedIn profile for TerpenOX, will let other people get an overall view of what the company does, without us having to introduce ourselves directly to them. Moreover, a website will give credibility to TerpenOX, which will aid our engagement in the different markets. Other online platforms and social media, such as LinkedIn, will allow us to share company-related content and updates, and interact directly with the community of professionals that may be interested in our solutions. We mentioned above that internal champions at target licensees would be a very effective means of reaching an agreement with the latter, and LinkedIn could serve us greatly in that sense, as these individuals would be exposed to our technology less invasively, ultimately reaching out to us to know more about it. Eventually, that interaction will culminate in a signed license agreement. Overall, online presence is a way for us to introduce our company more passively, fostering TerpenOX's business development.

6. Financials

6.1. Financial Model

To bring the project from a laboratory scale to efficient large-scale manufacturing some topics like costs, safety aspects, logistics: unitary operations such as heating, cooling, and distillation, or engineering operations like mechanical stirring will need better understanding. To establish industrial feasibility, we need to define plant needs, CAPEX (Capital Expenditures) and OPEX (Operating Expenditures) and conduct an LCA (Life Cycle Analysis) - taking into account raw material extraction and processing, production, distribution, usage, recycling, and final disposal.

6.1.1. Revenue Breakdown

The licensing model englobes three main possible revenue streams – royalties, upfront payments, and milestones payments. As such, those are the main revenue streams we expect to have throughout the years, all of them coming from our licensees.

Table 2 *Revenue breakdown*

Revenue Parameters

	Stage I	Stage II & III	Stage IV	Licensing Stage	
	2022	2023	2024	2025	2026
Revenue from Royalties					
BASF	€ -	€ -	€ -	6 400 000 €	6 784 000 €
Takasago	€ -	€ -	€ -	1 787 008 €	1 894 228 €
Total Royalties	**€ -**	**€ -**	**€ -**	**8 187 008 €**	**8 678 228 €**
Revenue From Upfront payments					
BASF	€ -	€ -	€ 3 370 500	€ -	- €
Takasago	€ -	€ -	€ 2 296 350	€ -	- €
Total Upfront payments	**€ -**	**€ -**	**€ 5 666 850**	**€ -**	**- €**
Total Revenue	€ -	€ -	**5 666 850 €**	**8 187 008 €**	**8 678 228 €**

6.1.1.1. Royalties

In our licensing model, royalties constitute the main source of revenue. In simple terms, we give licensees the right to use our patented technology, they adapt it to their manufacturing facilities, and afterwards, they will produce and commercialize the compounds outputted (e.g., l-menthol). After TerpenOX analysis, the price for menthol we find reasonable is approximately EUR 15 per kilogram. As demand for synthetical menthol manufacture is significant and expanding, a demand of 16,000 tons would generate a market opportunity of EUR 240 million a year.

Taking BASF as an example and after carefully analysing the market:

- 10,700 tons BASF production
- Considering that 1 ton = 1000kg
- 10,700 tons x 15 EUR/Kg = EUR 160,500,000 BASF revenue
- EUR 160,500,000 x 0,7 markup = EUR 112,350,000 COGS
- EUR 112,350,000 COGS x 20% cost savings = EUR 22,470,000 per year on cost savings

Takasago

- 30,000 tons global menthol demand x 24.3% Takasago market share = 7,290 tons Takasago production
- Considering that 1 ton = 1000kg
- 7,290 tons times 15kg/EUR = EUR 109,350,000 BASF revenue
- EUR 109,350,000 x 0,7 markup = EUR 76,545,000 COGS
- EUR 76,545,000 COGS x 20% cost savings = EUR 15,309,000 per year on cost savings

Because our production technique is less expensive and more cost-effective, we will be able to match supply to demand while keeping pricing lower and more stable – around 20% of cost savings with the ONESTEP technology. Manufacturers of synthetical menthol would profit from lower COGS and hence be able to create more menthol with larger margins if they used our technology. In terms of temperature, catalysers, and other factors, our technique is inexpensive. This implies that menthol makers save energy and resources by lowering their energy use and reliance on heavy metals. This method also has the benefit of lowering installation emissions and ensuring compliance with emission requirements. By lowering the CO_2 price to be paid and permitting the monetization of those emission reductions, these emissions savings can provide an extra economic advantage. By delivering a solution for a contemporary, resource-efficient, and sustainable industry, our technique is completely aligned with the industry 5.0 plan – an industry that must lead to digital and green transitions.

According to an IPSCIO Report (2017), using data over 30 years to establish license rate standards for 15 sectors and using the average median royalty rates by industry (as a percentage of sales):

- Chemical sector has an average royalty rate of 4.8%
- Pharmaceutical & Biotechnology has an average royalty rate of 7.4%

Comparing royalty rates by vintage year (that can be used to determine economic patterns at a specific point in time) is challenging due to variances in the technology licensed, industry activity, and the fact that nearly every phrase in the licensing agreement has some economic weight that influences the royalty rate negotiated. As a result, we've decided to use a royalty rate of 5% of the final menthol price which will allow TerpenOX to have a revenue of EUR 8 million only in the first year for BASF.

Because royalties are based on sales and are one of the primary sources of revenue. To safeguard cases where our licensees do not sell any of the products that use TerpenOX technology, or even end up not installing the technology in its facilities we will:

1) target more players that cover other industries and,

2) charge an upfront payment that is not based on sales.

In this front, there are three main provisions we can use in licensing agreements established with future licensees, and those are step-up royalty rates, step-down royalty rates, and minimum royalties. *Step-up royalty* rates allow a licensee to pay lower royalty rates early after the agreement is settled, later increasing as production and sales grow. This is a benefit, first and foremost, for licensees, who get a relief from paying high royalty rates in a time when they're incurring start-up costs to adapt or install the technology into their facilities. In that sense, this may be a concession we're willing to give away to negotiate a higher royalty rate overall, i.e., the average of the earlier and later royalty rates, but which also ends up being greatly beneficial for us if sales in the future grow beyond expected, even though that may not be the case in mature markets. *Step-down royalty rates* allow licensees to pay decreasing royalty rates as sales increase, which makes for more stable and capped royalties over time, while also incentivizing customers to produce and commercialize the respective compounds quickly, in order to minimize the weight of royalty payments on their operating margins. The *minimum royalties* provision produces a similar effect, but its main function is to dissuade licensees from trying to design around the patent. For that, the minimum amount to be paid periodically, say quarterly, must be high enough to cause the desired effect. This will more likely be something we aim at getting from licensees, since it also ensures that we keep on with our operations, namely regarding further R&D to improve the company's knowledge capacity, and eventually obtain additional patents.

6.1.1.2. Upfront Payments

Upfront payments will be implemented to discourage licensees from trying to design around our patents, during the establishment of the licensing agreement. Such effect is achieved by making licensees pay a meaningful amount for our technology right away and making it unappealing for them to incur the additional bulky costs and resources which come from replicating the same technology internally.

At TerpenOX, we decided that 15% of what each company would save in the first years would be a fair price: BASF will be saving EUR 22.5 million per year and Takasago EUR 15.4 million, so upfront payment for these two giants will be EUR 3.4 million and EUR 2.3 million, respectively. Furthermore, it certainly ensures us with a significant amount (EUR 5.7 million) of cash rapidly (just with BASF and Takasago), which we can then employ into satisfying our company's basic needs (salaries, rent, legal, administrative, etc.), as well to sustain growth by investing in additional R&D.

With a royalty rate of 4% BASF would make a profit of, approximately, EUR 12.7 million and Takasago a profit of, approximately, EUR 11.3 million if they decide to invest in TerpenOX technology (considering already upfront payments) in 2025.

6.1.2. Cost Structure

6.1.2.1. University of Vienna

As University of Vienna is the creator of the ONESTEP technology, TerpenOX will pay a royalty rate of 5% of our revenues from 2025 onwards. As seen in ***Table 3***, these royalties will translate to approximately EUR 400,000 in year 4 and 5. TerpenOX will also contribute with a milestone payment of EUR 150,000 to University of Vienna in order to make this business

possible. Milestone payments are based on the achievement of certain goals, and they are usually included in license agreements to account for the overperformance a technology may show, thus rewarding University of Vienna for the great results that TerpenOX has experienced. In case our company cannot be profitable or encounters any other obstacles that result in the company's closure, University of Vienna will receive EUR 150,000 regardless TerpenOX' success.

Table 3 *Breakdown of Costs of Good Sold*

Costs of good sold: input values

Cost type	Parameter description	2022	2023	2024	2025	2026
Licencing cost to University of Vienna						
Royalties (5%) of our revenue		- €	- €	- €	409 350 €	433 911 €
Milestone payments	Once we raised EUR 1 million we will give UV a lumb-sumb payment of EUR 150K	- €	150 000 €	- €	- €	- €
Total licensing costs UV		**- €**	**150 000 €**	**- €**	**409 350 €**	**433 911 €**
Raw material	Buying Citronella to then transform it into Menthol; This estimate also includes other raw materials for future R&D for other compounds	2 000 €	10 000 €	25 000 €	5 000 €	10 000 €

Examples of milestone payments are related to the quantity of compounds manufactured and/or sold, market expansion or growth to other segments (such as healthcare, food & beverage, etc.).

6.1.2.2. Research & Development

Despite the attractiveness of the licensing revenue model, the truth is that, in order to license out the technology, we first need to fully develop it and be able to demonstrate that it can deliver what we are promising – the industrial-scale production of l-menthol possessing the same or higher quality than potential licensees currently output, to then file for a robustly designed patent.

The R&D process, in general, can be broken into three main stages: 1) generation of a proof-of-concept after performing lab, 2) bench-scale research and optimization, 3) testing performance in a pilot unit, and 4) validating the results obtained in the previous stages in a

pre-industrialized setting, to test the technology capability to mass-produce a compound. Therefore, before licensing, all R&D stages must be completed, and each of them has costs implicit that arise mainly from the key resources used – raw materials, human resources, facilities, insurance, equipment, etc. R&D costs will be the heaviest in our cost structure, especially in the first three years.

Inside the R&D process, generation of a proof-of-concept after performing lab (stage I) and bench-scale research and optimization (stage II), will require a laboratory, some of the materials might need to be acquired (CAPEX), raw materials, such as the citronellal required to produce the l-menthol, as well as other needed reagents to serve as catalysts, and energy costs that will vary according to the level of activity during the testing phases. For this phase, TerpenOX will rent a lab space since the project is very early stage and we only need to do small research. Depending on where the lab is located this expense can vary between EUR 3,000 up to EUR 8,000 per month.

Table 4 *Breakdown of Occupancy Costs*

Occupancy costs

Cost type	Parameter	Parameter description	2022	2023	2024	2025	2026
Rent: office building & admin	Rent per year	2,000€ Monthly rent for office in Lisbon	- €	- €	- €	24 000 €	24 000 €
Utilities	Total Utilities per year	10% of total rent costs	- €	- €	- €	2 400 €	2 400 €
Repair & maintenance	Total Maintenance per year	€5 per m^2	- €	- €	- €	1 000 €	1 000 €
Office furniture	On-going investment per demand	Investment for office equipment such as tables, chairs, container (Big desk a 6 chairs) for €650	- €	- €	- €	3 000 €	1 000 €
Office Supplies (e.g. Computer, Software license)	One-time	Yearly, costs that are resulting to increasing team and usage of office supplies	1 500 €	3 000 €	4 000 €	10 000 €	10 000 €
Rent: Lab space (equipped)	Rent per year		60 000 €	60 000 €	- €	- €	- €
Lab equipment, materials etc.	Rent per year		20 000 €	30 000 €	25 000 €	30 000 €	20 000 €
Rent: Incubator for pilot unit	Rent per year	Considering the lab is located in Oliveira do Hospital, the price would be 10€/m2	- €	24 000 €	24 000 €	24 000 €	24 000 €
Pilot unit equipment	Rent per year	Reactor tanks, pipes, heating, etc.	- €	600 000 €	50 000 €	50 000 €	50 000 €
Total occupancy cost	**Rent per year**		**81 500 €**	**717 000 €**	**103 000 €**	**144 400 €**	**132 400 €**

Further, to test the technology in a pre-industrialized setting, TerpenOX will rent a space in an incubator and use its production facilities, which will imply higher costs than for instance

setting up a partnership with a local company that has a facility already available with most the equipment available.

By performing our pilot unit in an incubator, TerpenOX has more control over the whole process. Even though choosing an incubator to start our project would be more cost extensive than partnering up with a local company, we think it is the best option since TerpenOX is a very early-stage company whereas it does not have a granted Intellectual Property yet, so subcontracting a company to do part of the work can be very messy and dangerous as there's the possibility of leak of information. The Intellectual Property in a company like TerpenOX is its biggest asset. Worst case scenario, there could be a leak of information to a big competitor such as BASF or Takasago about the TerpenOX process' and they could replicate it. A company in such an early stage as ours does not have the financial means to fight against these giants. Another downside that could exist would be the type of contract signed with the subcontracted company. The developments in R&D could be considered by both parties, even if TerpenOX just used the rented space. This matter can be ambiguous and questionable whether the Intellectual Property is fully from TerpenOX, or the contracted company owns part of it.

Like this, in order to have full control over this matter, TerpenOX plans that in year 2 will be part of an incubator in Oliveira do Hospital to perform phase III - testing performance in a pilot unit. After deep research, we decided to choose BLC3 – Campus of Technology and Innovation because of their structure and network of international excellence that accounts for 55 companies from nine European countries and more than 115 world-class researchers and scientists focused on knowledge transfer and industrialization. The estimated costs for this phase would include pilot unit equipment that would round to EUR 500,000 in the first years (buying materials such as reactor are cost extensive) and the rent to start this stage. As

mentioned in BLC3's website, the facilities have rooms that go from 20m^2 to 60m^2, this with a price of EUR 10 per m^2 (estimated price for m^2 in Oliveira do Hospital) times 12 months would result in an extra cost of EUR 24,000 per year.

6.1.2.3. Intellectual Property & Legal

In order to protect TerpenOX's intellectual property generated through R&D efforts more costs will be generated. First off, the costs of obtaining a patent depend primarily on the scope of application, the complexity of the application, and the duration of the grant. Because TerpenOX considers itself to be highly threatened due to the nature of business, the strategy will rely on filing a patent in all key expected regions and having its patents valid for as long as possible (20 years), in order to achieve long-term licensing deals since patent-related costs are expected to be high – potentially exceeding EUR 100,000. (Patent Pilot 2022).

Patent costs are not only associated with the application process, but also include patent attorneys' fees and annual maintenance fees for supplementary protection certificates. Patent attorneys usually charge based on hourly rates, and due to the big scope of the patent we require, we expect patent attorney fees to be significant. Moreover, the fact that we intend large markets with competitive players, forces us to hire a patent attorney/law firm with relevant experience in IP-related issues which TerpenOX predicts that will be no lower than EUR 50,000 a year (we intend to file for several patents throughout R&D in order to protect our competitive advantage).

In order to contain future additional costs (during examination phase or even legal disputes with large compounds suppliers) on such important matters that can easily become a fatal step for the success of TerpenOX, we intend to spend the amount necessary to effectively protect our technology. The patent protection maintenance fees translate into annual costs that escalate

quickly over the years, significantly exceeding application fees. The closer a patent is to expire, the higher the annual fees to renew it. All in all, the management team considers that there is not enough expertise in this field in Portugal, so filling for a patent will incur in total of EUR 50,000 in 2023; EUR 100,000 in 2024; EUR 120,000 in 2025; EUR 20,000 in 2026 - ***Table 9*** *Breakdown of General and Administrative expenses*.

6.1.2.4. Operational Costs

Once the licensing deals are signed with the licensees, costs still exist, but these tend to be rather administrative. As in any other company, we will have the operational costs that are inherent to most business models, which include salaries, administrative and legal costs, rent from office (in Lisbon), energy, and other small day-to-day expenditures. Notwithstanding, it is worth mentioning that the process repeats itself over again whenever R&D for new compounds takes place, the aim being to fund these new avenues through the income from already licensed terpenoids, thus bootstrapping our operations.

6.1.3. Cash Flow projections

This step is important as it is prediction to determine whether TerpenOX will be a viable business or to provide sufficient information to negotiate with suppliers, clients, and manage inventories so TerpenOX does not go bankrupt.

As TerpenOX requires a large amount of money invested in R&D in the first years, the financial resources at the end of the period are negative in the first two years (year 1: (EUR 278,100); year 2: (EUR 1,226,550); – ***Table 8***) and our company will start to be profitable at year 3 because TerpenOX will start having revenue from the upfront payments agreements that have with the licensees.

Typically, this industry has high conversion cycles because clients, the companies buying our license, will take a long time to settle (usually happens in situations where there are installment payment schedules involved). According to Bougheas et al. (2001), R&D investments have usually liquidity constraints. From a cash flow management point of view, the conversion cycle should be as low as possible to minimize the risk associated with TerpenOX, and ensure less pressure on liquidity, and less need for external financing in the future.

Table 5 *Cash Flow KPIs*

Cashflow KPIs					
Cash Burn rate per year	- 278 100 €	- 1 226 550 €	3 580 816 €	6 325 664 €	6 810 467 €
Break-Even-Analysis	-	-	548 148 €	1 121 919 €	1 050 691 €

The burn rate is the rate at which TerpenOX will burn cash through its initial capital before it generates any positive cash flow. Meaning that, in order to get our company started we need to have a total of EUR 1,504,650 available. This amount is the minimum possible to get TerpenOX operational, besides day-to-day expenses. Furthermore, we plan to raise a total capital of EUR 2,000,000.

6.1.4. Yearly KPIs

Establishing a coherent yearly growth ratio that is realistic both in the short and long-term is important to quantify progress and have continuous improvement. Measuring the source of this increase each year based on the expanding the market is more lasting than growth based on trying to grow at the expense of competitors.

To sustain this is important to analyse several KPIs:

- Operational KPIs: being able to compare operational performance to benchmarks in order to achieve targeted production outputs, including quality and maintenance. The

end goal is to achieve high Overall Equipment Effectiveness (OEE) while also lowering expenditures.

- Regulatory KPIs: TerpenOX as a chemical manufacturing business can use KPIs for regulation compliance to track, monitor, and preserve records needed by numerous laws and regulations. To measure the long-term efficacy of our compliance operations, TerpenOX should establish and monitor KPIs connected to Regulatory Affairs (RA).
- Inventory Utilization KPIs: While keeping higher-than-normal inventory levels increases overall expenses, stock-outs can exacerbate production bottlenecks. The importance of maintaining adequate inventory levels stems from this. Chemical businesses can attain the inventory levels necessary to keep production running without increasing inventory expenses by sticking to throughput rate and buffer levels. Inventory KPIs can aid in keeping inventory turnover rates consistent.
- Environmental Impact and Sustainability KPIs: As TerpenOX is part of an industry that processes still consume a lot of resources and have the potential to harm the environment, we will explore and advise customers to invest in greener, more sustainable working practices in order to maintain the correct governance in the industry.

6.2. Fundraising

Some would argue that investing in a company that is resource extensive as an R&D company is very risky. Others would say that innovation drives economic growth. According to the RAND Journal of Economics, VC-backed firms accounted for 86% of Research & Development between 1974 and 2015.

As important as the internal expertise we have, the people who can advise us on our strategic direction, and who often have relevant experience as scientists, start-up founders, executives

at large companies, investors, and sometimes in all of those roles. Having people with such backgrounds, and with whom we can take counselling, will help us overcome difficult challenges we will inevitably encounter, support our decision-making over the multiple aspects that managing a company encompasses, and ultimately help TerpenOX succeed.

TerpenOX will need to raise EUR 2,000,000 and will do that through 3 different institutions:

Our first option of funding will be through the European Innovation Council that has a program called EIC Accelerator which is supporting companies, especially start-ups, to develop and scaleup game-changing innovations. This support is made through a grant funding up to EUR 2,500,000 for innovation and development costs, whereas the equity of TerpenOX will not be diluted. Therefore, EIC grant is our first option, so all the owners of TerpenOX keep full control of their stake of the company.

The chosen start-ups will receive coaching, mentorship, access to investors and businesses, and many other perks as part of the EIC network. All EU Member States and Horizon Europe partner countries are encouraged to submit proposals to the EIC. Horizon Europe, with a budget of EUR 95.5 billion, is the EU's biggest research and innovation financing project. This initiative combats climate change, helps the UN reach its Sustainable Development Goals, and boosts the EU's competitiveness and prosperity. While tackling global issues, the initiative promotes collaboration and enhances the impact of research and innovation in the development, support, and implementation of EU policy. It encourages the invention and spread of advanced knowledge and technologies.

TerpenOX does not expect to get the full funding through the EIC grant so we will also consider external funding from venture capitalists. Even though, a part of the ownership of the company

will be diluted there are several reasons why we think this approach can also be beneficial for TerpenOX:

- Scale more quickly: With the money of the EIC grant TerpenOX will be able to launch the business, however we also believe that venture financing gives the possibility to scale up the business to a considered operating size in order to hire good talent. This could be a result of going to the market faster and be ahead of competition in our niche.
- Gain credibility: When venture capitalists are ready to invest a significant amount of money in a company, it means that after all the due diligence they still believe the company has potential to succeed, provide something appealing to the market and add value to their target customers. A venture capitalist's outward approbation establishes instant credibility with stakeholders. Venture capitalist investment is frequently highlighted in the media, allowing more people to realize that a respectable investor believed in a company. Along with receiving funds, TerpenOX may also receive extensive media publicity.
- Tap into resources beyond money: Besides the financial backing when a company raises money, this investment comes with wealth of resources, business skills, and immediate network expansion. Legal & tax advisory and access to research are other examples that as first-time founders we may not have access to. The investor relationship can also lead to introductions to others in their network such as similar companies that invested in, potential new customers and more.
- Receive assistance with risk and strategic direction: The experience of venture investors who understand risk, strategy and difficult decisions in order to get their investment back and the return associated. As first time founders our experience is limited to the areas of study each of us has so experience in areas such as human resources, legal or even day-to-day decisions may improve the whole experience of raising cash.

- Generous funding terms: Raising funds through a venture capital also gives more flexibility when it comes to repaying the investment. Unlike bank loans, venture investments do not demand monthly repayment or interest. Like this, cash flow conversion cycles will be better managed allowing TerpenOX to reinvest in new items, hire more people, and grow operations. Last but not least, by having a venture investment each of the founders does not need to use personal assets to expand the company or use it as security for loans. Leaving personal assets off the table will help to relief some stress and pressure about the success of TerpenOX.

Following this line of thought, we think that there are two Venture Capital funds that have a fit with TerpenOX:

MAZE Impact is an Impact Venture Capital fund based in Lisbon, Portugal. MAZE created a program called MAZE X which is an impact accelerator to help ambitious impact start-ups become impact unicorns. It focuses on tenacious entrepreneurs who are willing to try new ideas and strive for creative results. The program is headquartered in Lisbon, and lasts three months, with six months of follow-up assistance and equity-free cash. Even though there is only availability for 10 early-stage start-ups for this program, if TerpenOX can get this investment from MAZE X, it will have access to things such as:

- Pro bono legal support
- Access to corporate pilot opportunities with the legal support of PLMJ and the financial background of BNP Paribas
- Coworking space
- International roadshow
- Great partnerships in the Portuguese ecosystem: This program is empowered by The Calouste Gulbenkian Foundation and The Edmond de Rothschild Foundations, has

acceleration partners such as Hospital da Luz Learning Health and Casa do Impacto and last but not less important has also a partnership with Microsoft for Start-ups.

- GAN membership: Global Accelerator Network, LLC is an invite-only network of short-term, mentorship-driven accelerators with parameters that benefit entrepreneurs.

On the other hand, TerpenOX would be a good fit for MAZE X to help diversify their investment range and include more biotech companies in its portfolio. Even though is a very risky industry since some research & development content might never see the light of day, biotech companies have incredible returns. Furthermore, TerpenOX technology can be a great fit for several partners, in specific Hospital da Luz Learning Health since our company can adapt to this segment of healthcare.

Planet A Ventures is a European green-tech venture capital fund based in Hamburg, Germany. They invest in start-ups that have a major beneficial impact on the environment while establishing internationally scalable businesses. The objective of the team behind Planet A is to contribute to a sustainable global economy. Climate mitigation, waste reduction, resource conservation, and biodiversity protection are all areas where they promote innovation. Planet A is the first European venture capital firm to provide scientific impact evaluations to inform their investment decisions and to educate entrepreneurs to monitor and increase their effectiveness. Even though the fund was founded in 2020, it has already achieved a total of 8 investments of which 7 of them are still active. Their main focus is B2B businesses, and their portfolio firms are supported by a large network of experienced founders and specialists as the firm seeks to provide funding and mentoring while forecasting the impact on a scientific base throughout:

- Early-stage capital
- Operational best practices

- Scientific impact measurement & forecasting support
- Business development & Customer access
- Support for follow-on financing rounds
- Strategic sparring and contracts through Planet A Network supported start-ups maximizing their potential impact faster and more accurate

What attracted TerpenOX was that the impact of VC shows that beneficial environmental effects and financial gains can coexist, making them a role model for sustainable enterprise and investment. Another big advantage of partnering up with Planet A is the fact that they offer a complete view of the environmental implications, and that they consider modifications to current supply chains or market players in their analyses. The Planet A team can precisely establish how much superior the start-up's innovation will be by comparing the results to reference items or services. Their innovative method enables them to assess not just greenhouse gas emissions, but also plastic, water, and land-use footprints. Not only does the fund makes the environmental effect a fundamental indicator in their decision-making, but we also establish impact KPIs for all of the company's part of the portfolio and connect carried interest to meet these impact goals. Moreover, the largest chemical producer in the world and also our target customer, BASF, is based in Germany. Thus, having the trust of an impact venture capital firm like Planet A Ventures would give a lot of credibility to TerpenOX.

Following the same line of thinking as Planet A Ventures, it is now or never. The world is on the verge of collapsing due to an economy based on the exploitation of natural resources, a disposable culture, and the pursuit of short-term financial success. For many, the present course endangers their livelihoods, health, and prosperity. The severity of our situation is exacerbated by demographic expansion, leaving us with little time to develop an economy that operates within global bounds. TerpenOX could be a great fit to Planet A since our technology relies on

the synthetic production of menthol in order to ease the demand for menthol extracted naturally, which does a great match from all that was said before.

All in all, an optimal scenario would be getting an investment from the EIC Accelerator program approximately of EUR 1,500,000 together with MAZE X we will suggest a contribution of EUR 350,000 and another EUR 150,000 from Planet A Ventures, making a total seed round of EUR 2 million. With this investment TerpenOX will be able to:

- Technology R&D: Continue technology research & development investment to deliver our roadmap and create more value for our customers. Furthermore, around the time TerpenOX is profitable the R&D will expand to other compounds
- General & administrative expenses such as patent lawyers, marketing costs, etc.
- Growth: Expand the team and accelerate the entrance in new markets such Asia-Pacific region
- Sales & Marketing: Scaling our brand and get more customers to license our technology and meet growth demand

Besides the financial return and big opportunity that TerpenOX is creating for EIC Accelerator, MAZE X and Planet A Ventures entering in this market that is about to boom, TerpenOX also offer a very passionate and dedicated team that has a very complete and diverse background board of advisors ready to make the supply chain of manufacturing more sustainable.

6.3. Pre-Money Valuation

6.3.1. Comparable Analysis & Multiples Valuation

In order to determine the true value of our company, TerpenOX used Comparable Analysis and Multiples Valuation to determine its pre-money valuation (before external funding or latest

round of funding). This valuation is often used when there is no prior financial information, to get an approximate valuation within the industry, in our case within the commodity chemicals industry. Based on the mean EV/Revenue from direct competitors such as Takasago, BASF, Symrise and Givaudan the multiple is 3.0x.

Table 6 *Breakdown of Multiples Valuation*

	Market	Enterprise	LTM Financial Metrics				LTM Multiples			
Name	Capitalization	Value (TEV)	Revenue	EBITDA	EBIT	Net Income	TEV / Revenu	TEV / EBITDA	TEV / EBIT	P/E
Takasago International	€ 373 686	€ 591 223	€ 1 217 080	€ 137 015	€ 87 328	€ 50 700	0,5x	4,3x	6,8x	7,4x
BASF SE	€ 46 300 511	€ 63 611 539	€ 78 600 000	€ 11 493 000	€ 7 806 000	€ 5 848 900	0,8x	5,5x	8,1x	7,9x
Symrise	€ 15 857 140	€ 17 257 080	€ 3 825 691	€ 804 471	€ 550 791	€ 356 096	4,5x	21,5x	31,3x	44,5x
Givaudan	€ 35 184 321	€ 39 437 613	€ 6 183 709	€ 1 403 454	€ 972 334	€ 814 429	6,4x	28,1x	40,6x	43,2x
Minimum							0,5x	4,3x	6,8x	7,4x
25th Percentile							0,7x	5,2x	7,8x	7,8x
Median							**2,7x**	**13,5x**	**19,7x**	**25,6x**
Mean							**3,0x**	**14,9x**	**21,7x**	**25,8x**
75th Percentile							5,0x	23,1x	33,6x	43,5x
Maximum							6,4x	28,1x	40,6x	44,5x

Taking the revenue forecast of TerpenOX from ***Table 8*** and the mean multiple mentioned before, in 2024 (the year TerpenOX will start having a revenue) the analysis will be following:

- Revenue in 2024: EUR 5,666,850

For competitor comparables, multiple identified above – 3,0x – the valuation of TerpenOX would be EUR 17,000,550. As for other companies in the market, the average median multiple for BioTech & Geonomics companies in Q4 of 2021 was 8.9x (one of the lowest in the past 2 years). Like this, considering and compared with privately held companies the EV of TerpenOX would be EUR 50,434,965.

Besides comparable analysis, investors also care about more qualitative aspects such as the founders' team or even deal interest. Investors put a lot of faith in "excellent" entrepreneurs when it comes to choosing early-stage successes. Usually, founders are described as people that make things happen or are down-to-earth, or even that are persistently resourceful. VCs are interested in founders that have a strong track record of starting new businesses and have put together a team of clever individuals to help them. Furthermore, if a lot of investors show

interest in TerpenOX, we, as founders, not only have bargaining power but also can increase the company's valuation, allowing us to keep greater control. However, in the worst scenario, if the deal is undersubscribed (low demand), the investors have the ability to set the TerpenOX's worth.

All in all, pre-money valuation is very subjective however, TerpenOX's team is confident to say that we consider a fair valuation of EUR 17,000,550 since there is no revenue yet.

6.3.2. Shareholding Structure

According to Manifold (2021), start-ups that count on a helpful board advisory have much more success when fundraising. Further, the document states that the funding raised is a reasonable proxy for start-up success and progress. In order to demonstrate that TerpenOX appreciates its board of advisors, the company is willing to give 1% of shares with a two-year vesting schedule with six months cliff, meaning that if the relationship between TerpenOX and the board of advisory does not work during the first six months and the advisors leave the company, TerpenOX retains the equity.

Employee stock option plans (ESOPs) or also known as option pools are an excellent method to reward employees and recruit new staff. Employees that work hard and take risks understand their value and want to be rewarded for it. Working for a start-up achieves this purpose through the lottery ticket component, which is not part of the Venture Capitalists' size of the pie.

Summing up, the equity of the company will be split in 4 main parts:

- Advisory Board: 1% per member so total members will have 4% of total equity of TerpenOX
- Option pool: 15% (3% to our senior chemist that we consider a key employee)

- Venture Capital: Since MAZE Impact program does not require equity, TerpenOX will only dilute equity with Planet A Ventures
    - As Planet A is investing in TerpenOX EUR 150,000, the total Ownership over TerpenOX would be 0.9%

Table 7 *Breakdown of Pre-Money Valuation and Post-Money Valuation*

Pre-Money Valuation		
Pre-Money Valuation	€	17 000 550,00
% Founders Ownership		100,00%
Pre-Money Founder Equity	**€**	**17 000 550,00**

Funding Round		
Investment Size	€	2 000,00
% New Investors Onwership		19,9%

Post-Money Valuation		
Post-Money Valuation	€	17 002 550,00
% Founders Ownership		80,10%
Post-Money Founder Equity	**€**	**13 619 042,55**

- Founders: as the founding team is represented by 4, each founder would keep 20.025% of the equity of TerpenOX

The issue of how much of the founder's equity will be diluted is a function of pre-money valuation and the amount of investment sought. Furthermore, we do not know how much investors and the advisory board would accept as these calculations are all forecasted based on market research and comparables analysis.

All in all, when it comes to define an exit strategy this matter is very ambiguous. As TerpenOX is licensing its technology to other companies, there will not be an exponential growth unless our portfolio of clients keeps increasing. Moreover, we do think an IPO is highly improbable if TerpenOX is only present in the menthol market.

On the other hand, there's also the possibility of getting acquired by one of our licensees (such as BASF or Takasago). If this is the case, investors would have an extra motivated to invest in TerpenOX.

7. Risks & Opportunities

7.1. Risks

7.1.1. Threat of Global Recession

The current unstable outlook on the international financial markets further poses a threat for businesses worldwide, and TerpenOX is no exception. The pandemic brought with it alarming inflation rates and global supply chain shortages, which are now being prolonged by the ongoing armed conflict involving Ukraine and Russia. As a result, the odds of a recession taking place in Europe, the United States, and China are significantly increasing, more so when an eventual downturn in any one of these can trigger the same effect on the other two (Rogoff 2022). This conjuncture further poses a risk for TerpenOX. Given the fact that we will be having significant CAPEX needs to resume our R&D operations, we can expect these will be much higher than we would anticipate at first. In addition to the higher cost, the delivery is also likely to suffer significant delays – up to 12 months, as it stands. This delay comes in great part from the specific equipment and materials we need to perform our R&D and get the technology ready for patent application, but also from a systematic delay noticeable in most markets and sectors. Time is money, and therefore this challenge may cause second-order effects to arise, such as the increased difficulty to get funding, subsequently leading to the impairment of some founding members' ability to subsist without a salary, which directly would affect the whole future of TerpenOX. To mitigate that risk, we are only spending in what we think is indispensable for the success of the company.

7.1.2. R&D Risk

Besides procurement issues another challenge will be of scientific nature. Being a biochemistry company with a focus on research and development there are inherent risks as advancements in science do not follow a simple step-by-step blueprint. As scaling up and inventing novel reactions in organic chemistry is inherently a very complex undertaking, we are reliant of the vast knowledge, abilities and experience of our scientists and engineers. Finding people to fill those key staff positions will be a curtail task for TerpenOX to accomplish our ambitions. Even with the best research team possible we are expecting setbacks and failures throughout the research and development phase of both our menthol process innovation journey as well as other future compound adaptations. Yet, we are confident that we are capable to overcome these challenges eventually as the largest breakthrough – the proof of concept – has already been achieved.

7.1.3. Reliance on Menthol Opportunity

Another specific risk to TerpenOX is its heavy reliance on the menthol market players to kickstart the business, even more, when there are only two viable companies to whom we can license our novel technology. That will impede us from diversifying our revenue streams at the first stage, which we state as one key factor for the long-term success of the company. That said, the short-term success of TerpenOX depends largely on our ability to establish a licensing agreement in this concentrated market. If we are not able to do so, we will have to either delay our commercial activities, and possibly slow down our R&D activities due to the lack of funding that is likely to arise from the failure to achieve the market entry milestone, or we can target smaller end-users of menthol, such as Mentolis (Vieira de Castro) and Drops Nazaré, both producers sweets and candies, and supply them with relatively small samples of menthol.

7.2. Opportunities

7.2.1. Sustainability Trend

With sustainability initiatives coming from every front, companies worldwide are feeling the pressure to shift to more environmental-friendly, carbon-neutral practices. Initiatives like the recent COP26, along with increasing regulation and policies around sustainability matters (e.g., Paris Agreement, Germany's Climate Protection Act, EU's Green Deal, and the UN's Sustainable Development Goals), push whole industries to adopt new solutions that can help meet these goals relatively fast (targets are usually set to be accomplished between 2030 and 2050). This presents an opportunity for TerpenOX as its potential licensees now have a greater urgency to perform those changes. In that sense, if presented with a solution that is more cost-effective than developing a solution with the same benefits – namely efficiency – internally, these large companies will certainly be inclined to opt for joining efforts with TerpenOX.

Additionally, there is also an increasing number of funds targeting socially and environmentally impactful ventures. We include TerpenOX in that category, which points to the fact that our fundraising may be a bit easier than it would were it not for these progressing trends in the venture capital sector.

7.2.2. Strategic Alliance with Large Company

Despite the risks associated with our initial heavy reliance on the menthol opportunity, there are also some possibilities that come with it. Given the dimension of the two largest players in this market, it is very likely that by establishing a licensing agreement with one of them, a strong relationship will flow, which will generate new opportunities in the future, such as the facilitated entrance into other compound markets beyond menthol's and will generally enhance synergies between the two parties. Through such an alliance, our sustainability as a business

becomes better secured, and we are further able to focus on our mission, which is developing innovative technologies for the development of various chemical compounds, thereby placing more efforts into specializing on what we are good at – Research & Development. Furthermore, the synergies that arise from it may make it a rational option for our counterpart to acquire us, which is our most probable exit option.

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9. Appendix

Figure 11 *The eight possible menthol stereoisomers. The most common form, l-menthol, highlighted in green. (Source: Spartax Chemicals)*

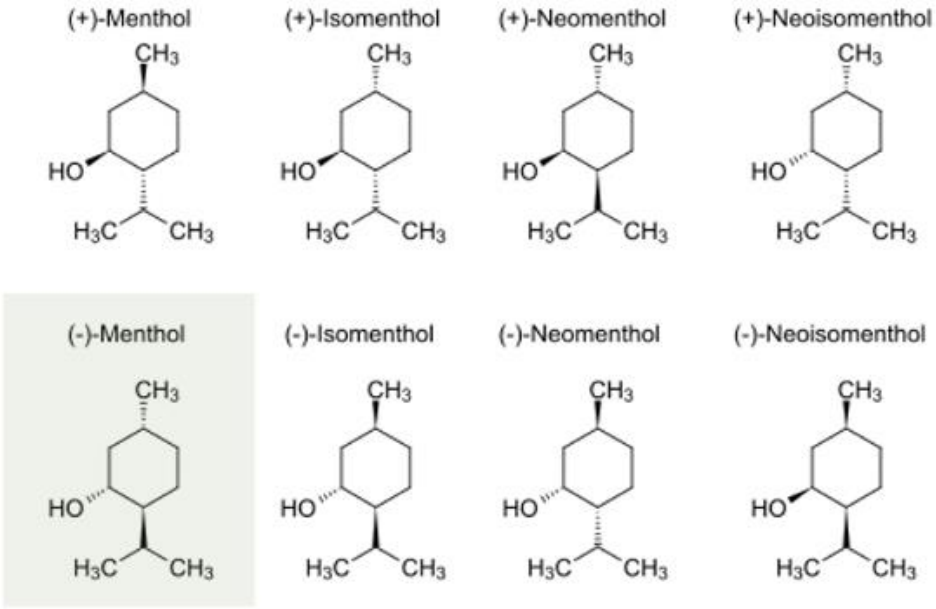

Figure 12 *Steam distillation process for essential oil extraction from plant material (Source: https://essentialoilseurope.com/distillery/)*

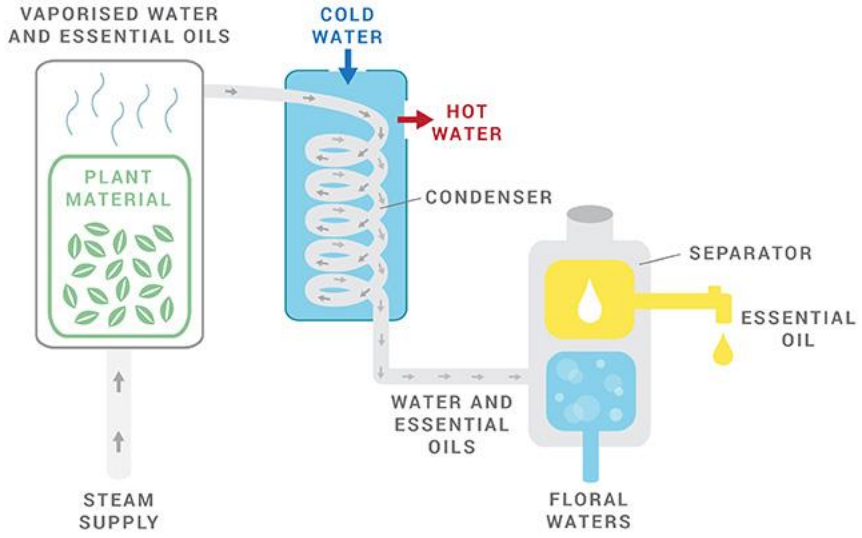

Figure 13 *Takasago semi-synthetic process for l-menthol synthesis from myrcene. (Source: http://www.leffingwell.com)*

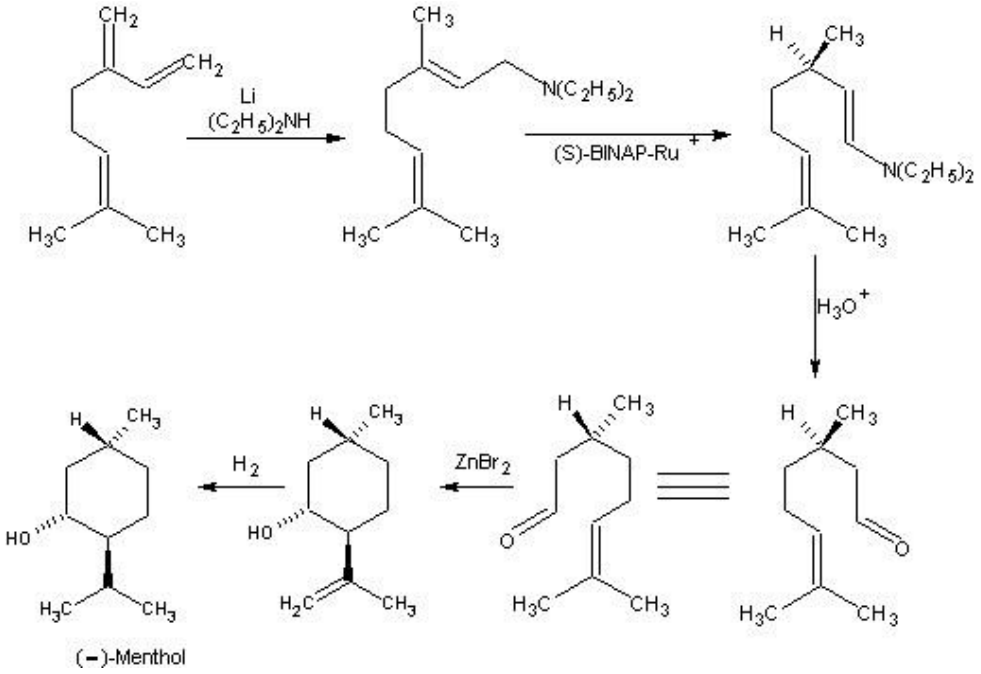

Figure 14 *BASF synthetic process for l-menthol production from citral products. (Source: http://www.leffingwell.com)*

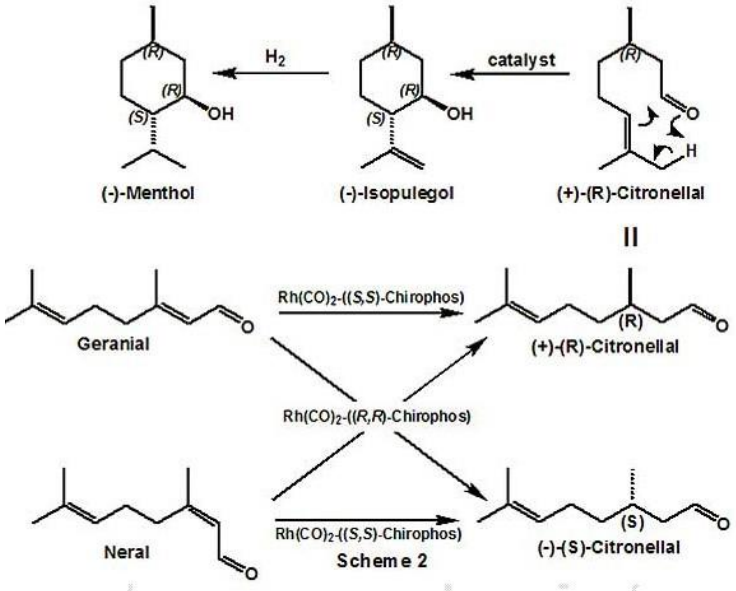

Figure 15 *Symrise synthetic process for l-menthol synthesis from m-cresol. (Source: http://www.leffingwell.com)*

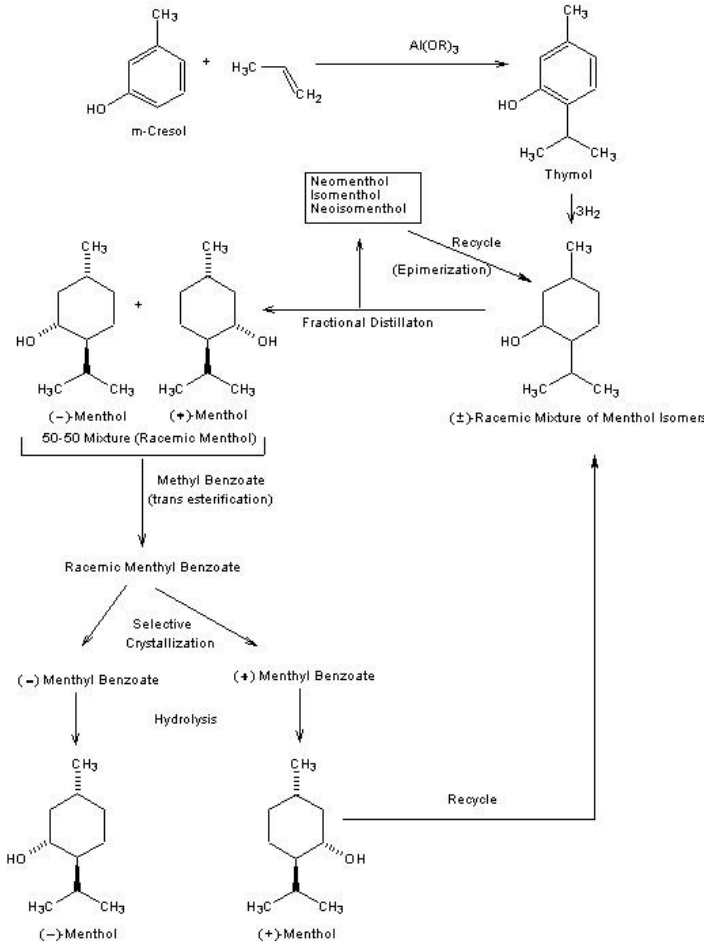

Table 8 *Management Overview of TerpenOX*

			2022	2023	2024	2025	2026
Revenue		Revenue from Royalties	- €	- €	- €	8 187 008 €	8 678 228 €
	+	Revenues from Upfroant payments	- €	- €	5 666 850 €	- €	- €
	=	**Total net sales**	**- €**	**- €**	**5 666 850 €**	**8 187 008 €**	**8 678 228 €**
COGS	-	Royalties to University of Vienna (5%) of our revenue	- €	- €	- €	409 350 €	433 911 €
	-	Milestone payments	- €	150 000 €	- €	- €	- €
		Total licensing cost UV	**- €**	**150 000 €**	**- €**	**409 350 €**	**433 911 €**
	-	Raw materials	2 000 €	10 000 €	25 000 €	5 000 €	10 000 €
		Total COGS	**2 000 €**	**160 000 €**	**25 000 €**	**414 350 €**	**443 911 €**
	=	**Gross profit**	**- 2 000 €**	**- 160 000 €**	**5 641 850 €**	**7 772 658 €**	**8 234 317 €**
SG&A costs	-	Founding costs	800 €	- €	- €	- €	- €
	-	Patent lawyers	- €	50 000 €	100 000 €	120 000 €	20 000 €
	-	Corporate Lawyers	3 000 €	3 000 €	3 150 €	3 308 €	3 473 €
	-	Accounting	3 300 €	3 300 €	3 300 €	3 300 €	3 300 €
	-	Data Science	- €	- €	- €	10 000 €	5 000 €
	-	Marketing cost	5 000 €	5 000 €	5 000 €	15 000 €	15 000 €
	-	Cost related to Sales	10 000 €	20 000 €	20 000 €	50 000 €	50 000 €
	-	Business insurance	10 000 €	12 000 €	14 400 €	17 280 €	20 736 €
		Total SG&A costs	**32 100 €**	**93 300 €**	**145 850 €**	**218 888 €**	**117 509 €**
Employment exp.	-	Salaries/Wages	162 500 €	256 250 €	271 875 €	287 500 €	303 125 €
		Total personell costs	**162 500 €**	**256 250 €**	**271 875 €**	**287 500 €**	**303 125 €**
Occupancy costs	-	Rent: office building & admin	- €	- €	- €	24 000 €	24 000 €
	-	Utilities	- €	- €	- €	2 400 €	2 400 €
	-	Repair & maintenance	- €	- €	- €	1 000 €	1 000 €
	-	Office furniture	- €	- €	- €	3 000 €	1 000 €
	-	Office Supplies (e.g. Computer, Software license)	1 500 €	3 000 €	4 000 €	10 000 €	10 000 €
	-	Rent: Lab space	60 000 €	60 000 €	- €	- €	- €
	-	Lab equipment, materials etc.	20 000 €	30 000 €	25 000 €	30 000 €	20 000 €
	-	Rent: Space for pilot unit	- €	24 000 €	24 000 €	24 000 €	24 000 €
	-	Pilot unit equipment	- €	600 000 €	50 000 €	50 000 €	50 000 €
		Total occupancy costs	**81 500 €**	**717 000 €**	**103 000 €**	**144 400 €**	**132 400 €**
		Total expenses / costs	**278 100 €**	**1 226 550 €**	**545 725 €**	**1 065 138 €**	**996 945 €**
	=	**EBITDA**	**- 278 100 €**	**- 1 226 550 €**	**5 121 125 €**	**7 121 870 €**	**7 681 283 €**

Income	=	**EBITDA**	**- 278 100 €**	**- 1 226 550 €**	**5 121 125 €**	**7 121 870 €**	**7 681 283 €**
	-	Amortization / Depreciation	4 000 €	60 000 €	70 000 €	81 600 €	90 800 €
	=	**Operational EBIT**	**- 282 100 €**	**- 1 286 550 €**	**5 051 125 €**	**7 040 270 €**	**7 590 483 €**
	-	Financial expenses (interests)	- €	- €	- €	- €	- €
	=	**EBIT**	**- 282 100 €**	**- 1 286 550 €**	**5 051 125 €**	**7 040 270 €**	**7 590 483 €**
	-/+	Corporate tax (21% in Portugal)	- €	- €	1 060 736 €	1 478 457 €	1 594 001 €
	=	**Net income**	**- 282 100 €**	**- 1 286 550 €**	**3 990 389 €**	**5 561 813 €**	**5 996 482 €**
Cashflow / Liquidity	+	Depreciation / Amortization	4 000 €	60 000 €	70 000 €	81 600 €	90 800 €
	-/+	(Increase) / Decrease in account receivables	- €	- €	- 472 238 €	682 251 €	723 186 €
	+/-	Increase / (Decrease) in account payable	- €	- €	- €	- €	- €
	=	**Operating Cashflow**	**- 278 100 €**	**- 1 226 550 €**	**3 588 151 €**	**6 325 664 €**	**6 810 467 €**
	+	Cash inflows from investment activities	- €	- €	- €	- €	- €
	-	Cash outflow from investment activities	- €	- €	- €	- €	- €
	=	**Investing Cashflow**	**- 278 100 €**	**- 1 226 550 €**	**3 588 151 €**	**6 325 664 €**	**6 810 467 €**
	+	Increase in short-term debt	- €	- €	- €	- €	- €
	+	Increase in long-term debt	- €	- €	- €	- €	- €
	+	Increase from external financing (investments)	- €	2 000 000 €	- €	- €	- €
	-	Repayment of loans	- €	- €	- €	- €	- €
	=	**Free Cashflow**	**- 278 100 €**	**773 450 €**	**3 588 151 €**	**6 325 664 €**	**6 810 467 €**
	+/-	Financial resources at the beginning of the period	- €	- 278 100 €	495 350 €	4 083 501 €	10 409 165 €
	=	**Financial resources at the end of the period**	**- 278 100 €**	**495 350 €**	**4 083 501 €**	**10 409 165 €**	**17 219 633 €**

Table 9 *Breakdown of General and Administrative expenses*

General and Administrative Costs: input values

Cost type	Parameter	Parameter description	2022	2023	2024	2025	2026
Founding costs	One-time	Cost related to founding a company	800 €	- €	- €	- €	- €
Patent lawyers	Yearly fee		- €	50 000 €	100 000 €	120 000 €	20 000 €
Corporate Lawyers	Yearly fee	Yearly legal costs	3 000 €	3 000 €	3 150 €	3 308 €	3 473 €
Accounting	Yearly fee		3 300 €	3 300 €	3 300 €	3 300 €	3 300 €
Data Science	Yearly fee		- €	- €	- €	10 000 €	5 000 €
Marketing cost	Yearly costs	Business Cards, Industry Events, Website etc.	5 000 €	5 000 €	5 000 €	15 000 €	15 000 €
Cost related to Sales	Yearly costs	Travelexpenses etc.	10 000 €	20 000 €	20 000 €	50 000 €	50 000 €
Business insurance	Yearly, third party insurance	Insurance costs related to damages, cybercrime and other necessary insurances (increase 20% yeraly)	10 000 €	12 000 €	14 400 €	17 280 €	20 736 €
Total SG&A costs			**32 100 €**	**93 300 €**	**145 850 €**	**218 888 €**	**117 509 €**

Table 10 *Breakdown of Personnel costs*

Employment input values

				STAGE I		STAGE II & III		STAGE IV		Licensing Stage			
				2022		2023		2024		2025		2026	
Cost type	Total personnel	Salary	Bonus/ Ancillary	Costs	Number	Costs	Number	Costs	Number	Costs	Number	Costs	Number
Founder													
CEO (Pedro dos Santos)	€ 43 750	€ 35 000	€ 8 750	€ -	1	€ 26 250	1	€ 30 625	1	€ 35 000	1	€ 39 375	1
CFO (Maria Margarida Ferreira)	€ 37 500	€ 30 000	€ 7 500	€ -	1	€ 22 500	1	€ 26 250	1	€ 30 000	1	€ 33 750	1
CINO (Maximilian Palige)	€ 37 500	€ 30 000	€ 7 500	€ -	1	€ 22 500	1	€ 26 250	1	€ 30 000	1	€ 33 750	1
CSO (Alessandro Piccolo)	€ 37 500	€ 30 000	€ 7 500	€ -	1	€ 22 500	1	€ 26 250	1	€ 30 000	1	€ 33 750	1
	€ 156 250			**€ -**	**4**	**€ 93 750**	**4**	**€ 109 375**	**4**	**€ 125 000**	**4**	**€ 140 625**	**4**
Production													
Senior Chemist	€ 75 000	€ 60 000	€ 15 000	€ 75 000	1	€ 75 000	1	€ 75 000	1	€ 75 000	1	€ 75 000	1
Junior Chemist	€ 18 750	€ 15 000	€ 3 750	€ 18 750	1	€ 18 750	1	€ 18 750	1	€ 18 750	1	€ 18 750	1
Senior Engineer	€ 37 500	€ 30 000	€ 7 500	€ 37 500	1	€ 37 500	1	€ 37 500	1	€ 37 500	1	€ 37 500	1
Junior Technician	€ 31 250	€ 25 000	€ 6 250	€ 31 250	1	€ 31 250	1	€ 31 250	1	€ 31 250	1	€ 31 250	1
	€ 162 500			**€ 162 500**	**4**	**€ 162 500**	**4**	**€ 162 500**	**4**	**€ 162 500**	**4**	**€ 162 500**	**4**
	€ 318 750			**€ 162 500**		**€ 256 250**		**€ 271 875**		**€ 287 500**		**€ 303 125**	

Rate of ancilliary staff costs* 25,00%

**** Costs include bonus payments/ business travel / meals etc***

Table 11 *Breakdown of Fundraising Strategy*

Financing: input values

Item	Item type	Parameter description	2022	2023	2024	2025	2026
MAZE Impact	Venture Capital Investment	MAZE will invest €350K	0 €	350 000 €	0 €	0 €	0 €
Planet A Ventures	Venture Capital Investment	Planet A is determined to invest €150K	0 €	150 000 €	0 €	0 €	0 €
European Innovation Council	Grant	Up to €2.5M investment without dilluting any equity	0 €	1 500 000 €	0 €	0 €	0 €
European Innovation Council Fund	Venture Capital Investment	In case, TerpenOX needs additional funding EIC Fund will also be na investor	0 €	0 €	0 €	0 €	0 €