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Recent advances in pest-repellents based on the *Lamiaceae* family's plants: a patent analysis overview

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The development of natural and eco-friendly repellents, specifically those derived from plants, has particular relevance because these plant-based repellents offer a promising alternative to chemical-based repellents. Also, plant-derived repellents could be cost-effective and safer for non-target organisms. However, the pure form of plant extracts could be hazardous as a repellent. Thus, safe concentrations and convenient delivery forms are essential. The plants of the *Lamiaceae* family have shown great potential in the formulation of this type of repellent against a wide range of pests, especially thanks to the properties of the components of their extracts and essential oils. This research aims to identify recent innovations in the field of plant-based repellents of the *Lamiaceae* family, founded on patent documents. Therefore, patent databases were searched, using appropriate

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keywords and refining the search using patent classification codes. We reviewed 72 patent documents, grouped into 52 simple families, published over the last ten years. The United States is the jurisdiction in which 64% of those documents were filed. The year 2019 showed the publication of the largest number of patent documents, with ten patent applications and four granted patents. We conclude that, in parallel with research in this field, which continues to advance, many innovative solutions that take advantage of the natural repellent properties of plants in the *Lamiaceae* family contribute to ongoing sustainable and ecological pest management efforts.

KEYWORDS: *Lamiaceae* / biorepellents / pest management / biochemistry / patent

The food supply of the world's population depends mainly on agricultural activity [Hemathilake and Gunathilake, 2022]. To ensure increasingly high yields capable of meeting the demand of a growing number of consumers, the protection of plants against pests through the use of repellents becomes essential [Dayan *et al.* 2009]. These repellents work within the perimeter of their application to prevent pests from approaching or infesting crops. However, while synthetic chemical repellents have long been used in agriculture, they do present a variety of environmental problems, including contamination of soil, water sources, and air [Aktar *et al.* 2009]. In addition, the excessive use of chemical repellents can lead to the development of pesticide resistance in pests, which gradually renders a number of these products ineffective [Sparks and Nauen 2015].

Insect repellents are also very useful for public health. Indeed, the prevalence of vector-borne diseases, such as malaria, Lyme disease, dengue fever, West Nile virus, and yellow fever, has been on the rise in recent years [Kilpatrick and Randolph 2012]. Mosquitoes are the main cause of these diseases; however, other insects are also implicated, such as the tsetse fly that causes sleeping sickness, sandflies that cause leishmaniasis, or the parasitic worm *Onchocerca volvulus* that causes onchocerciasis (river blindness) [Thomson *et al.* 2018].

For this reason, plant-based repellents offer a promising alternative to chemical repellents [Dubey *et al.* 2010]. Biorepellents have several benefits (Fig. 1) and are a sustainable and environmentally friendly method for plant protection, making them increasingly important in agriculture [Maia and Moore 2011]. These biorepellents are derived from natural sources such as essential oils and plant extracts. In addition, plant-based repellents may be economically advantageous and more tolerated by non-target organisms [Asadollahi *et al.* 2019].

The *Lamiaceae* family, commonly known as the mint family, contains various plants that have shown great potential in the formulation of repellents against a wide spectrum of pests, leveraging the properties of their extracts and essential oils [Ebadollahi *et al.* 2020]. Table 1 provides examples of *Lamiaceae* family plants whose essential oils have demonstrated significant repellent effects on various arthropod species, highlighting their potential use in natural insect repellent formulations [Ansari *et al.* 2000, Prajapati *et al.* 2005, Trongtokit *et al.* 2005]. Compounds such as pulegone, thymol, carvacrol, and citral derived from *Lamiaceae* plants exhibit strong antifungal properties, effectively controlling fungi in food production chains and demonstrating

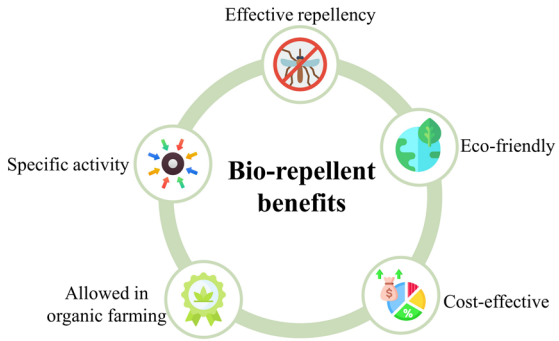

Fig. 1. Some benefits of biorepellents [López *et al.* 2021, Aboelhadid *et al.* 2023, Chattopadhyay *et al.* 2015, Lacotte *et al.* 2023].

Table 1. Examples of essential oils from plants in the *Lamiaceae* family that have shown high repellency to various arthropod species

Plant-based essential oils	Arthropod species studied	Reference
Mentha piperita	*Anopheles annularis* *Anopheles culicifacies* *Culex quinquefasciatus*	Ansari *et al.* [2000]
Ocimum basilicum	*Anopheles stephensi* *Aedes aegypti* *Culex quinquefasciatus*	Prajapati *et al.* [2005]
Rosmarinus officinalis	*Anopheles stephensi* *Aedes aegypti* *Culex quinquefasciatus*	Prajapati *et al.* [2005]
Pogostemon cablin	*Aedes aegypti* *Culex quinquefasciatus* *Anopheles dirus*	Trongtokit *et al.* [2005]

insecticidal effects on specific pest species [Abbaszadeh *et al.* 2014, Chebli *et al.* 2003, El Boukhari and Fatimi 2024a, 2024c]. Additionally, plant-derived essential oils are known to repel and combat pests through contact insecticidal and fumigant actions [Park *et al.* 2005]. However, uncontrolled concentrations of plant extracts can pose risks, emphasizing the need for precise knowledge of safe concentrations and practical administration methods [Nerio *et al.* 2010].

Moreover, detailed technical information crucial for the safe and effective application of these botanical extracts can often be found in patent documents [El Boukhari and Fatimi 2023c, 2023a, 2024b]. These documents provide comprehensive insights into the scientific innovations and methodologies employed, supporting regulatory processes at international, regional, or national levels [World Intellectual Property Organization 2024c]. Decisions on patent applications, which typically grant

a monopoly on the use of innovations for around 20 years upon approval, rely heavily on the thorough examination of these technical-legal documents [Fatimi 2022a].

In the interests of scientific and technical monitoring, this study aims first to report on the advances made over the last 10 years in innovation relating to biorepellents developed based on *Lamiaceae* derivatives. Next, we will review examples of patents relevant to the field of study to illustrate recent technologies. Thereby, the specific objectives of this study are to: (1) analyze trends in patent filings related to *Lamiaceae*-based repellents over the past decade; (2) identify key jurisdictions and applicants in this field; (3) examine the most common patent classifications to understand technological focus areas; and (4) review selected patents to highlight recent innovations in *Lamiaceae*-based repellent formulations and applications.

Material and metods

Databases and keywords

The patent databases The Lens and Google patents were used for the search and collection of patent documents [Google 2024, Cambia Institute 2024]. The keyword "repellent" was used for the search that looked at titles, abstracts, and claims of patent documents. The keyword search was combined with the search codes from the International Patent Classification (IPC) in order to isolate documents related to plants of the family *Lamiaceae* [World Intellectual Property Organization 2024b]. Indeed, specific codes are assigned to patent documents when applications are examined by intellectual property offices, depending on the technological fields concerned by the invention. The use of IPC search allows us to collect patents relating to the different plants used without having to write their respective names, which would be tedious and could lead to omissions due to a lack of correct spellings or synonyms [World Intellectual Property Organization 2024a].

Filter and relevant documents

The results were then filtered to include only patent documents, such as patent applications and granted patents, that were published between January 2014 and March 2024, in order to focus on recent innovations. Similarly, the analysis used data relating to publication dates, jurisdictions, classifications, and applicants. To illustrate recent developments in the field studied, we have summarized the description of five relevant granted patents. To choose the patents presented, we propose an evaluation grid of the importance of the patents based on their legal status, age, and the size of the simple and then extended family to which the patent belongs.

Results and discussion

Publication of patent documents

The number of patents filed globally in the area of *Lamiaceae*-based repellents indicates 72 patent documents presented as 16 granted patents and 56 patent applications. This number confirms rapid developments, environmental targets, and the pressing need for innovations in biorepellents since they offer several benefits for soil health and biodiversity. Figure 2 presents patent documents related to *Lamiaceae*-based repellents over the last ten years.

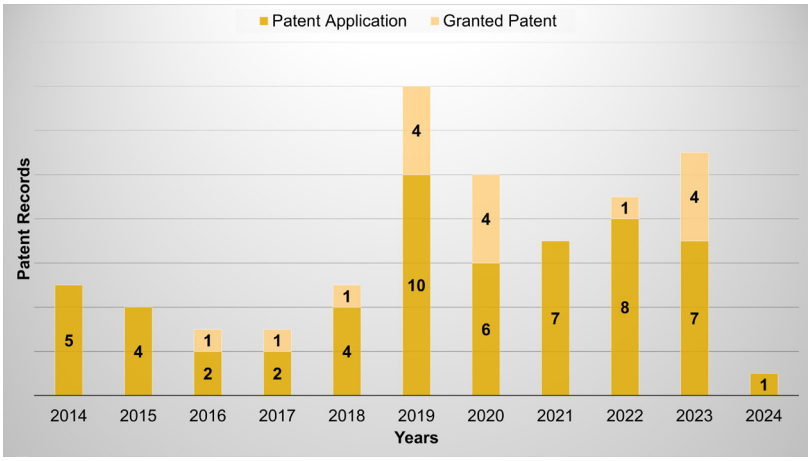

Fig. 2. Record of patent documents related to *Lamiaceae*-based repellents over last ten years.

The data covers a span of ten years (2014-2024) and includes both granted patents and patent applications. The number of granted patents shows variability from year to year. It started with no granted patents in 2014 and 2015, gradually increasing in subsequent years. There were peaks in 2019 and 2023, with four granted patents each. However, there were no granted patents in 2014 or 2021 and only one in 2017. The number of patent applications generally follows a similar trend to granted patents, indicating consistent interest and investment in intellectual property protection in this field. The highest number of patent applications was in 2019 with 10 patent applications, and the lowest were in 2016 and 2017 with 2 patent applications each. Total patent documents combine both granted patents and patent applications to give a comprehensive view of the total patent activity each year. The highest total was in 2019 with 14 documents, reflecting both a high number of applications and granted patents.

The data shows some variability from year to year, which could be influenced by factors such as research breakthroughs, regulatory changes, market demand, and competitive pressures. Peaks and dips in granted patents and applications indicate fluctuations in innovation activity and strategic filings. Over the decade analyzed,

there has been an overall increasing trend in patent activity, suggesting sustained interest and investment in developing *Lamiaceae*-based repellents. This long-term perspective is important for understanding the evolving landscape of patent protection in this specific technological area.

Patent jurisdictions

The data on patent filings related to *Lamiaceae*-based repellents over the past decade reveals distinct trends in jurisdictional preferences and strategic priorities among innovators and companies in this field (Fig. 3).

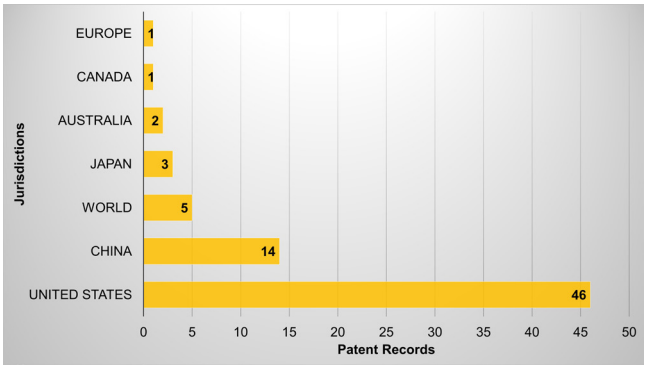

Fig. 3. Top jurisdictions where patents related to *Lamiaceae*-based repellents were filed over the last ten years.

Leading the pack by a significant margin is the United States, with 46 patent records. This dominance underscores the country's pivotal role in both innovation and commercialization of technologies utilizing *Lamiaceae* plants for repellent purposes. The high number of filings reflects robust intellectual property protection strategies and a competitive landscape conducive to innovation.

Following the United States is China, with 14 patent records, indicating substantial interest and investment in developing and patenting *Lamiaceae*-based repellents within the Chinese market. China's growing emphasis on intellectual property rights and its burgeoning domestic market for consumer products likely contribute to this significant number of filings. This suggests a keen focus on securing market share and protecting technological advancements in this specialized area.

The category labeled "World", representing international patent applications likely filed under the Patent Cooperation Treaty (PCT) through the World Intellectual Property Organization (WIPO), comprises five patent records. This reflects a strategic approach by global innovators to secure broad protection across multiple jurisdictions, highlighting the importance of global market access and regulatory compliance in the repellent technology sector.

In contrast, Japan, Australia, Canada, and Europe show lower numbers of patent records, ranging from one to three filings each. This suggests varying levels

of engagement or strategic priority in these regions compared to the United States and China. Despite lower numbers, these filings indicate ongoing interest and efforts to protect intellectual property rights and potentially explore market opportunities in these jurisdictions. Overall, the dominance of the United States in patent filings may be attributed to its robust research infrastructure, strong intellectual property protection laws, and significant market demand for natural pest control products. China's second-place position likely reflects its growing emphasis on innovation and the expansion of its domestic market for plant-based products.

Patent classifications

The International Patent Classification (IPC) is a classification system administered by the WIPO. It categorizes patent documents and technical literature into hierarchical groups and subgroups based on the technical features of inventions. Each IPC code represents a specific area of technology, allowing patent examiners, researchers, and industry professionals to easily identify and retrieve relevant patent information. Table 2 provides an example of the relevant IPC code in the areas of biocides, pest repellants or attractants, or plant growth regulators derived from *Lamiaceae* plants.

Table 2. Example of the IPC code: A01N65/22

IPC type	Code	Description
Section	A	Human necessities
Class	A01	Agriculture; forestry; animal husbandry; hunting; trapping; fishing
Subclass	A01N	Preservation of bodies of humans or animals or plants or parts thereof; biocides (e.g., as disinfectants, as pesticides or as herbicides); pest repellants or attractants; plant growth regulators
Group	A01N65	Biocides, pest repellants or attractants, or plant growth regulators containing material from algae, lichens, bryophyta, multi-cellular fungi or plants, or extracts thereof
Subgroup	A01N65/22	*Lamiaceae* or *Labiatae* (i.e., Mint family), such as thyme, rosemary, skullcap, selfheal, lavender, perilla, pennyroyal, peppermint, or spearmint

The IPC code A01N65/22 falls under Class A01 (agriculture; forestry; animal husbandry; hunting; trapping; fishing) and Subclass A01N (i.e., preservation of bodies of humans or animals or plants or parts thereof; biocides, pest repellants, or attractants; plant growth regulators). It belongs to Group A01N65, which includes biocides, pest repellants/attractants, or plant growth regulators containing materials from algae, lichens, bryophyta, multi-cellular fungi or plants, or extracts thereof. Specifically, Subgroup A01N65/22 focuses on inventions utilizing materials from the *Lamiaceae* or *Labiatae* family (commonly known as the Mint family). This includes plants such as thyme, rosemary, skullcap, selfheal, lavender, perilla, pennyroyal, peppermint, or spearmint, which are known for their biological activities and potential applications in

pest control, plant growth regulation, or other related fields [El Boukhari and Fatimi 2023b].

Concerning repellents based on the *Lamiaceae* family's plants, the patent classifications suggest that there are four main IPC groups (Fig. 4). Firstly, in group A01N65, which specifically covers biocides, pest repellants, or attractants derived from natural sources, including plants, several subgroups show notable patent activity. Subgroup A01N65/22 leads significantly with 72 documents, emphasizing a robust focus on inventions utilizing plants from the *Lamiaceae* family (such as thyme, rosemary, and lavender) known for their pesticidal properties. This indicates a strong interest and investment in developing natural and botanical-based solutions for pest management and related applications. Additionally, group A01P17, focusing on plant growth regulators, also shows substantial activity, with 19 documents in subgroup A01P17/00. This suggests ongoing innovation in technologies aimed at enhancing plant growth and productivity through regulatory methods. Other groups, like A01N25 and A01N27, which cover broader aspects of pesticides and biocides, demonstrate varying levels of patent activity across their respective subgroups [Fatimi, 2022b, Hafiane and Fatimi 2022]. For instance, A01N25/04 and A01N25/34 focus on specific formulations or methods of application for pesticides, indicating continuous efforts to optimize pest control strategies.

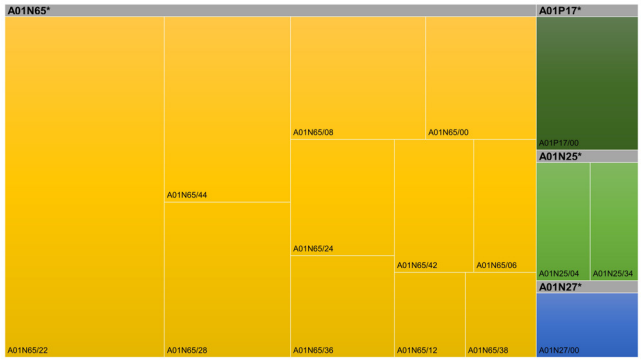

Fig. 4. Top IPC codes of published patents related to *Lamiaceae*-based repellents over the last ten years. The area of each IPC code is proportional to the obtained patent record. *The IPC codes in bold denote the 4 main IPC-groups.

Overall, these IPC classifications not only categorize patent documents but also provide valuable insights into technological trends and innovations within the fields of agriculture, pest management, and plant science. The data highlights the diversity of approaches - from natural botanical extracts to synthetic biocides - to addressing challenges related to pest control and plant health. These insights are crucial for researchers, businesses, and policymakers seeking to understand and capitalize on advancements in agricultural technologies and sustainable pest management practices.

Patent applicants

Based on the findings obtained through this patent analysis in relation to *Lamiaceae*-based repellents, patent applicants could be categorized by type and their associated document counts (Fig. 5).

Fig. 5. Leading patent applicants related to *Lamiaceae*-based repellents.

Five applicants lead the studied field. Avon Products Inc. (London, United Kingdom), Insight Pharmaceuticals Corp. (Memphis, TN, United States), Operation Organic Llc. (Feasterville Trevose, PA, United States), and Panteros Trading Pty Ltd. (Toowoomba, Australia) are categorized as companies, and each has three documents associated with them. Companies with multiple documents typically indicate involvement in diverse activities such as product development, regulatory compliance, legal matters, or operational management across various projects or divisions. Furthermore, Auburn University (Auburn, AL, United States), which is also categorized as a university, has three documents listed. Universities often generate a significant amount of documentation related to research projects, academic programs, administrative processes, and compliance with educational regulations.

On the other hand, two documents are associated with the companies Aspen Healthcare Solutions Llc. (Chicago, IL, United States) and Bio-Up Mimetic Technologies Inc. (La Habra, CA, United States). Companies in this category likely span different sectors such as healthcare solutions, technology development, biotechnology, and international collaboration, requiring documentation for regulatory compliance, business operations, and project management. Natural persons (Atley Bettina, Huggins John, and Laing David) have two documents each associated with them. Natural persons typically include sole proprietors, consultants, or individuals engaged in professional activities that require documentation for contractual purposes, regulatory compliance, or personal transactions.

The distribution of document counts among these entities reflects a range of organizational sizes, types, and operational complexities. Firstly, entities like Avon Products Inc., Insight Pharmaceuticals Corp., Operation Organic Llc., Panteros Trading Pty Ltd., and Auburn University demonstrate substantial documentation needs, likely due to their extensive operations, regulatory requirements, and multi-faceted engagements. However, individuals such as Atley Bettina, Huggins John, and Laing David, along with smaller companies like Aspen Healthcare Solutions Llc. and Bio-Up Mimetic Technologies Inc., show moderate document counts, suggesting focused operations or specific project involvements. Moreover, the presence of entities with different document counts (ranging from two to three) underscores the variability in operational scale, regulatory obligations, and project diversity across sectors represented.

Relevant granted patents related to repellents based on the *Lamiaceae* family's plants

The patent rankings typically offered by the databases used in this work are based on the query match score used in Elasticsearch [Apache Software Foundation, 2024]. This match score increases, for example, if the keywords in the search query are cited often in the document and also when those keywords are in the document title. On the other hand, this match score is reduced for a search term if the term is common to all documents and therefore less specific than other terms. To improve the process of choosing relevant patents, we propose a grid for evaluating the importance of patents based on their relevance, legal status, age, simple family size, and then the extended family size to which the patent belongs. Indeed, an active patent whose technology is still under the monopoly of the patent owner is of greater value than a patent whose

Table 3. Patent suitability assessment grid

Criterion	Value	Score
Relevance grad	First quartile	3
	Second quartile	2
	Third quartile	1
	Last quartile	0
Legal status	Active / Patented	3
	Inactive / Pending	2
	Unknown / Discontinued	1
	Expired	0
Patent age	Less than 6 years	3
	Between 7 and 12 years	2
	Between 13 and 19 years	1
	More than 20 years	0
Simple family size	More than 11	3
	Between 6 and 10	2
	Between 2 and 5	1
	Equal to 1	0
Extended family	Difference between extended and simple family size > 10	3
	Difference between extended and simple family size $\in$ [6,10]	2
	Difference between extended and simple family size $\in$ [1,5]	1
	Difference between extended and simple family size = 0	0

term of protection has expired or a patent that is pending (Tab. 3). In addition, since the legal protection of patents generally lasts for 20 years from the filing date of the patent application, a young patent is of greater value than a patent that is close to or exceeds 20 years of age. In addition, in patent law, the concept of family concerns two levels. First, the simple family represents the set of patent applications filed in several countries to protect the same invention by the same applicant or his successors. Secondly, the extended family includes, in addition to the applications of the simple family, all applications linked by the same previous priority application. Thus, the value of a patent is all the greater when the size of the simple and extended family to which it belongs is large. The following table shows the patent evaluation grill that we propose and use.

Once this grid has been applied to the patents issued as a result of our research, the documents that accumulate a score greater than or equal to 10 are presented (Tab. 4) and discussed in the following.

Table 4. Relevant granted patents related to repellents based on the *Lamiaceae* family's plants

Patent number	Publication	Title	Family size		Reference
			simple	extended	
US9717237B2	2017	Extended release insect repellant or fragrance compositions	23	23	Lull *et al.* [2017]
US10321678B2	2019	Composition containing a cellulose derived capsule with a sunscreen	27	45	Cohen [2019]
US10701942B2	2020	Insect repellants and methods of making and using the same	2	2	Huggins [2020]
US10863738B2	2020	Protective coating for use on plant foliage, branch and trunk related application	2	2	Malki [2020]
US11641963B2	2023	Beverage holder and method	2	2	Rollett [2023]

The patent US9717237B2, published in 2017, describes an insect-repellent composition that allows a sustained release of active products over time. This innovation is possible through the combination of a modified hydrophilic cross-linked silicone elastomer and an acrylic rheology modifier (or gelling agent), resulting in a synergistic improvement in the repellent release time that becomes longer than the release time of the same components separately used. The compositions are typically in the form of a clear or translucent gel [Lull *et al.* 2017]. The essentially anhydrous formula includes a polyol (e.g., glycerin), ethanol, and an insect-repellent oil. A variant of this composition can also be used for the sustained release of fragrances, incorporating fragrance oils (e.g., limonene) instead of repellent oils (Tab. 5). Various oils can be used, such as those produced from *Lamiaceae* plants (e.g., lavender, marjoram, mint, lavandin, oregano, rosemary, sage, etc.). Based on the results of Table 5, the inventive gel retained 36.8% of limonene after 24 hours, which was much higher than expected based on the individual effects of the components. The chemistry

Table 5. Results of experiment assessing fragrance retention time as a function of fragrance compositions over a 24 hours period, as determined by gas chromatography analysis of headspace. The fragrance oil in each of the formulations was limonene [Lull *et al*. 2017]

Fragrance compositions	Retention (24 hours vs. initial)
Inventive gel	36.8%
Gel A	3.6%
Gel B	1.3%
Hydro-alcoholic EDT spray	4.9%
Gelled hydro-alcoholic EDT spray	0.3%

behind this invention involves the interaction between these components to create a matrix that slowly releases the fragrance or insect repellent over an extended period. The hydrophilically modified silicone elastomers and acrylic rheology modifiers likely form a complex network that entraps the fragrance molecules, allowing for their gradual release [Tian *et al.* 2018]. Lull *et al.* confirmed then that these fragrance oils could therefore be used for aesthetic benefits as a fragrance or for functional benefits as a repellent. This composition is designed to be applied to human skin, ensuring even distribution and prolonged effectiveness.

Cohen's patent (US10321678B2) published in 2019 describes a formulation that protects against solar rays coupled with cellulose-derived capsules, which encapsulate insect repellents [Cohen 2019]. Repellents can be synthetic or plant-based, such as lemongrass or rosemary oil. The size of the capsules (between 300 and 700 nm in diameter) allows them to be easily integrated into everyday cosmetic products, such as shampoos, creams, gels, and lotions. On the other hand, it ensures a uniform spreading of the encapsulated products and thus allows good protection of the treated surface. The proposed formulation by the inventor also contains surfactants and film-forming

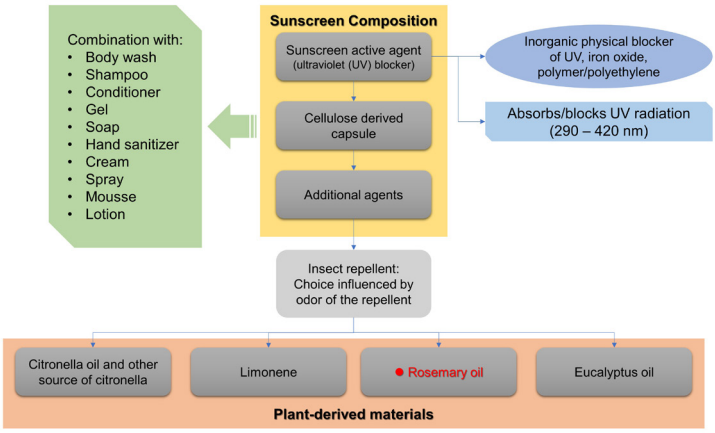

Fig. 6. Main elements and relationships in the invented sunscreen composition and the potential additional insect repellent agents according to the patent US10321678B2 [Cohen 2019].

agents to improve adhesion and efficacy. When the invention is used as sunscreen, tests show that even after activities like swimming or sweating, the capsules remain evenly distributed on the skin, providing increased protection without the greasy feeling felt when using traditional sunscreens. Figure 6 summarizes the main elements and relationships in the sunscreen composition and the potential additional insect repellent agents, along with the products it can be combined with.

In 2020, the inventor Huggins invented a novel plant-based insect repellent [Huggins 2020]. The patent US10701942B2 describes an insect repellent comprising a mixture, in an aqueous phase, of effective amounts of vegetable essential oils produced from neem, peppermint, vanilla, lemongrass, and lemon eucalyptus. The specific concentrations of each oil are defined, with possible variations. The invented formulation has the advantage of not containing synthetic insecticides or added alcohol. The manufacturing method described in the patent involves mixing the oils with water and applying the composition to a surface to repel insects. Thanks to Huggins, different formulations of the invention have been tested and proven effective against insects, including mosquitoes and several types of midges. Figure 7 summarizes the relationships and structure of the insect repellant invention, including its natural components, key features, and methods of making and using the repellant.

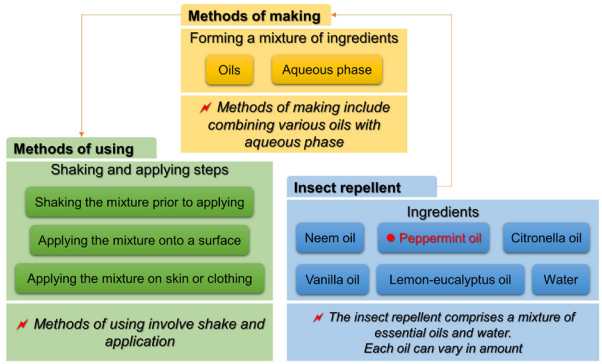

Fig. 7. Diagram showing the relationships and structure of the insect repellant invention through the patent US10701942B2 [Huggins 2020].

Plants need to be protected from environmental stresses that damage them [Hafiane and Fatimi 2022]. The sources of this stress can be of the abiotic type, such as strong gusts of wind, large and rapid changes in temperature, and the sun's rays, or of the biotic type, such as microbes, insects, and rodents. To meet this objective, Malki's patent (US10863738B2), published in 2020, describes a protective coating formulated to be applied to different plant parts, namely leaves, branches, and trunks [Malki 2020]. The aqueous formulation of this invention comprises one or more essential oils (e.g., peppermint, rosemary, etc.) that are insect repellent. The formulation also contains a rodent-repellent oil (e.g., castor oil). The majority component of the

formulation (between 89 and 91%) is a paint powder that protects against abiotic stresses by reflecting the sun's rays and retaining heat. The binder that unites the paint powder and the repellent oils is methylcellulose, treated with an acid and methyl chloride (Fig. 8).

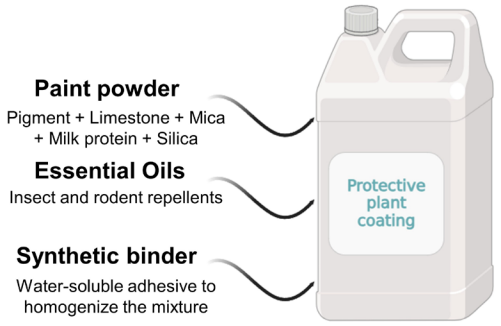

Fig. 8. Component of the invented protective coating through the patent US10863738B2 [Malki 2020].

Three years later, an invention by Rollett claims a cup holder adapted to be attached to different beverage containers [Rollett 2023]. The cup holder can be made of cardboard and has an annular wall with an internal surface designed to adhere by friction to the outer surface of the container. According to patent US11641963B, an outer part of the wall diffuses a safely edible pest repellent. The repellent, composed of water and a plant compound (e.g., peppermint extract), can be placed in or around the wall. Figure 9 shows a perspective view of an invented beverage holder. The descriptions of the numbers are as follows: 100 is the beverage holder. It is the main component designed to fit around a beverage container. It can provide insulation and may include a pest-repellent feature. 105 is the outer side surface. It refers to the exterior surface of the beverage container that the beverage holder (100) engages

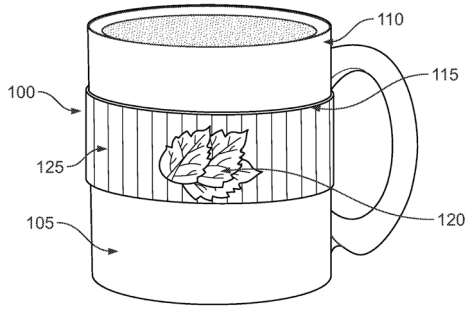

Fig. 9. Beverage holder with pest repellent features and insulating layer according to the invention through the patent US11641963B [Rollett 2023]. The beverage holder's components are described as follows: (100) beverage holder body; (105) outer contact surface; (110) beverage container; (115) structural support layer; (120) pest repellent layer; (125) treated outer surface.

with or covers. 110 is the beverage container. It is the container holding the beverage, such as a cup or mug, around which the beverage holder (100) is placed. 115 is the supporting layer. This layer of the beverage holder (100) provides structural support and is made from materials like cardboard, chipboard, or other insulating materials. 120 is the pest repellent portion. This part of the beverage holder (100) contains or is treated with a pest repellent composition to deter insects and pests from the beverage area. 125 is the outer surface. It is the external surface of the beverage holder (100), which can be coated or infused with the pest repellent composition to provide the repellent effect [Rollett 2023].

Conclusion

The data reveals a dynamic landscape of patenting activity related to *Lamiaceae*-based repellents over the past decade. While there are fluctuations from year to year, overall there is a trend towards increasing patent applications and granted patents, particularly peaking in 2019. This indicates ongoing innovation and investment in developing and protecting technologies using *Lamiaceae* plants for repellent purposes. Overall, the data underscores a dynamic global landscape for *Lamiaceae*-based repellent patents, with distinct concentrations in the United States and China, strategic international filings, and varying levels of activity across other key regions. These insights are crucial for stakeholders in navigating intellectual property strategies, market expansion plans, and competitive positioning in the evolving field of botanical-based repellent technologies. IPC codes play a crucial role in patent examination, classification, and information retrieval within the global patent system. They provide a standardized way to organize and search for patent documents based on technological content, facilitating innovation, patent drafting, and strategic patent portfolio management. By using IPC codes like A01N65/22, stakeholders can efficiently navigate the vast landscape of intellectual property and technological advancements related to *Lamiaceae*-based repellents and other innovative fields. The analysis of patent applicants provides a nuanced view of document management needs across various types of entities, highlighting their organizational complexities, operational scopes, and regulatory environments. Finally, our analysis indicates that while *Lamiaceae* plant-based repellents have significant potential in agriculture, they are also finding innovative applications in personal care, environmental protection, and consumer products. The findings broaden the scope of potential markets and applications for the technology.

As implications and trends, this study emphasizes the increasing relevance of natural pest management as a sustainable, eco-friendly approach to reducing synthetic pesticide usage, with a particular focus on biorepellents derived from the *Lamiaceae* family. The findings underscore how plant-based repellents, enriched with bioactive components like linalool, carvacrol, and thymol, provide effective pest control while minimizing environmental impact. Insights from patent analysis reveal that

integrating these *Lamiaceae*-derived compounds into pest management strategies supports biodiversity conservation and reduces dependency on chemical solutions, benefiting both agriculture and the public health sectors.

Additionally, the confirmed efficacy of botanical extracts in deterring a wide spectrum of pests reinforces their promise as natural and effective substitutes for synthetic repellents. The bioactive compounds within these plants act by disrupting pest sensory mechanisms, offering prolonged protection with significantly lower toxicity to humans and other non-target species. Moreover, the natural biodegradability of these botanical compounds mitigates the risk of environmental chemical accumulation, enhancing their suitability for sustainable pest management. This study highlights the strong potential of *Lamiaceae*-derived botanical extracts to address pest control challenges across agricultural and residential settings, advancing eco-friendly practices adaptable to diverse applications.

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