TECHNOLOGY PROSPECTING IN MYCOPIGMENTS

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ABSTRACT

Since prehistoric times, humans have been concerned with identifying and protecting their creations. With the advance of technology and mass production, the need arose for a formal intellectual property system to protect inventions and processes. Mycopigments have emerged as safe alternatives to synthetic pigments, attracting consumer preference and industrial interest. These pigments are produced under controlled conditions, with high productivity and without seasonal limitations, due to the genetic diversity of microorganisms. Fungi produce pigments in response to environmental conditions, offering advantages such as various colors, high yields, and ease of optimizing production. In addition, they have biological activities such as antimicrobial, antiproliferative, metal chelating, and antioxidant properties, making them economically viable and sought after by industry. This study aims to search for prior art in three patent databases to identify the number of technologies involving the production and application of mycopigments. To explore technological prospects for micropigments, patents filed in three databases were analyzed: INPI, Espacenet, and Patentscope. Records related to the production and application of fungal pigments were identified, focusing on filamentous fungi. The results reveal a growing number of international patents, especially in countries like Denmark, the United States, and Japan, while Brazil's participation remains modest, albeit with promising potential.

Keywords: *Intellectual property, International patent classification, Filamentous fungi, Secondary metabolites, Natural dyes.*

I. INTRODUCTION

In the 6th century BC, the most rudimentary notion of protection for innovative authorship emerged; however, it was only around the year 1400 that the discussion about what constituted a patent entered the daily life of society, arising from the need for each ruler to establish the most valuable and profitable arts in his territory, or even attract those that did not exist there [1][2].

The concept of a patent, more or less as we know it today, came about in 1421 in Florence, Italy, when the engineer Felippo Brunelleschi developed a device for transporting marble. In 1449 in England, master glassmaker John de Utynam received a 20-year monopoly on a process for producing stained glass from King Henry VI. However, in 1474 in Venice, the world's first patent law was enacted [3].

Venice was sustained through trade, through buying and selling transactions. To protect those who produced new things in that region, laws protected anyone who brought or developed new works there. It was an economic issue, a tug-of-war with competitors [4].

The so-called principle of territoriality governed patent protection at that time and to this day. If someone established themselves in Venice to produce something unprecedented there, they gained protection and the right to exploit their invention for a set period. This period varied from state to state, but the principle of exclusivity was the same. The industrial property protection associated with the patent allowed the manufacturer to invest safely in their business, as there was no risk of their invention being copied by third parties. Thus, assured of their rights, the patent holder, throughout history, invested their capital in technology and research, driving the development of the global economy. This guarantees that the patent remains intact today [4] [5].

In 1622, King James I granted a patent for producing soap in England and Scotland, where he also reigned. In exchange for the monopoly, the manufacturer undertook to give a percentage of the profits to the royal treasury. In 1623, James I issued the Statute of Monopolies to regulate the issuing of patents [3].

1790 England produced the second known Patent Act, with a protection concept similar to current legislation. It established that the inventor should describe their invention so that the knowledge could serve society [3]. In other words, with the patent, he guaranteed exclusivity in the manufacture. However, he had to make his technology available for others to develop new creations through a detailed description of methods and tests. At the end of the exclusivity period provided for in the patent, the innovation could be exploited by others, improved, in a continuous movement of renewal [4].

In 1791, France, fresh from the revolution (1789), created its Patent Law and this event signaled to the whole world that there was a certain uniformity of interpretation in the definition: a temporary property title granted by the state, and backed by the courts, which authorized the inventor or author to prevent third parties, without his prior authorization, from carrying out any acts relating to the protected matter, such as manufacturing, marketing or importing [4].

Brazil underwent major economic transformations during the second half of the 19th century. These changes continued the previous period, when Brazil was elevated to the Viceroyalty of Portugal and gained political and economic emancipation from the metropolis. Evidence of these transformations is the 1808 charter, which revoked the 1785 charter of Queen Maria, which prohibited the establishment of factories in Brazil. The following year, 1809, the country's first patent law was passed, regulating, albeit in a simplified manner, the patent registration process in the country. This law demonstrated the need for regulations that would instruct the rights and duties of inventors [2].

Chapter VI of Dom João VI's charter of April 28, 1809, states:

> "Since, conveniently, the inventors and introducers of some new machine and invention in the arts enjoy the exclusive privilege, in addition to the right they may have to the pecuniary favor, which I am served to establish for the benefit of industry and the arts, I order that all persons who are in this case present the plan of their new invention to the Royal Board of Trade; and that the latter, recognizing its truth and foundation, grant them the exclusive privilege for fourteen years, being obliged to manufacture it afterwards, so that at the end of this period, the whole nation may enjoy the fruit of this invention. I also order that an exact review be made of those that are currently granted, making them public in the manner determined above and revoking all those that by false allegation or without well-founded reasons have obtained similar concessions [6]."

Brazilian Emperor Dom Pedro I promulgated a law on August 28, 1830, that addressed aspects of patent granting; however, it was still an almost telegraphic attempt to deal with the matter. It fell to Dom Pedro II to regulate the granting of patents in the Empire broadly through Law 3,129 of October 14, 1882. It was significantly more robust than the Magna Carta of 1809 and Dom Pedro I's essay—the latter differed, among many other things, in that it included a fee for patents, which until then had been granted free of charge. [4]

Dom Pedro II's law was drafted at the same time that the countries most involved in the patent debate were concluding an international meeting to resolve outstanding details. The first joint meeting took

place in Paris in 1880, with the intention of discussing international legislation protecting industrial property. Eleven signatory countries were part of the Convention. Brazil was included the following year, demonstrating its place on the international stage in industrial property matters and inaugurating a new era in its national legislation. From that moment on, the country became part of a group of nations committed to ensuring ownership of their creations worldwide [4][2].

After three years of debate, on March 20, 1883, fourteen countries, including Brazil, signed the Paris Convention, the first joint international agreement on patents, trademarks, and industrial designs, which effectively entered into force in 1884. [3][7]

However, Brazil had already approved the signing of a final report of this Convention on January 29, 1881, two years before the general signing of the treaty. Thanks to this "early" signature, Brazil could sign Law No. 3,129 on patents on October 14, 1882. The law was created not solely due to the changes imposed by the Convention, but rather due to the absolute need to detail the application process. [2]

The law of October 14, 1882, is the most significant piece of 19th-century patent legislation, as it details some of the points necessary for granting privileges and regulating the system. The legislation, proposed by Brazil in 1882, also demonstrated the country's interest in developing its industry, investing in technology by encouraging inventors, improvers, and introducers of innovations, and with a capitalist vision of increasing production and profits [2].

Brazil signed the Patent Cooperation Treaty (PCT) 1970, the most important international cooperation treaty. It provided that a single patent application became legally effective in the countries that signed the treaty and designated by the applicant, simplifying the process of obtaining the document abroad [3].

It is worth mentioning that the search for prior art is a crucial stage in verifying and protecting the originality of a technology/patent. This process involves defining keywords that align with the topic of interest, selecting patent databases, and analyzing the results found. Based on the documents discovered, avoiding legal conflicts and validating and protecting the projects generated is possible.

In the 21st century, there has been a growing search for natural products to replace synthetic compounds, due to their association with allergies and poisoning. It is necessary to look for natural alternatives such as those derived from plants, animals, and microorganisms [8][9].

Pigments of natural origin are considered safer options compared to synthetic pigments, attracting consumer preference and arousing industrial and research interest. Interestingly, pigments of microbial origin, mainly from bacteria and fungi, have gained greater relevance due to the ability of these organisms to develop under controlled conditions and with limited resources, as well as their ease of manipulation, resulting in high productivity without any seasonal limitations [10].

Furthermore, genetic diversity in microorganisms has been associated with their ability to produce a variety of pigments with high yields. Generally, most fungi produce pigments to fulfill their ecological functions and respond to prevailing environmental conditions. Fungal pigment production offers several advantages over other natural sources, including the ability to produce a range of soluble pigments, high production yields, and relative ease of production optimization. Fungal pigments also exhibit diverse biological activities, ranging from antimicrobial to antiproliferative, metal chelating, and antioxidant properties. All this makes fungal pigments economically viable and industrially sought after [11][12].

This work, therefore, aimed to carry out a prior art search on the subject of pigments produced by filamentous fungi on the INPI [13], Espacenet [14], and Patentscope [15] platforms.

II. METHODOLOGY

Patents were identified on INPI's national patent database, Espacenet, and Patentscope, analyzing patent records related to the keywords "pigments" and "filamentous fungi" or "fungal pigments" or associated with the IPC (*International Patent Classification*) code related to the topic.

According to the WIPO (*World Intellectual Property Organization*) [16], IPC is a hierarchical system of language-independent symbols for classifying patents and utility models according to the different technological areas to which they belong.

The following data was recorded: patent publication date, patent applicant, database registration code, patent title, and code of related patent documents. The search was carried out between October 2024 and July 2025.

III. RESULTS AND DISCUSSIONS

Only one result was generated when using the keywords in the advanced search mode on the INPI. This is a patent filed in 2013 and accepted in 2021, with IPC code D06P 1/34, which relates to dyeing or printing textiles using natural dyes.

According to the description, the patent describes innovative ways of using pigments from pigment-producing fungi, particularly *Fusarium oxysporum*, for dyeing fabrics and plastics. The procedures described in this invention are used to dye plastic materials red and to dye textile materials colors ranging from purple to blue. However, when searching for the IPC code corresponding to dyes of natural origin prepared from natural sources (C09B 61/00), 132 results were obtained, six of which, including those obtained with keywords, are consistent with the topic (Table 1). It was noted that, although the patent application was made for Brazilian territory, there were requests from Denmark and the Netherlands.

Table 1. Patents found in the INPI database related to fungal pigments.

Code	Title	Applicant
BR 10 2023 021988 8 A2	Filamentous fungus as a natural source of red pigment and its application in the dyeing of natural and synthetic fibers	Catholic University of Pernambuco (BR/PE)
BR 13 2021 017911 1E2	Production process and application of pigment from the fungus *Fusarium oxysporum*	Federal University of São João Del Rei (BR/MG) / State University of Campinas (BR/SP)
BR 11 2021 008691 9 A2	A new class of pigments in Aspergillus	Danmarks Tekniske Universitet (DK)
BR 10 2017 024884 4 A2	Microbial pigment production process for use in dyeing textile fibers and paper	Catholic University of Pernambuco (BR/PE) / Federal Rural University of Pernambuco (BR/PE)
BR 10 2013 027036 9 B1	Dyeing processes for fabrics and plastics using fungal pigments	Federal University of São João Del Rei (BR/MG)
PI 0215469-2 A8	Improved method for producing lycopene by fermentation of selected strains *of Blakeslea trispora*, formulations, and uses of the lycopene obtained	DSM IP assets BV (NL)

Minas Gerais and Pernambuco filed two patents in 10 years, while the state of São Paulo had one patent application (Figure 1).

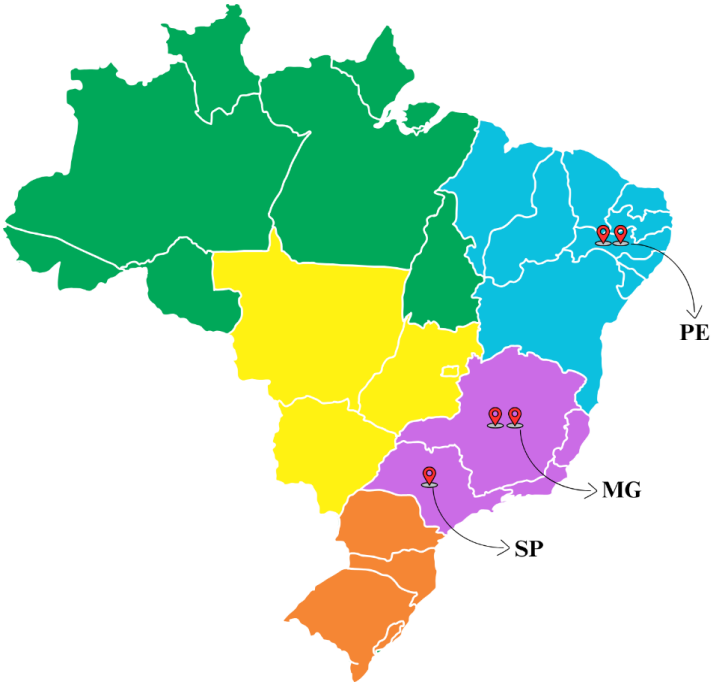

Figure 1. Brazilian states applying for patents related to fungal pigments in the INPI database. (PE) Pernanbuco, (MG) Minas Gerais, and (SP) São Paulo.

The EspaceNet search platform generated forty-eight results when searching for "*pigments and filamentous fungi or fungal pigments*". The search for these terms was restricted to their use in the title or abstract of the patent.

The search results describe processes involving mycopigments (Table 2). Among these results, it was noted that patents were applied for in different countries. There were eleven global applications (code WO) and nine for European countries (code EP). There were also nine patents filed in the United States (US), six in Japan (JP) and China (CN), four in Canada (CA), two in France (FR), Denmark (DK) and Belgium (BE) and one patent in Russia (RU), Portugal (PT), Spain (ES), Germany (DE), Brazil (BR) and Austria (AT).

Table 2. Patents related to fungal pigments were found in the Espacenet database.

Code	Title	Depositor
ATE551402T1 CN101970580A DK2262862T3 EP2262862A2 EP2262862B1 US2011250656A1 WO2009026923A2 WO2009026923A3 WO2009026923A4 WO2009026923A8 WO2009026923A9 BR112021008691A2	Production of Monascus-like azaphilone pigment	DTU Technical University of Denmark [DK]; Mapari Sameer's [DK]; Meyer Anne's [DK]; Frisvad jens c [DK]; Thrane ulf [DK]
CA3118617A1 CN113166555A EP3877466A1 JP2022512957A US2022002551A1	A novel class of pigments in Aspergillus	Univ danmarks tekniske [DK]

WO2020094830A1		
BE1031452A1 BE1031452B1 WO2024194372A1	Process for the production of active biomolecules such as pigments, UV filters, antioxidants, and anti-radical substances by solid fermentation of a fibrous substrate	Novobiom [BE]
US10479906B2 US2017081540A1	Use of fungal pigments from wood-staining fungi as colorants in wood finishes and paints	Oregon State Univ [US]
FR2830757A1 FR2830757B1	Composition for skin coloration, especially artificial tanning, comprises pigments obtained by extracting a Monascus fungal culture with an organic or aqueous-organic solvent.	Oreal [FR]
CA3062518A1 CN110914443A CN110914443B DE202018006762U1 DK3622081T3 EP3622081A1 EP3622081B1 EP3909954A1 ES2886236T3 JP2020518267A JP7264826B2 PT3622081T US11427843B2 US2020165645A1 WO2018206590A1	Process for producing an azaphilone in Talaromyces atroroseus	Univ danmarks tekniske [DK]
EP4499807A1 JP2025511344A WO2023187100A1	Isolated Fusarium solani IIA and its use for dyeing substrates	Vtl gmbh [AT]
CA2828121A1 CA2828121C EP2683533A1 EP2683533A4 US2015033480A1 WO2012119228A1 WO2012119228A4	Wood coloring with fungi and the treating process	Ang dian-qing [CA]; Gignac manon [CA]
CN115215902A CN115215902B	Water-soluble red edible fungal pigment with anti-inflammatory activity, as well as preparation method and application thereof	Chengdu inst biology cas
RU2156691C1	Wood bleaching process	Ooo npf diehlektrik
JP2014109032A JP6147170B2 US2014152748A1 US9090758B2	Phase change ink comprising modified naturally-derived colorants	Xerox corp

When analyzing the PATENTSCOPE database, eighty-seven results were generated from the search for "*fungal pigments*", of which fifteen patents used fungal pigments in their description (Table 3). Some results coincided with those found on ESPACENET. This is likely because both platforms share the part of the database referring to international applications made via the PCT (*Patent Cooperation Treaty*). It is worth mentioning that it was possible to observe that the country that filed the most patents in the last 25 years was Denmark, with four patents (Figure 2).

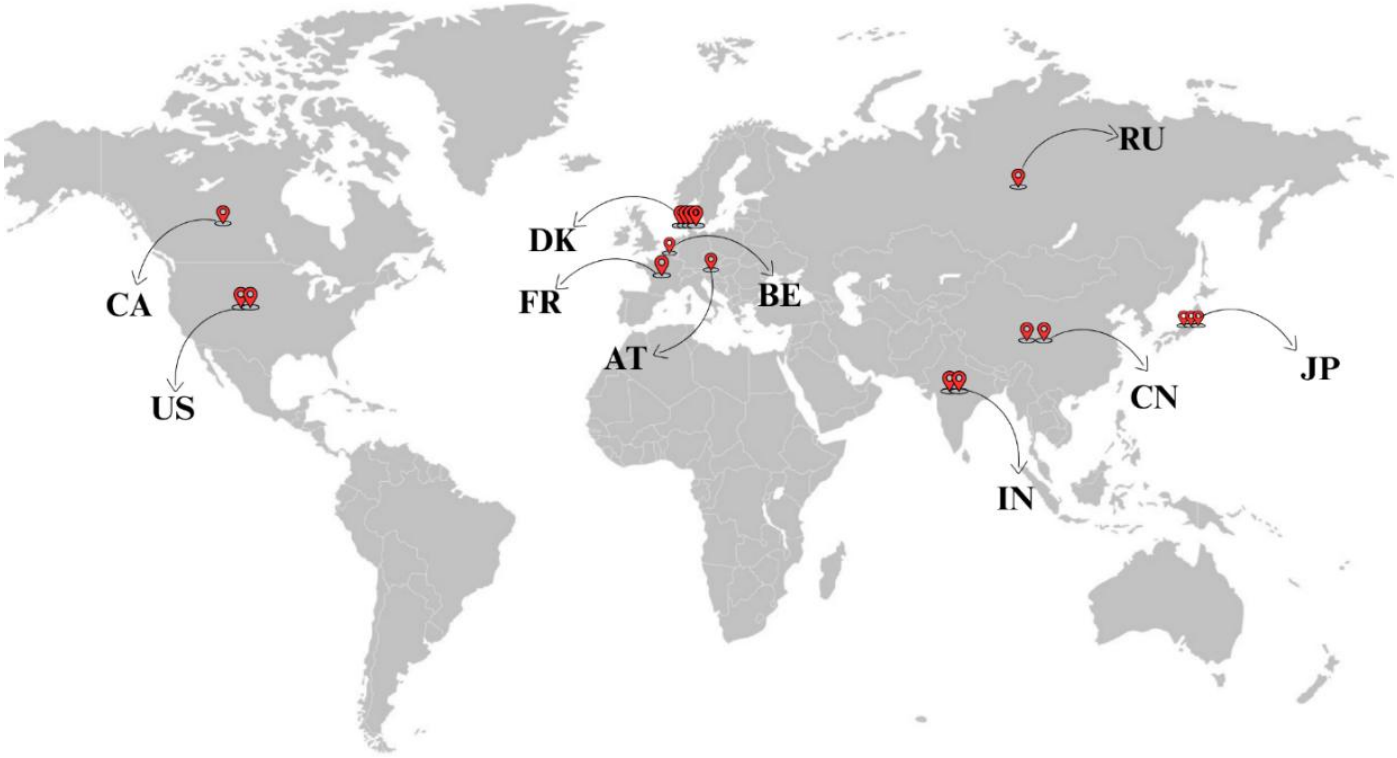

Figure 2. Countries applying for patents in Patentscope (CA) Canada, (US) United States, (AT) Austria, (FR) France, (DK) Denmark, (BE) Belgium, (RU) Russia, (IN) India, (CN) China, and (JP) Japan.

Table 3. Patents found in the Patentscope database related to fungal pigments.

Code*	Patent Title	Applicant
20170081540	Use of fungal pigments from wood-satinizing fungi	Oregon State University [US]
02156691	Wood bleaching process	Obshchestvo s ogranichennoj otvetstvennost'ju "NPF Diehlektrik" Общество с ограниченной ответственностью "НПФ Диэлектрик" [RU]
112778797	Method for extracting natural green pigment in *Metarhizium anisopliae*	Anhui Agricultural University [CN]
2014109032	Phase change ink comprising modified naturally-derived colorants	Xerox Corp [JP]
WO/2023/187100 4499807	Isolated *Fusarium solani* IIA and its use for dyeing substrates	VTL GMBH [WO] [EP]
202211063268	A method of processing a psychrotolerant fungus for production of cold-active pigments under temperature influence	Graphic Era (Deemed to Be University) [IN]
WO/2024/194372	Process for the production of active biomolecules such as pigments, UV filters, antioxidants, and anti-radical substances by solid fermentation of a fibrous substrate	NOVOBIOM [WO]
2830755 2830757 2830756	Composition for skin coloration, especially artificial tanning, comprises pigments obtained by extracting a Monascus fungal culture with an organic or aqueous-organic solvent	OREAL [FR]
3877466 WO/2020/094830	A novel class of pigments in *Aspergillus*	Univ Danmarks Tekniske [EP] [CA] [WO]

3118617 20220002551 113166555 3622081 WO/2018/206590 3062518 201947049679 20200165645 3622081 110914443	Process for producing an azaphilone in *Talaromyces atroroseus*	Univ Danmarks Tekniske [DK] [CN] [US] [IN] [CA] [WO]
WO/2009/026923 2262862	Production of *Monascus*-like azaphilone pigment	DTU Technical University of Denmark [WO] [EP]
4456/CHE/2011	Process of extracting yellow pigment from *Thermomyces sp*	Tamil Nadu Agricultural University [IN]
2683533 WO/2012/119228 2828121 20150033480	Wood coloring with fungi and the treating process	FPINNOVATIONS [EP] [WO] [US] [CA]
3909954	Unique processes yielding a novel class of compounds in *Talaromyces atroroseus*	Univ Danmarks Tekniske [EP] [DK]

*In the table, the term "code" is not the patent, but a distinction given by the patentscope.

From the observations, it emerged that developing a food product with direct application of the fungal pigment is an area that deserves to be explored. In this sector, several studies have looked at using mycopigments in food and drink, especially those colored by fungi of the *Monascus* genus. In addition to adding color to the food, these pigments perform various bioactive functions, further increasing their positive influence on those who consume them.

IV. CONCLUSIONS

The search for precedents is a great tool that not only allows technologies to be mapped and monitored over a given period, but also serves as a point of reference for identifying countries where a particular technology will be better accepted, which areas are more targeted, whether there are any existing processes, and how this can interfere with the development of a new product.

Throughout this work, Brazil is not yet a major player in the fungal pigment sector, but it has great potential in this area, which justifies greater investment in research in this field of knowledge.

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