

Pyroligneous extracts with therapeutic action: A technological prospect

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The Pyroligneous extract is a product from the combustion of plant biomass with applications in the fields of health, industrial chemistry, and agriculture. The discovery of new molecules with therapeutic potential and of natural origin continues to be one of the great challenges for research centres around the world. The following work aims to analyze, through a technological prospection, the use of pyroligneous extracts for therapeutic purposes. To carry out the study, searches were carried out in documents deposited in Brazil, Europe, and the United States and searched on platforms specialized in patents. The number of inventions using pyroligneous extract with therapeutic applications is still quite small, however, innovations have been observed for the treatment of diseases of great clinical relevance such as cancer and hypertension. The systematic mapping of innovations is of great importance for the development of new technologies.

Keywords: Pyroligneous extract. Patent. Pharmacology.

INTRODUCTION

The use of extracts from the combustion of plant biomass for the discovery of low-cost compounds

continues to be a major challenge for the scientific community (Souza *et al.*, 2018). Through the process of pyrolysis, biomass can be converted into a variety of products through thermal decomposition in the total or partial absence of oxygen. During combustion, the organic material decomposes, giving rise to three phases: a solid one, charcoal; another gaseous and finally a liquid, the latter being called pyroligneous extract (Félix *et al.*, 2017).

The main countries producing pyroligneous extracts are Japan, China, Indonesia, Malaysia, Brazil and Chile, including others in Southeast Asia and South America (Mueller *et al.*, 2021). To date, there is no standardization in quality control in the production of extracts, and there

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is no definition in the specification of the components and technology to be used, however, some parameters are recommended such as colour, odour, transparency, pH and density to obtain a product with acceptable quality (Campos, 2018).

There are more than 100 chemical compounds found in pyroligneous extracts (Chiamenti *et al.*, 2016), consisting mainly of water, acetic and formic acid, ether, methyl and ethyl alcohols, acetone, and tar (Santiago, Andrade, 2005). Evidence suggests that the compounds found in these extracts have antimicrobial activity against pathogenic microorganisms in humans and animals, however, studies need to be carried out to prove their clinical effectiveness (Souza *et al.*, 2018).

Currently, pyroligneous extracts are primarily used in agriculture, helping to absorb nutrients; in soil conditioning and microbial associations in the rhizosphere, acting as a rooting inducer (Schnitzer *et al.*, 2015). Given its employability in agriculture and as a possible therapeutic agent, it is necessary to know characteristics such as acidity value, density, pH, and tar content, in addition to chemical analysis using instrumental techniques (Vieira *et al.*, 2014).

The exercise of prospecting has been fundamental to guiding the creation of innovation systems that respond to the interests of society, directing the development of research to the most relevant needs (Silva *et al.*, 2016). Therefore, this work aims to present a scientific and technological overview related to the

use of pyroligneous extracts with therapeutic activity through prospecting.

MATERIAL AND METHODS

Technological prospecting was carried out through the search for patents and patent applications filed in Europe (*European Patent Office – EPO*), the United States (*United States Patent and Trademark Office – USPTO*), Brazil (*Instituto Nacional de Propriedade Industrial - INPI*) and in databases specializing in patent research (*The Lens / World Intellectual Property Organization - WIPO*) from January 1, 2012, to December 31, 2022.

Data collection was carried out in June 2023. The combination of the pyroligneous descriptor was used with the descriptors pharmacological / pharmaceutical / therapeutic / medicine / drug / cancer / hypertension / diabetes / anti-inflammatory / antimicrobial / using the Boolean operator AND. The research at INPI was carried out using descriptors in Portuguese.

Through exploratory reading of titles and abstracts, patents and patent applications were selected that presented the use of pyroligneous extracts for therapeutic purposes. The selected documents were plotted manually in the Microsoft Office Excel program, version 2021, excluding those that were repeated in the databases researched. The research flowchart is presented in Figure 1.

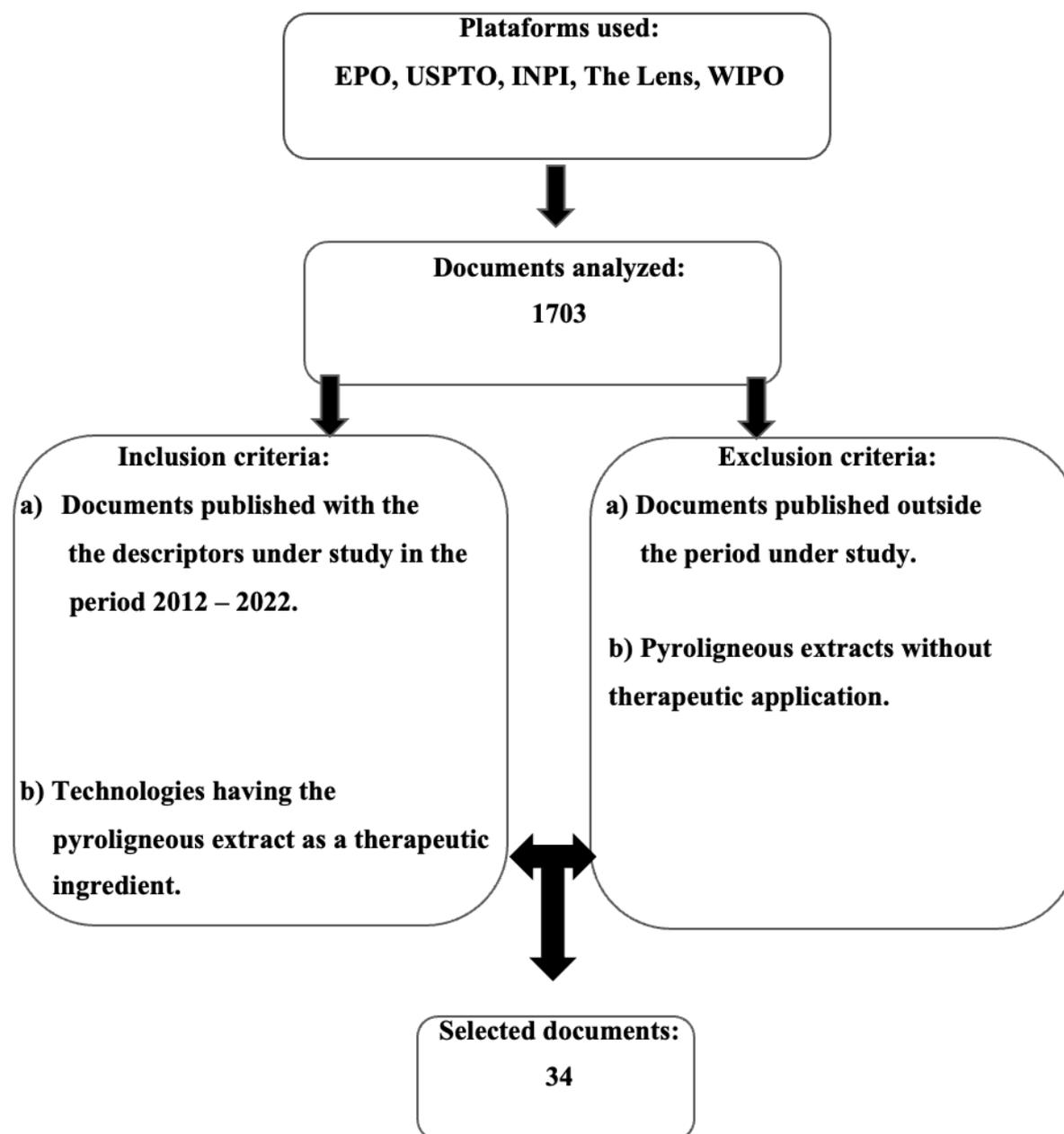


FIGURE 1 - Document search flowchart.

RESULTS AND DISCUSSIONS

A total of 1703 patents and patent applications were verified in the databases searched, as shown in Table I. Only one deposit was found on the Brazilian platform with the combination of descriptors used in this research. Brazil and a large part of Latin American countries benefit from the wide vegetation cover, which can favour research to obtain promising molecules from

plant products for the treatment of the most diverse diseases.

The Amazon rainforest offers a true pharmacological arsenal, being able to create complex molecules that are difficult to reproduce in the laboratory (Feldmann, 2021). In this context, pyroligneous extracts, through their processing, can contribute to pharmaceutical innovations for the treatment of the most diverse diseases, in addition to reducing the rate of gaseous emissions resulting from

the combustion of plant biomass (Vieira *et al.*, 2014). Pharmaceutical industries, universities, and research centres are primarily responsible for the development

of active principles that can serve as the basis for a new drug to be patented.

TABLE I - Distribution of search results in patent databases

<i>Descriptors</i>	<i>EPO</i>	<i>USPTO</i>	<i>The Lens</i>	<i>INPI</i>	<i>WIPO</i>
pyroligneous AND pharmacological	26	16	20	00	00
pyroligneous AND pharmaceutical	97	71	124	00	02
pyroligneous AND therapeutic	39	24	35	00	05
pyroligneous AND medicine	193	20	80	00	29
pyroligneous AND drug	140	64	121	00	09
pyroligneous AND cancer	48	47	62	00	03
pyroligneous AND hypertension	21	06	09	00	01
pyroligneous AND diabetes	30	24	26	00	00
pyroligneous AND anti-inflammatory	52	11	35	00	03
pyroligneous AND antimicrobial	100	37	67	01	05

Titles and abstracts were analyzed, excluding those that were not related to the object of study. Those selected were assessed for registration status, making it possible to determine whether the examination of a patent application is still pending, the application was rejected or withdrawn, the application was granted and is still valid, or a granted patent has expired, or has been revoked.

As shown in Table II, the selected documents were categorized into document number, title, year

of publication, country of origin, international patent code, inventor, and legal status. Through its descriptive analysis, it is possible to verify relevant aspects such as the predominance of Asian countries in the number of deposits and the prevalence of the interrupted status for the deposited documents. Asian countries dominated patent filings in 2021, surpassing the threshold of two-thirds of the world's total (WIPO, 2022).

TABLE II – Documents related to pyroligneous extract with therapeutic action

<i>DOCUMENT.</i>	<i>TITLE</i>	<i>YEAR OF PUBLICATION</i>	<i>COUNTRY</i>	<i>CPI</i>	<i>INVENTOR</i>	<i>STATUS</i>
KR 20140021357 A	Complex ferment extract and manufacturing method thereof	2014	KR	A61K	Park Dong Ki, Park Hoi Bum,	Active
JP 2015199717 A	Cox-2 inhibitor	2015	JP	A61K, A61P, A61Q	Inoue Hiroyoshi, Mori Ayako	Active
KR 20200143725 A	Personal care products and their manufacturing methods	2020	KR	A61K, A61Q	Chong Kwik Chuah, Shin Siong Loh (Diamond Star Global Sdn Bhd)	Active
JP 2018203852 A	Low formaldehyde pyroligneous acid	2018	JP	C10C	Miyaki Hiroshi, Yamaguchi Shinya, Kikuchi Toru (Aomori Prefectural Industrial Tech Research Center)	Active
JP 2020152709 A	Skin disease therapeutic agent and production method thereof	2020	JP	A61K	Hirayama Mitsuo (Toso Eco Clean)	Active
EP 2007744 B1	Thermal extraction method for producing a taxane extract	2017	CA	C10C A61K	Boulard David, Graham Robert, Freel Barry (Pharmatherm Chemicals Inc)	Active
JP 2018118955 A	Antifungal and antiyeast agent containing novel pyroligneous acid as active ingredient	2018	JP	A01N; A01P	Yamagushi Shinya; Kikuchi Toru (Aomori Prefectural Industrial Tech Research Center)	Pending
WO 2020204391 A2	Clinical usage of pyroligneous liquor	2020	KR	A61K	Wang Sung Ho	Pending
BR 1020200137514 A2	Pyroligneous extract for the treatment of microbial infections	2022	BR	A61K, A61P	Tatiane L. Balliano, Mozart D. Bispo, João I. Soletti, Wedja T. Vieira, Gustavo V. Amaral, Marina B. de Farias, Sandra HV de Carvalho, Maria Anilda dos S. Araújo and Ricardo Soletti (Federal University of Alagoas)	Pending
WO 2019/221593 A1	Hygiene wash	2019	MY	A61K	Chong Kwik Chuah, Shin Siong Loh (Diamond Star Global.SDN. BHD)	Pending

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<i>DOCUMENT.</i>	<i>TITLE</i>	<i>YEAR OF PUBLICATION</i>	<i>COUNTRY</i>	<i>CPI</i>	<i>INVENTOR</i>	<i>STATUS</i>
CN 111742936 A	Antibacterial liquid containing pyroligneous composition and preparation method of antibacterial liquid	2020	CN	A01P	Zhu Siqing (Tangshan Jinhai New Mat)	Interrupted
CN 111920863 A	Beriberi-removing direct-injection spray containing apple branch pyroligneous liquor and preparation method thereof	2020	CN	A61K	Hu Shengchun, Hunag Xiaohua, Wei Yitao (Univ Northwest A&f Shaanxi Jinjie Bioenergy Co Ltd)	Interrupted
CN 105616393 A	Composition for treating bromhidrosis	2016	CN	A61K	Hu Haixia; Zhong Si; Han Peitong, Zang Lin, Liu Haiyun; Hao Jianshe; Huang Kang, Hao Yinghe, Hao Qiangzhu, Hao Xiaozhu (Xinji Yuanxiang Green Energy Technology Co Ltd)	Interrupted
KR 20170023234 A	Components for soap containing medicinal herbs	2017	KR	C11D	Park Ok Gyu	Interrupted
CN 105687248 A	Composition for treating oral ulcers	2016	CN	A61K	Wu Haixia, Zhong Si, Han Peitong, Zhang Lin, Liu Haiyun, Hao Jianshe, Huang Kang, Hao Yinghe, Hao Xiaozhu, Hao Qiangzhu (Xinji Yuanxiang Env Prot Green Energy Tech Co Ltd)	Interrupted
CN 105663175 A	Composition for treating wart	2016	CN	A61K	Wu Haixia, Zhong Si, Han Peitong, Zhang Lin, Liu Haiyun, Hao Jianshe, Huang Kang, Hao Yinghe, Hao Xiaozhu, Hao Qiangzhu (Xinji Yuanxiang Green Energy Tech Co Ltd)	Interrupted
KR 20170041149 A	Composition for improving atopic skin	2017	KR	A61K	Choi yong ho	Interrupted

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CN 105708827 A	Composition for treating acute and chronic pharyngitis	2016	CN	A61K	Hu Haixia; Zhong Si; Han Peitong, Zang Lin, Liu Haiyun; Hao Jianshe; Huang Kang, Hao Yinghe, Hao Qiangzhu, Hao Xiaozhu (Xinji Yuanxiang Green Energy Technology Co Ltd)	Interrupted
CN 105663377 A	Composition for treating hyperostosis	2016	CN	A61K	Wu Haixia, Zhong Si, Han Peitong, Zhang Lin, Liu Haiyun, Hao Jianshe, Huang Kang, Hao Yinghe, Hao Xiaozhu, IHao Qiangzhu, Liu Jialong (Xinji Yuanxiang Green Energy Technology Co Ltd)	Interrupted
KR 20160000145 A	Deodorizing shoes insoles with built-in filter	2016	KR	A43B	Moon Byoung Joon; Yu Beom Sang (Daeduk College Iacf)	Interrupted
CN 106039052 A	External - application Du - channel - dredging bonesetting liquid and preparation method thereof	2016	CN	A61K	Huan Dawei	Interrupted
CN 109999073 A	Healthcare and sleep-aid composition, foot patch using the same and preparation method of foot patch	2019	CN	A61K	Liu Wu (Hangzhou Bixin Biotechnology Co Ltd)	Interrupted
CN 105748486 A	Haemorrhoids treatment composition	2016	CN	A61K	Jia Xueqi, Wu Haixia, Hao Jianshe (Xinji Yuanxiang Green Energy Technology Co Ltd)	Interrupted
CN105194445A	Medicinal liquor for treating arthritis	2015	CN	A61K, A61P	Gong Canfeng	Interrupted
CN 105831646 A	Multifunctional health product composition	2016	CN	A23L	Ye Yong	Interrupted
KR 20160040924 A	Manufacturing method for massager and itself	2016	KR	C11D	Pae Jung Jun	Interrupted

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<i>DOCUMENT.</i>	<i>TITLE</i>	<i>YEAR OF PUBLICATION</i>	<i>COUNTRY</i>	<i>CPI</i>	<i>INVENTOR</i>	<i>STATUS</i>
CN 105560079 A	Mouthwash	2016	CN	A61K	Wu Haixia, Bai Xinfang, Huang Kang, Hao Yinghe, Hao Yunzhu, Hao Xiaozhu (Xinji Yuanxiang Green Energy Technology Co Ltd)	Interrupted
CN 104083471 A	Oral liquid for treating hypertension	2014	CN	A61K, A61P	Li Yongjun	Interrupted
CN 104083470 A	Preparation method of novel chinese herbal medicine pyroligneous liquor-containing anticancer drug	2014	CN	A61K, A61P	Li Yongjun	Interrupted
KR 20150128169 A	Pharmaceutical composition for preventing or improving nose's disease and sleepiness	2015	KR	A61K	Yoo Sang Ki	Interrupted
CN 112190626 A	Pyroligneous foot antibacterial product and preparation method thereof	2021	CN	A61K	Huang Zhixin, Chen Chao (Tangshan Xinyanuo Biotechnology)	Interrupted
CN 112402370 A	Pyroligneous liquor-containing pet dermatosis therapeutic agent and preparation method thereof	2021	CN	A61K	Sun Qiuyan, Sun Xia, Yang Shuren, Li Yunxiang, Wang Yanling, Wang Fang, Wang Caixia, Li Ruchun (Shandong Vocational Animal Science and Veterinary College, Shandong Susha Ecological Dev Co LTD)	Interrupted
CN 105497079 A	Tinea pedis treatment solution	2016	CN	A61K	Wu Haixia, Hao Yinghe, Huang Kang, Hao Yunzhu, Hao Xiaozhu (Xinji Yuanxiang Green Energy Technology Co Ltd)	Interrupted
CN 104367754 A	Traditional chinese medicine for treating rheumatoid arthritis	2015	CN	A61K	Cao Xinsheng, Wang Xiang	Interrupted

Abbreviations: BR – Brazil. KR – South Korea. CN – China. CA – Canada. JP – Japan. MY – Malaysia. IPC - International Patent Classification

Assessment of the Status of Deposited Documents

Initially, the classification of the legal status of documents with deposits published in the time interval

between January 1, 2012, and December 31, 2022, was analyzed, with this result expressed in Figure 2.

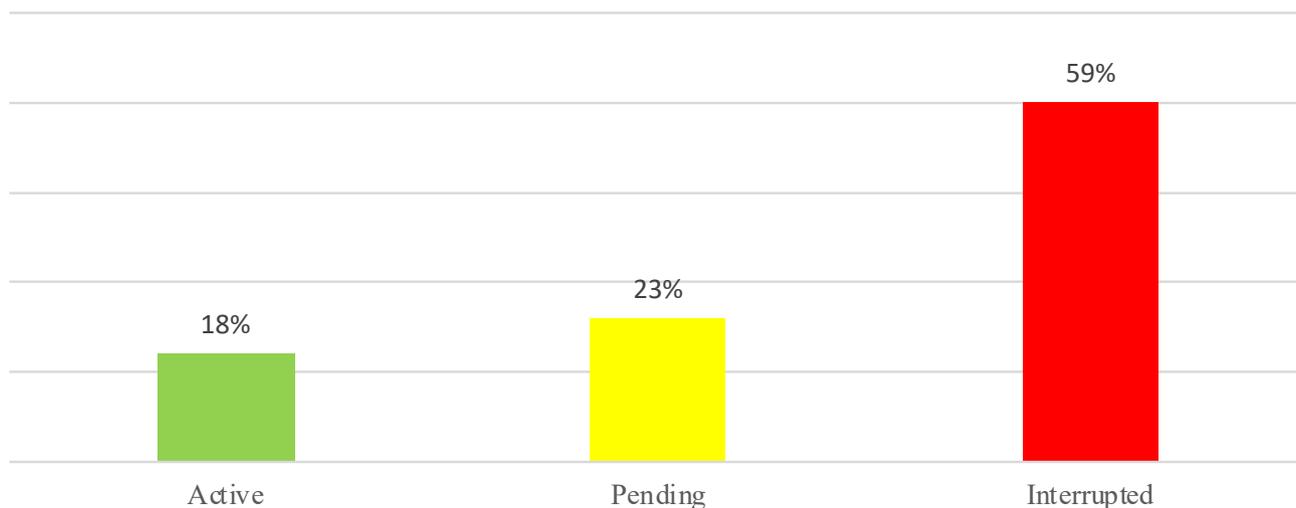


FIGURE 2 – Assessment of Legal Status.

During this period, there was a predominance of documents with Interrupted status (59%), where the inventor did not express an interest in extending the concession due to the use not having started or if their use occurred with the modification that implies an alteration of their original character or still occurring the expiration of the term, total or partial waiver. Documents classified as pending (23%) are those in which the examination of the patent application is under review. Active patents (18%) are all for which the requirements for granting have been met. At the end of the period granted, the interested party must arrange for the extension of the term if it wishes to maintain the concession (INPI, 2023).

Considering the percentage of documents with an interrupted or pending status, we can see how much we still need to explore the use of these extracts in the creation

of technologies with medicinal use. Pyroligneous extracts remain a major field of investigation for the worldwide scientific community. Research needs to be implemented with a view to its use in the pharmacological field.

Temporal Distribution of Deposits of Documents

Figure 3 shows the percentage of deposits published in the studied period. The result shows a significant oscillation in the indices. There was no deposit publication in the initial years of the research (2012/2013). The year 2016 had the highest percentage in the publication of deposited documents, making up 35% of the total. There was a quantitative reduction in the following years, with a resumption in 2020 followed by a further reduction in 2021 and 2022.

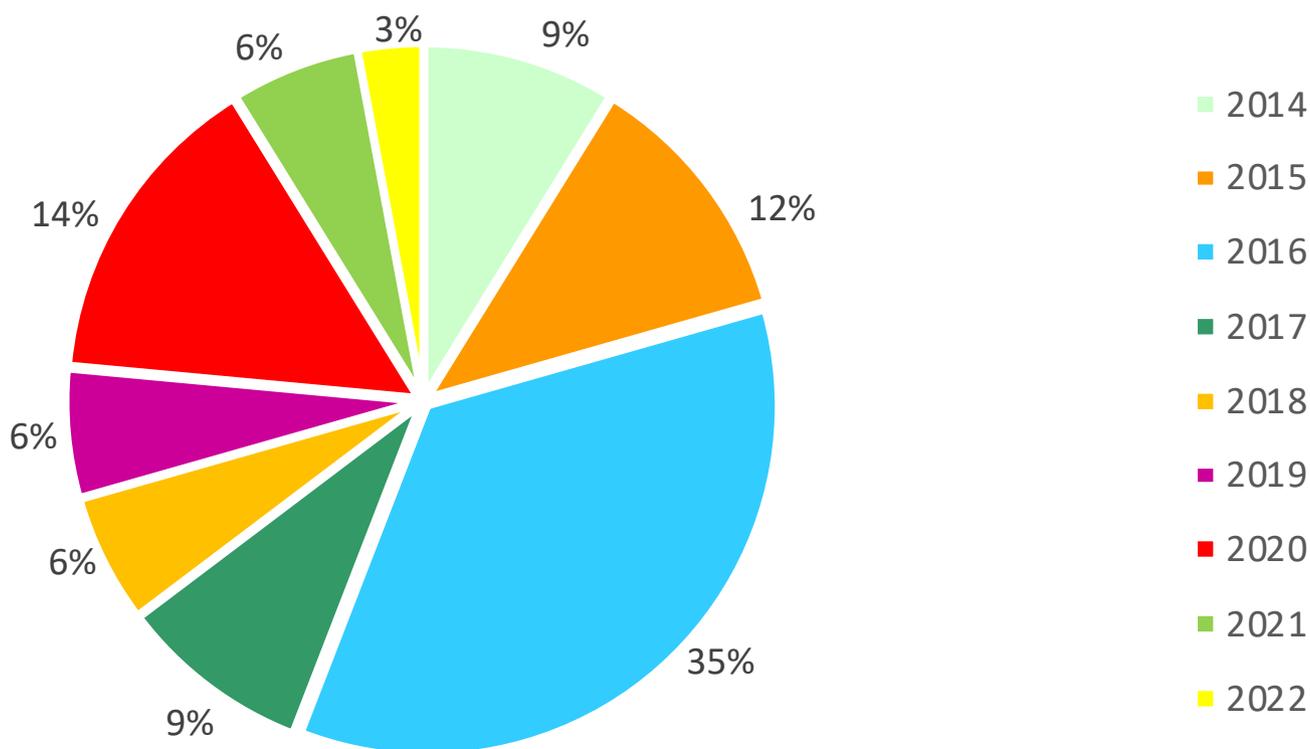


FIGURE 3 – Distribution of deposits.

The advent of the pandemic of new pandemic coronavirus (COVID-19) declared on March 11, 2020, by the World Health Organization (WHO, 2022) may have contributed to the decline in the following years in research at a global level, as Efforts by the international scientific community focused on obtaining vaccines that would bring promising results in reducing the number of new cases and deaths resulting from the infection. Therefore, the index of innovative formulations based on the pyroligneous extract with therapeutic applicability is still quite incipient. Monitoring the annual index of deposits accompanies scientific progress worldwide in the use of new technologies, which is essential for decision-making.

Geographical Distribution of Patent Deposits

To clarify the distribution of filings by country, the number of patent applications published in the period studied was evaluated, the results are shown in Figure 4. East and Southeast Asian countries, especially China (56%), predominate in research and the creation of innovation systems for the use of pyroligneous extracts for therapeutic application. Asia has a significant representation worldwide in the registration of patents, being driven by China, South Korea, and Japan (WIPO, 2019). China is the world's leading representative in patent filings with a total of 70,105 applications in 2022, which represents a slight increase of 0,6% compared to the previous year with a sharp increase in health-related technological fields (WIPO, 2023).

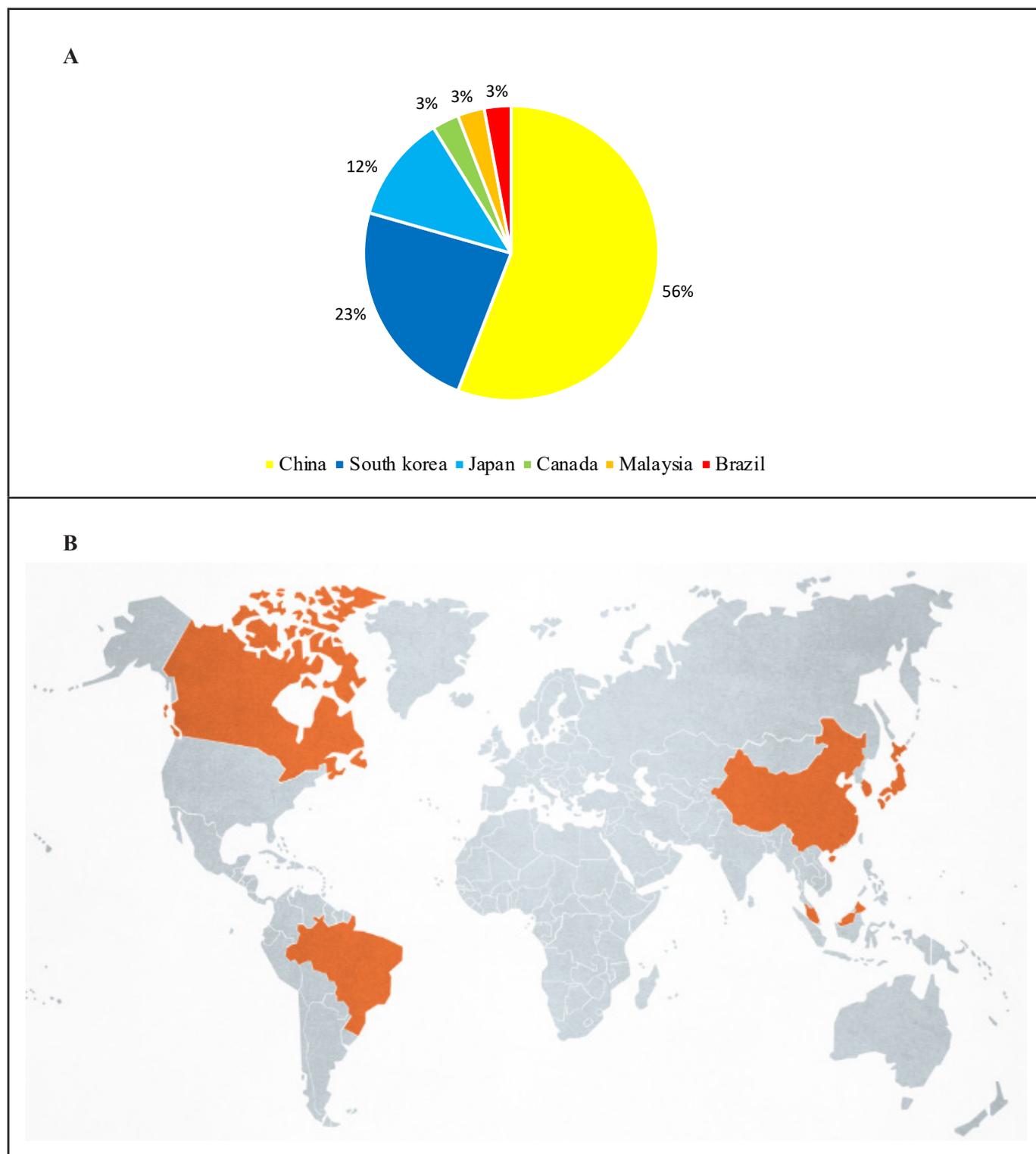


FIGURE 4 - A) Percentage of deposits by country; B) Geographic distribution of patent deposits.

In the American continent, only Brazil (3%) and Canada (3%) presented a deposited document. Brazil has used pyroligneous extracts primarily in agriculture

as a liquid fertilizer; soil disinfectant and antioxidant, providing an increase in vegetative development in plant cultivation (Silva *et al.*, 2021).

Despite the significant increase in deposits of health-oriented technologies in the last year, pyroligneous extracts still lack research aimed at exploring their therapeutic potential, the need for standardization in obtaining these extracts and the elaboration of protocols for quality control are fundamental for research that seeks to patent the pharmacological action of a given compound (Paulino, Afonso, 2021).

The geographic and environmental conditions of the American continent contribute to the availability of biomasses that can be used in the production and development of extracts from the most varied plant species and that serve as a basis for the discovery of new pharmacological compounds which can be compared to the drugs already used (Campos, 2018).

The worldwide scientific community is eager for pharmaceutical innovations originating from natural

products that can be effective in the treatment of pathologies that still have a limited therapeutic arsenal (Casanova, Costa, 2017). In addition, pyroligneous extracts have already been used mainly in the fight against microbial infections, and antineoplastic and dermatological treatment. However, the safety of using these extracts for therapeutic purposes still needs to be better evaluated.

Patents filed under the International Patent Classification (IPC)

Figure 5 expresses the distribution of patents and patent applications selected according to their international classification, whose technological areas are divided into classes from A to H. Within each class, there are subclasses and main groups, through a hierarchical system (INPI, 2015).

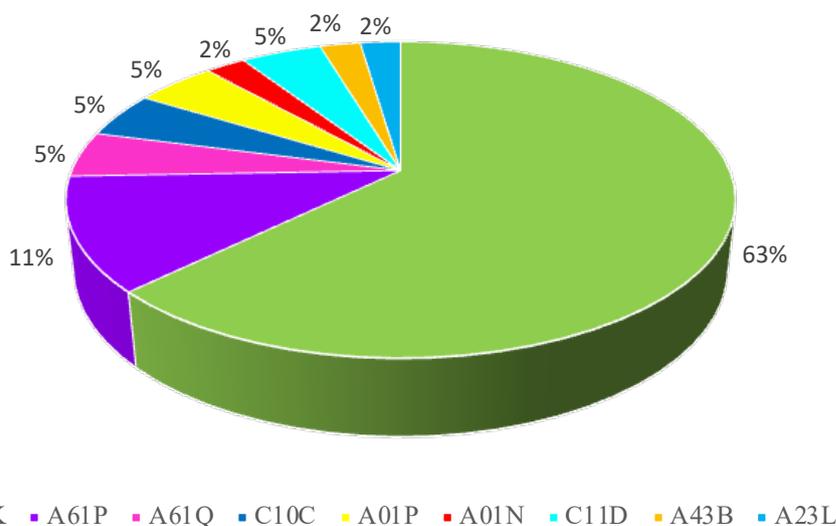


FIGURE 5 – Distribution of the International Patent Classification.

The most frequent subclass was A61K (63%), referring to preparations for medical, dental, or sanitary purposes; followed by subclass A61P (11%) intended for medicinal preparations. The other subclasses were classified as C61Q – cosmetics. C10C – preparation containing pyroligneous acid. A01P – compounds with biocidal activity. A01N – preparations that prevent the growth of unwanted microorganisms. C11D – soap or

soap manufacturing. A43B – personal or household items. A23L – modified food.

The most observed IPC code was A61K31/19 – Products for medical, dental, or sanitary purposes containing carboxylic acids in their composition. The growing concern in the creation of chemotherapeutic drugs has led to the creation of formulations of new antimicrobial agents. In this context, the use of organic acids, substances

with the general structure R-COOH, and derivatives of carboxylic acids have been highlighted (Dian *et al.*, 2020). Organic acids and aromatic compounds predominate in the pyroligneous extracts of the most diverse plant species. The concentration of these compounds is directly related to the degree of toxicity of these extracts (Campos, 2018). Instrumental chemical analysis is of fundamental importance in identifying molecules that may contribute to a possible chemotherapy application.

Distribution of Patents by Depositors

The study was able to assess the profile of the selected deposits, the results are shown in Figure 6. Companies stand out as the main holders of patent applications, accounting for 36% of the total number of selected documents. The company Xinji Yuan Xiang Green Energy Technology filed eight patent applications; it was the biggest contributor to the number of deposits. This company's market focus is on pharmaceuticals, basic materials chemistry, and environmental technology. Research Institutes, Universities, and Inventors without intermediary institutions or companies contributed 32% of the total deposits of selected documents.

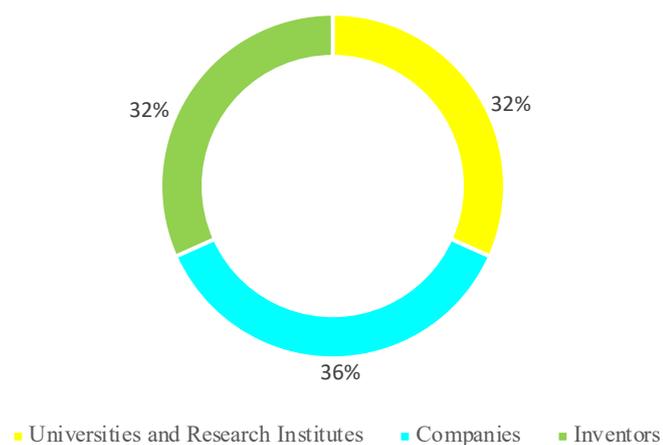


FIGURE 6 – Distribution by Depositor.

The ability to innovate gives companies competitive advantages in international trade. In this sense, the

development of scientific activities; organizational; financial, and commercial, can lead to the implementation of new technologies that seek to solve the needs presented by societies (Hoffmann, Coral, Jara, 2014).

Description of Patents Granted and with Active Status

Complex ferment extract and manufacturing method thereof [KR 20140021357 A]

The invention relates to a fermentation extract for hair treatment. The extract is obtained from the fermentation of the following components: *Poncirus trifoliata* which promotes increased blood flow; Bamboo Pyroligneous Liqueur and Ginger which are hair follicle stimulants; root of *Sephora japonica* that has anti-inflammatory action, in addition to other organic components that provide nutrients to the hair roots (Ki, Bum, 2014).

The cosmetics market has shown a progressive increase in demand for products of natural origin. The use of plant actives and their incorporation into food and hygiene products has given a high economic value to several plant species. In this context, plant extracts stand out as important constituents that add value to the product which is incorporated, promoting therapeutic actions, sustainability, and economic potential (Silva, Santos, 2021).

Cox – 2 inhibitor [JP 2015199717 A]

The invention consists of a tonic that induces hair growth with COX-2 inhibitory activity. It has a pyroligneous extract of tangerine as an active component. The therapeutic action consists of inhibiting cellular apoptosis of hair follicles promoting hair growth (Hiro Yoshi, Ayako, 2015).

Many therapeutic strategies and regimens are based on the use of COX-2 inhibitors. These chemical agents are considered safer and less toxic, especially in prolonged treatments, and are considered the first-choice therapeutic class aimed at reducing the formation of mediators in the inflammatory process (Etienne *et al.*, 2020).

Therapeutic agent for skin diseases and production method [JP 2020152709 A]

The present invention relates to a therapeutic agent for the treatment of dermatological pathologies such as atopic dermatitis, eczema, and rash. Corticosteroids are the main drugs used in the treatment of skin diseases, but their prolonged use has shown a series of side effects. Therefore, there is a strong demand for the emergence of safe therapeutic agents that have few side effects even after prolonged use and can achieve satisfactory therapeutic effects (Mitsuo, 2020).

In dermatology, drugs with immunomodulatory action are frequently used in the treatment of inflammatory skin diseases. These drugs target cytokines, immune mediators, molecules, and cell surface receptors, response components of the inflammatory cascade that correspond to important elements of the body's physiological response and cell cycle control (Casanova *et al.*, 2021).

Corticosteroid therapy is applied to a range of pathologies and, for this reason, corticosteroids are one of the most prescribed drugs worldwide, with a turnover of around 10 billion dollars a year. Despite the advantages of this treatment, its prolonged use can lead to serious adverse effects such as increased blood glucose, fluid retention, acidosis, hypokalemia, and increased intraocular pressure, among others (Pinto *et al.*, 2020).

Given the above, the present invention was conceived to provide an effective pharmaceutical innovation without providing the side effects commonly observed with the prolonged use of corticosteroids. The formulation features *Commiphora myrrha* extract (70%) and an acetic acid solution obtained from the pyroligneous extract of bamboo. The invention has satisfactory effects in the treatment of dermatology, promoting anti-inflammatory and antibacterial effects (Mitsuo, 2020).

Thermal extraction method to produce a taxane extract [EP 2007744 B1]

The invention aims to provide a method for obtaining an extract rich in taxanes by thermal extraction. Taxanes

are a group of diterpenoid compounds, some of which are useful in the treatment of cancer and other serious diseases such as multiple sclerosis and kidney disease. From the combustion at a temperature of 320°C to 400°C of plant biomass of the genus *Taxus* or *Austrotaxus*, a pyroligneous extract rich in taxanes is obtained (Boulard, Graham, Freel, 2017).

Taxanes are widely used in the treatment of breast cancer with a significant therapeutic response. They are derived from a natural substance found in the home of the yew tree, *Taxus baccata*, a tree that produces toxic substances (taxins) as well as medicinals (taxanes). Taxanes (Paclitaxel and Docetaxel) are drugs with antimycotic action, which act on tubulin microtubules, promoting their stabilization. Disruption of cellular balance alters its structure and functions, resulting in apoptosis. Paclitaxel and Docetaxel can be used directly in pharmaceutical applications without additional chemical modification, while other taxanes are seen as precursors to produce Paclitaxel and Docetaxel (Neris *et al.*, 2016).

Personal hygiene product and its manufacturing method [KR 20200143725 A]

The invention provides a method for obtaining a personal care product using wood vinegar. This pyroligneous extract is obtained by the thermal decomposition of *Rhizophora apiculata*. Its action consists of inactivating microorganisms that cause skin and urinary tract infections, without causing deleterious effects on the commensal microbiota (Chuah, Loh, 2020).

Pyroligneous acid is obtained by burning *R. apiculata* at a temperature of 240 – 500 °C. The collected smoke is condensed in a stainless-steel tube and the collected product is stored in a polyethylene container at room temperature. The extract described in the patent showed a significant fungistatic effect at low concentrations and a fungicide at higher concentrations for the *Candida albicans fungus*, bringing a new resource for the treatment of fungal infections with the use of a product of natural origin (Ibrahim *et al.*, 2013).

Pyroligneous acid with low formaldehyde content
[JP 2018203852 A]

The invention deals with the process of supplying a pyroligneous acid with a low formaldehyde content, high antimicrobial properties, and without significant toxicity. The solution has a formaldehyde concentration of less than 5 ppm (W/V) and an acidic pH. The extract can preferably be used as a bacteriostatic or bactericidal agent. The reduction of formaldehyde levels is achieved by adding tryptophan to the pyroligneous extract causing it to react with the formaldehyde present in the pyroligneous acid (Hiroshi, Shinya, Toru, 2018).

The pyroligneous extract is a complex mixture of fragments derived from oxygenated hydrocarbons from the structures of biopolymers. The relationship between the types of compounds present and the temperature to which the vapours were exposed before condensation is the most important point in the production of pyroligneous extract (Campos, 2018).

Summary of Patent Applications with Pending Status

Antifungal agent containing the new pyroligneous acid as an active ingredient [JP 2018118955 A]

The present invention provides a pyroligneous solution with a significant antifungal effect. Bamboo wood is preferably used as raw material, in which it is submitted to a combustion process at a temperature of 80 - 150 °C, the collected gases are condensed, stored, and left to rest for 90 days or more, with the tar removed. In the method of producing the pyroligneous acid solution of the present invention, tryptophan, which is an amino acid, is added to the pyroligneous acid solution to decrease the formaldehyde concentration. The weight of tryptophan added is preferably about 12 to 14 times the weight of formaldehyde in the pyroligneous solution (Shinya, Toru, 2018).

Clinical use of pyroligneous liquor [WO 2020204391 A2]

The present invention provides an anticancer adjuvant for preventing or treating cancer. Cancer is the second leading cause of death in the world, and advanced

methods of diagnosis and treatment are improving the prognosis. Cancer is associated with many symptoms such as fatigue, pain, weight loss, eating disorders, and nausea. Most of the medical community believes that cancer is caused by mutations in DNA. The invention was prepared from the pyroligneous extract that went through a plurality of purification processes. It is composed of a complex mixture of water, phenol, vanillin, acetic acid, formic acid, and other carboxylic acids. Organic acids and phenolic compounds were considered the main biologically active ingredients of the invention (Ho, 2020).

Pyroligneous extract for the treatment of microbial infections [BR 1020200137514 A2]

The invention relates to an antimicrobial product in the form of a solution, hydrogel, gel, and aerosol, rich in organic compounds with fungicidal and bactericidal action, indicated for the treatment of skin and nail infections. The proposed product comprises a short-term, effective, safe, low-toxicity, and low-cost topical treatment. The product is innovative in the dermatological field and can be widely used and easy to administer (Balliano *et al.*, 2022).

Hygienic washing [WO 2019/221593 A1]

The present invention relates to a personal hygiene product. Wood vinegar is obtained by pyrolysis of wood and leaves of *Rhizophora apiculata*, in which the pyroligneous acid has a bactericidal and fungicidal effect, effective in the treatment of dermatological and urinary tract infections. Pyroligneous extract at a concentration of 20% can be added to different formulations (Chuah, Loh, 2019).

Summary of Patents or Patent Applications with Interrupted Status

Antibacterial foot product and its preparation method [CN 112190626 A]

The invention refers to a product containing pyroligneous liquor with antibacterial action, indicated

for the treatment of feet. The product is prepared from the following components in parts by mass of 20-30 parts pyroligneous distillate, 4-6 parts beeswax, 2-4 parts monoglycoside ester, 2-4 parts paraffin oil, 4-6 parts of Olivem 1000, 1,5-3,5 parts of glyceryl monostearate, 1-3 parts of 305 cold-forming emulsifiers, 1-3 parts of DMSO, 1-3 parts of borneol, 1-3 parts of menthol, 1-3 parts of BHT, 1-3 parts of azone, 0,5-1,5 parts of salicylic acid and 0,3-0,7 parts of allantoin (Zhixin, Chao, 2021).

Antibacterial liquid containing pyroligneous composition and method of preparation [CN 111742936 A]

The invention discloses an antibacterial liquid containing a pyroligneous composition and its preparation method. The composition comprises the following raw materials in parts by weight: 15 parts of a phospholipid, 200 parts of ethanol, 2 parts of sodium deoxycholate, 300-1000 parts of pyroligneous liquor, and 3000 parts of ultrapure water. The antibacterial liquid prepared by the invention has a remarkable inhibition effect on various pathogenic bacteria, it is safe, effective, and convenient to use (Siqing, 2020).

Bone sedimentation liquid for external application and method of preparation [CN 106039052 A]

Bone fixation liquid is a drug for external application to the spine, it has clinical results in the treatment of rachopathy, hyperostosis, stiff spine, and scoliosis, and it is used for spine massage. It can effectively soften hyperplastic bone tissue and stiff muscle fascia, reducing the risk of bone injury. It contains pyroligneous acid and other plant extracts in its composition (Dawei, 2016).

Composition for the treatment of bromhidrosis [CN 105616393 A]

The invention provides a composition for the treatment of bromhidrosis. The composition is prepared from, by weight, 55-75 parts of pyroligneous liquor, 0.5-5 parts of sodium lauryl sulfate, 8-25 parts of sodium hexametaphosphate, 20-40 parts of sorbitol and 15-35

parts of pure water. When used, the composition is sprayed onto the bromhidrosis position and massaged until the composition is completely absorbed. The composition has a good clinical response, is free of toxic and side effects, and is suitable for people of all age groups (Haixia *et al.*, 2016b).

Components for soap containing medicinal herbs [KR 20170023234 A]

The present invention refers to a composition for soap containing medicinal herbs with dermatological function, being manufactured according to the following description: first step – extraction of pyroligneous liquor from charcoal; second stage – fermentation of the active principle of the medicinal herb to activate the active principle of absinthe; third stage – mixing the honeycomb with the pyroligneous liquor; fourth step – packing the fermented absinthe in a storage container, pouring water with the pyroligneous liquor mixed with honey to produce an extract with sufficient amount of the active ingredient of medicinal herbs; fifth step – addition of vegetable base and hyaluronic acid (Gyu, 2017).

Composition for the Treatment of oral ulcers [CN 105687248 A]

The invention provides a composition for treating oral ulcers. It is prepared from, by weight, 55-85 parts of pyroligneous liquor, 15-35 parts of honey, 5-25 parts of aspartic acid, and 0.5-5 parts of menthol. It has a significant therapeutic effect, with a low rate of side effects (Haixia *et al.*, 2016d).

Composition to treat warts [CN 105663175 A]

The invention provides a composition for treating warts. It is prepared from the following raw materials in parts by weight: 55 to 75 parts of pyroligneous liquor, 15 to 35 parts of cinnamic aldehyde, 0.5 to 4 parts of fatty alcohol polyoxyethylene ether, and 1 to 6 parts of polyacrylamide. The formulation is applied directly to the affected region with a great healing effect (Haixia *et al.*, 2016e).

Composition to improve atopic skin [KR 20170041149 A]

The formulation for improving atopic skin is disclosed. To achieve the objectives, the composition contains an extract of Aronia (40-60% by weight) to decompose enzymes, an extract of *Orosrachys malacophyllus* (40-60% by weight), and also oak pyroligneous liquid, which has been matured for 6 years (Ho, 2017).

Composition to treat acute and chronic pharyngitis [CN 105708827 A]

The invention discloses a composition for the treatment of acute and chronic pharyngitis. The composition is prepared from, by weight, 65-85 parts of pyroligneous liquid, 15-35 parts of maltitol, 15-35 parts of limonene, 8-18 parts of fumaric acid, and 20-40 parts of pure water. The composition has the advantage of having a high cure rate, free from toxicity and side effects (Haixia *et al.*, 2016a).

Composition for the treatment of hyperostosis [CN 105663377 A]

The invention provides a formulation for treating hyperostosis. The composition comprises the following raw materials in parts by weight: 45 to 75 parts of pyroligneous liquor, 15 to 35 parts of rutin, 10 to 25 parts of limonene, 5 to 15 parts of zanthoxylum oil, and 20 to 40 parts of water pure. The formulation is sprayed on the painful part and lightly massaged by hand until completely absorbed; the invention shows significant clinical results (Haixia *et al.*, 2016c).

Composition for healthcare [CN 109999073 A]

The invention relates to a healthcare product. The formulation consists of an adhesive that is used on the feet. The composition is prepared from, by weight, 1-30 parts of *Folium Artemisiae argyi*, 1-30 parts of a pyroligneous solution, 1-20 parts of chitin, 1-20 parts of ultrafine tourmaline powder, 1-20 parts of vitamins C, 1-30 parts of safflower, 1-20 parts of *Passion Flower*

incarnata and 0,1-10 parts of melatonin. The patch has the function of promoting circulation, relieving fatigue, and promoting sleep (Wu, 2019).

Composition for the treatment of hemorrhoids [CN 105748486 A]

The invention provides a formulation for treating haemorrhoids which are prepared from, by weight, 55-75 parts of pyroligneous acid, 5-15 parts of calcium pantothenate, 10-25 parts of retinoic acid, 5-15 parts of glycyrrhizin, 8-20 parts of hydroxy ethyl cellulose and 10-25 parts of butanediol. The use of the product consists of spraying the formulation on the inner side of the anus, being absorbed by the anal mucosa (Xueqi, Haixia, Jianshe, 2016).

Deodorant insoles with built-in filter [KR 20160000145 A]

The present invention relates to a shoe insole embedded with a filter lightly soaked as a pyroligneous solution for deodorization, capable of continuously obtaining antimicrobial and anti-inflammatory effects (Joon, Sang, 2016).

Direct injection spray containing apple branch pyroligneous liquor and its method of preparation [CN 111920863 A]

The invention relates to the technical field of drug synthesis. Wood vinegar from apple branches is a mixed solution with quite complex components. The extract is produced during pyrolysis or dry distillation of the pruning (wood) branches of apples. The main component is a liquid mixture composed of more than 200 components such as water, organic acids, phenols, ketones, and alcohols (Shengchun, Xiaohua, Yitao, 2020).

Medicinal liquor for treating arthritis [CN105194445A]

The invention relates to a medicinal liquor for treating arthritis. It consists of *Glabra sarcandra* herb, *Lophatherum common* herb, *Sarcandra glabra*, pyroligneous solutions, *Hibiscus taiwanensis*, and

Chinese hydrangea root bark, among other components of natural origin (Canfeng, 2015).

Multifunctional composition of a health product
[CN 105831646 A]

The composition of the multifunctional health product comprises, by weight, 25-30 parts of nanopowder, 1-3 parts of pumpkin seed bark pyroligneous liquor, 2-6 parts of American ginseng, 10-15 parts of seaweed extract, 2-6 parts of *Agaricus brasiliensis*, 2-6 parts of *Holy Thistle* and 2-6 parts of *Gynostemma pentaphylla*. The described product can reduce and prevent fatigue and is especially suitable for diabetic patients (Yong, 2016).

Method of making an herbal soap [KR 20160040924 A]

The present invention relates to a method of manufacturing an herbal soap with a composition capable of exerting various pharmacological actions. It is composed of a mixture of various medicinal herbs and pyroligneous extract. The pharmacological effects of the invention consist of improving blood circulation in the skin, and preventing atopy (Jun, 2016).

Mouthwash [CN 105560079 A]

The invention discloses a mouthwash comprising the following composition of the material in parts by weight 65-110 parts pyroligneous liquor, 5-15 parts vitamin (B2), 1-5 parts glyceryl stearate, 1-4 parts inositol, 8-20 parts of naringin and 80-100 parts of pure water. Pyroligneous liquor is selected as a deodorant and cleaning agent, and vitamin (B2), glyceryl stearate, inositol, and naringin are added, so that the oral hygiene function is enhanced; vitamin (B2) can treat oral diseases, inositol can enhance immune capacity, naringin can play an analgesic effect, and glyceryl stearate plays auxiliary roles in cleansing, permeation, and absorption (Haixia *et al.*, 2016f).

Oral liquid for treating hypertension [CN 104083471 A]

The invention consists of an oral liquid for the auxiliary treatment of hypertension. The oral liquid

comprises 50-60 parts of pyroligneous liquor, 10-20 parts of *Bidens pilosa*, 4-6 parts of *Gynostemma pentaphylla*, and 8-12 parts of the herb *Agrimonia hairyvein*. The formulation can be used safely has no side effects or toxic effects, and can be administered for long periods (Yongjun, 2014a).

Pharmaceutical composition for preventing or improving nose disease and sleepiness [KR 20150128169 A]

The invention relates to a composition intended for treating nasal diseases, especially allergic rhinitis, without causing drowsiness typical of products intended for treating allergic disorders. The formulation has active ingredients: acetic acid, pyroligneous extract, borneol, and menthol (Ki, 2015).

Preparation method of novel Chinese herbal medicine pyroligneous liquor-containing anticancer drug
[CN 104083470 A]

The invention consists of a method of preparing a new drug with anticancer potential. The formulation preparation steps are described as follows: extracting the pyroligneous liquor, separating the formulation components, adding a Chinese herbal extract, and filtering the formulation. The invention has no side or toxic effects and has definite anticancer effects (Yongjun, 2014b).

Therapeutic agent for pet dermatosis containing pyroligneous liquor and method of preparation
[CN 112402370 A]

The therapeutic agent for pet dermatitis is composed of a pyroligneous liquor, an antioxidant, a metal ion complexing agent, and a co-solvent. The pyroligneous liquor is prepared using a specific process that guarantees a high bactericidal effect. The other components present in the formulation guarantee a synergistic effect on the pyroligneous liquor, enhancing the bactericidal effect. The side effects of harmful components on the animal's skin are also reduced (Qiuyan *et al.*, 2021).

Tinea pedis treatment solution [CN 105497079 A]

The tinea pedis treatment solution is prepared from, by weight, 65-95 parts of pyroligneous liquor, 3-15 parts of sodium perborate, 1-5 parts of allantoin, 3-20 parts of demethylated pseudolaric acid, and 5 -15 parts of acidic phytic acid. Pyroligneous liquor is a natural plant material with strong antibacterial functions, mainly acetic acid (Haixia *et al.*, 2016g).

Traditional Chinese medicine for treating rheumatoid arthritis [CN 104367754 A]

The invention consists of a medicine derived from traditional Chinese medicine. the formulation has the following composition in parts by weight: 10-15 parts of ground beetle, 10-15 parts of centipede, 3-8 parts of pyroligneous extract, 5-9 parts of yam rhizome, 3 -6 parts of silkworm, 3-8 parts peach pit, plus other organic components. The medicine has the effect of improving blood circulation and reducing the symptoms of rheumatoid arthritis (Xinsheng, Xiang, 2015).

The increase in the number of patents by Asian countries is mainly due to the dominance of Asia as the continent of origin of technological innovations. Today, technologies derived from natural products are of great relevance in the cost-effectiveness of clinical treatments. Latin American countries, mainly Brazil, have great potential in producing plant biomass, which favours clinical research using pyroligneous extracts. These extracts still have a large field of exploration by research institutes, universities, and pharmaceutical industries in the search for chemical entities with pharmacological action.

CONCLUSION

This technological prospect showed a current overview of the use of pyroligneous extracts with medicinal applications, acting as an incentive for the growth of research that seeks alternatives for more cost-effective treatments. It was verified that the number of active patents is still quite incipient compared to the possible pharmacological potential of these extracts. The study showed the importance of technological

prospecting in the systematic mapping of innovations, significantly influencing the development of technologies that positively impact society.

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