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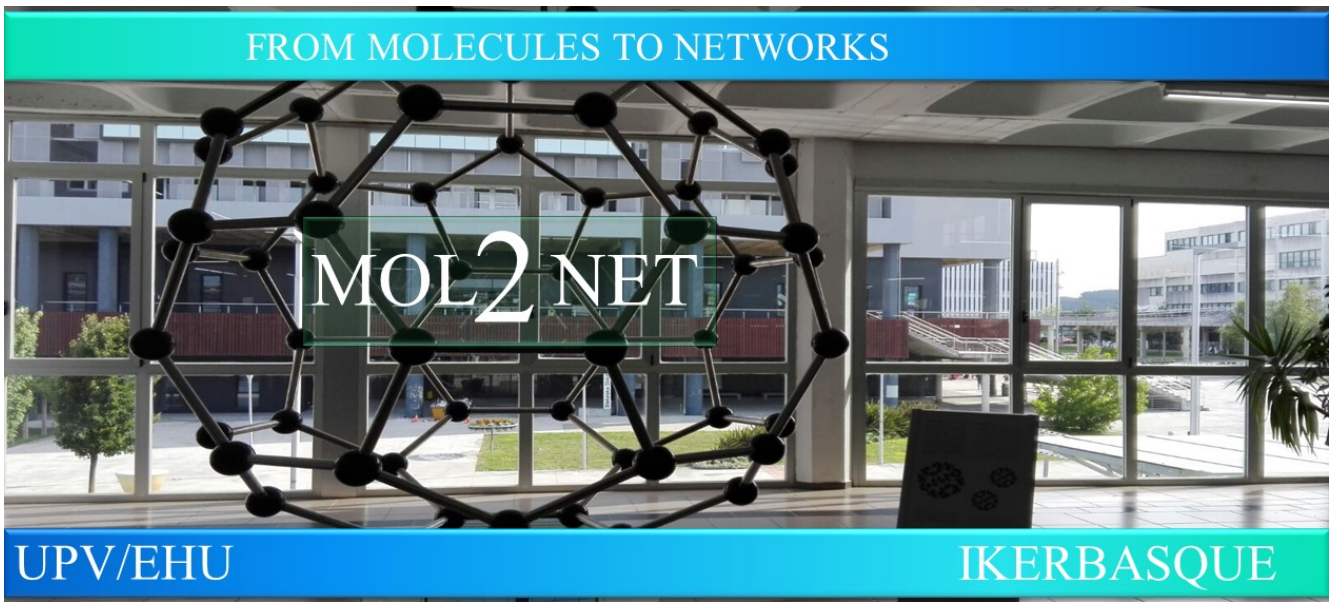

Use of patent information to characterize innovation and trends on biopolymers for agriculture

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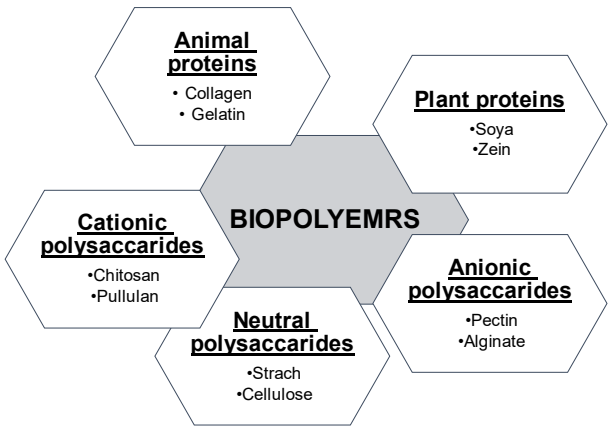
Graphical Abstract



Abstract.

This research concerns the worldwide patent applications on biopolymers used in agriculture filed under the PCT global system. This study, in particular, gives a patentability analysis of biopolymers utilized in agriculture by introducing what has been invented and patented. Furthermore, a detailed analysis is provided by using the Patentscope database.

Keywords: *biopolymers; formulation; agriculture; innovation; patent analysis.*

Introduction

Biopolymers are biodegradable water-soluble polymers that can swell by uptake water due to the macromolecular hydrophilicity [1]. Thanks to their rheological and biological properties, non-toxicity, biocompatibility, and flexibility, biopolymers were largely used for various applications (e.g., biomedicine [2], agriculture [3], etc.).

Different biopolymers have been used in agriculture in order to enhance the water holding capacity of the soil and controlled release of fertilizers. Examples include, but not limited to, starch, alginate, chitosan, poly(vinyl alcohol), and cellulose [3-5]. Biopolymers and their derivatives present a promising material for improving growth and quality of plants as well as biomass accumulation and greenness.

The research and development in the area of biopolymers for agriculture is developing rapidly through the innovation and improvement of raw materials, chemical synthesis, methods of preparation, formulations, and fabrication processes, as well as applications This is also evident from the increase in the number of patent applications filed worldwide each year in this area.

Use of patent information to characterize innovation and trends lead to various recommendations and may help one to plan and innovate a research strategy[6,7]. This research concerns the worldwide patent applications on biopolymers used in agriculture filed under the Patent Cooperation Treaty (PCT) global system. This study, in particular, gives a patentability analysis of biopolymers utilized in agriculture by introducing what has been invented and patented. In compliance with patent analysis criteria, it is established as a research planning tool [8-11]. Furthermore, a detailed analysis is provided regarding publication years, applicants, jurisdictions, and patent classifications by using the Patentscope database.

Materials and Methods

This study is based on the Patentscope search service of the World Intellectual Property Organization (WIPO) [12]. During the search, different keywords concerning biopolymers for agricultural applications was used, and patents were searched according to title, abstract, and claims. The search was then filtered to include only international patent publications through the PCT with a publication date until 2022.

Results and Discussion

Based on definitions of the terms used generally in the world of patent information, publication is the step when the patent document (patent application, granted patent, etc.) is made available to the public, to which a publication number and a publication date have been assigned by a patent authority. In other words, the publication date is the date on which a patent document is published, thereby making it part of the state of the art [8-11].

Figure 1 presents the publication dates for the resultant patents relating to the use of biopolymers in agriculture. 288 patent documents were found between 1996 and 2022. As result, 19 patent applications have been published each year in 2007, 2013, and 2021. However, the year 2022 recorded the maximum number of 21 patent documents. Finally, it should be noted that 30% of total patent applications have been published in the last five years.

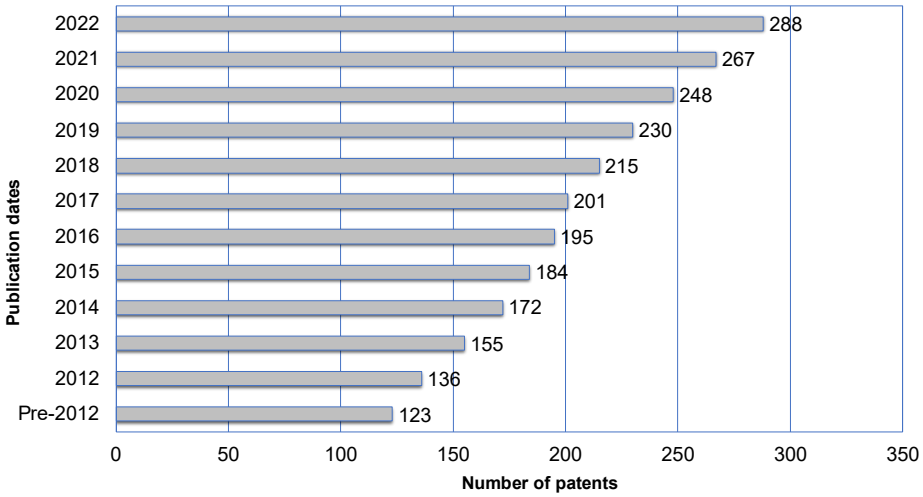


Figure 1. *Publication dates of resultant patents.*

An applicant is a person (i.e., a natural person) or an organization (i.e., a legal entity) that has filed a patent application. In several cases, the applicant can also be the inventor, and there may be more than one applicant per patent application [13,14].

Figure 2 presents the top 14 applications for resultant patents relating to the use of biopolymers in agriculture. As a legal entity, the company "Sekab E-Technology" (Örnsköldsvik, Sweden) is ranked as the first applicant that has published 7 patent documents.

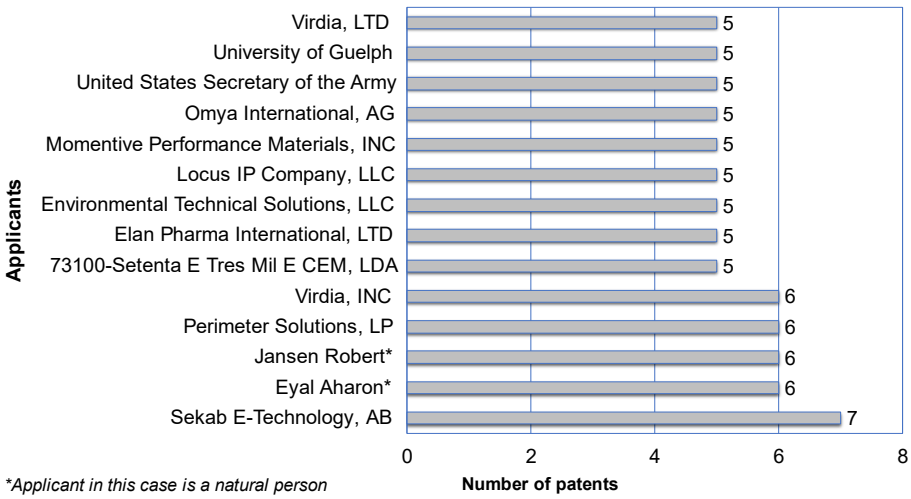


Figure 2. *Applicants (top 14) of resultant patents.*

An applicant, or first-mentioned applicant in the case of joint applicants, can file an application for a patent at the appropriate patent office under whose jurisdiction he normally resides, has his domicile, has a place of business, or the place from where the invention actually originated. If patent protection is sought in a number of countries worldwide, an applicant may consider filing an international application under the PCT global system [15,16].

Figure 3 presents the top 10 jurisdictions for resultant patents relating to the use of biopolymers in agriculture. The United States through the USPTO encompasses 84 patent documents. On the other hand,

the global system for filing pa-tent applications, known as PCT and administered by WIPO, encompasses 68 patent documents. Finally, the EPO, through which patent applications are filed regionally (Europe), encompasses 31 patent documents.

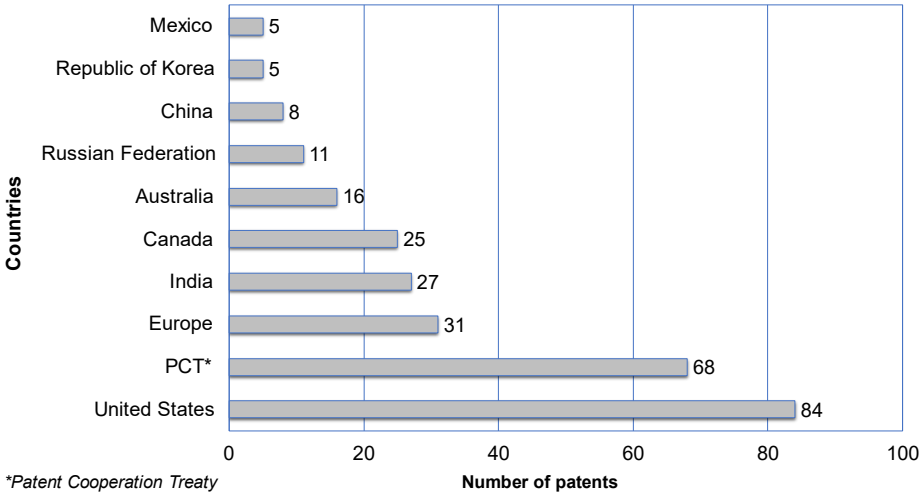


Figure 3. *Jurisdictions (top 10) of resultant patents.*

The International Patent Classification (IPC) is a hierarchical system in the form of codes that divides all technology areas into a range of sections, classes, subclasses, groups, and subgroups [17]. It is an international classification system that provides standard information to categorize inventions and evaluate their technological uniqueness [18,19].

For the resultant patents relating to the use of biopolymers in agriculture, the top 11 IPC codes are presented in Figure 4. These IPC codes concern only patent applications under the PCT global system. The most common IPC code relating to the use of biopolymers in agriculture corresponds to C08L, which is a subclass meaning compositions of macromolecular compounds. This subclass has recorded 62 patent documents alone. For more details concerning these top ten, a description of each IPC code is shown in Table 1.

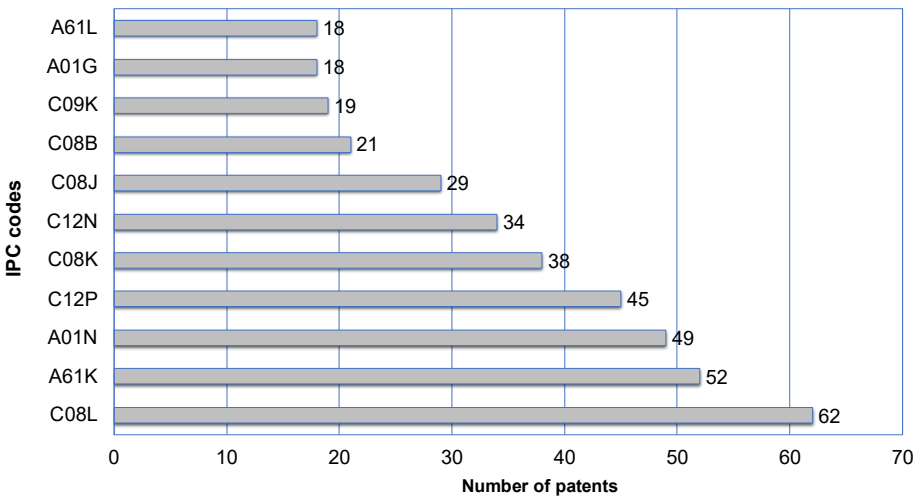


Figure 4. *IPC codes (top 11) of resultant patents.*

Table 1. *Description of patent classifications concerning the resulting patents [17].*

IPC	Description
C08L	Compositions of macromolecular compounds.
A61K	Preparations for medical, dental, or toilet purposes.
A01N	Preservation of bodies of humans, animals, plants, or parts thereof.
C12P	Fermentation or enzyme-using processes to synthesize a desired chemical compound.
C08K	Use of inorganic or non-macromolecular organic substances as compounding ingredients.
C12N	Microorganisms or enzymes and compositions thereof.
C08J	Working-up, general processes of compounding and after-treatment.
C08B	Polysaccharides and their derivatives.
C09K	Materials for applications not otherwise provided for.
A01G	Horticulture, forestry, or watering.
A61L	Methods or apparatus for sterilizing materials or objects.

Conclusions

During our search, 288 patent documents were found between 1996 and 2022. The United States was ranked first with 84 patent documents, followed by the PCT global system with 68 patent documents. The innovation and improvement of biopolymers for agricultural applications are concerned with raw materials, synthesis, and methods of preparation, as well as formulations and fabrication processes. Based on the patent classification codes, all granted patents and most inventions are intended for compositions of macromolecular compounds and use of inorganic or non-macromolecular organic substances as compounding ingredients, as well as polysaccharides and their derivatives. According to knowledge clusters and expert driving factors, research based on the preservation of the bodies of humans, animals, and plants is concentrated in the majority of patents.

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