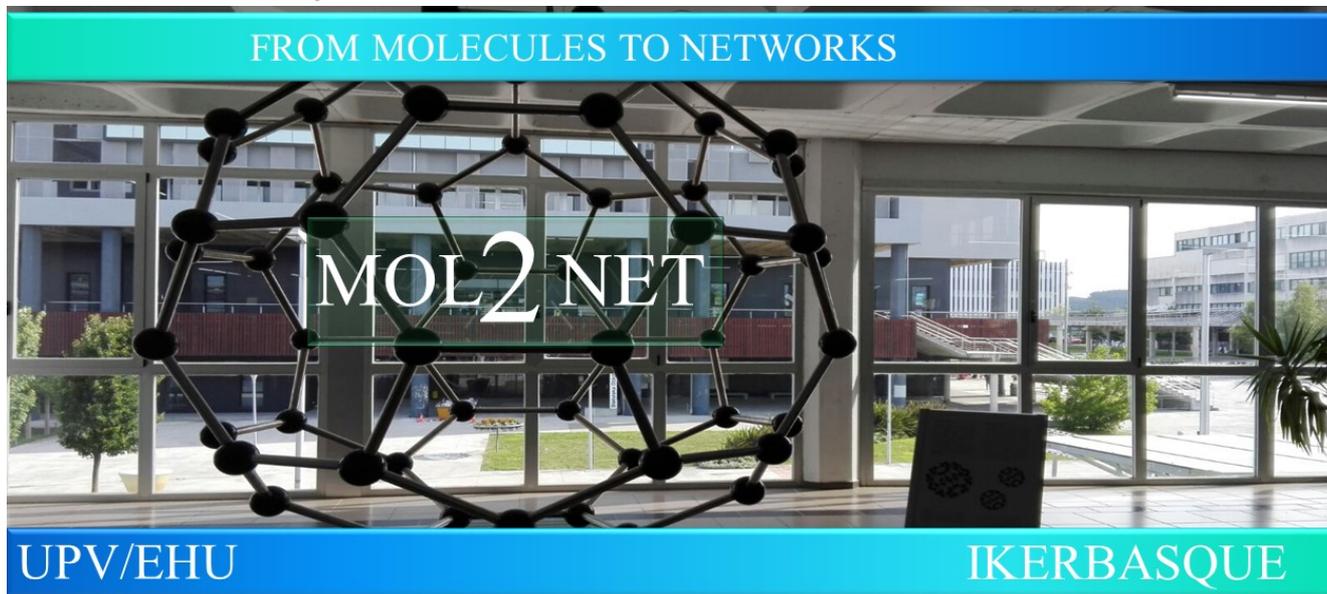




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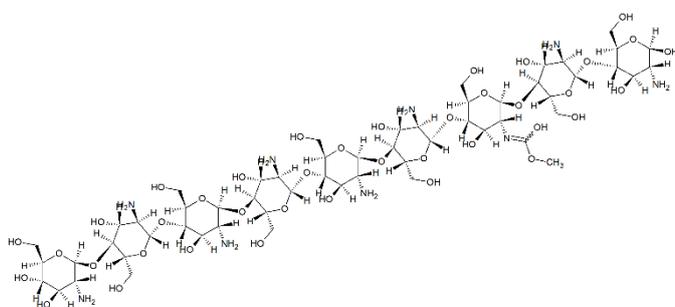
Chitosan biopolymer: An overview based on patents

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Graphical Abstract



Abstract

This work, in the form of patent analysis, presents the state by introducing what has been innovated and patented concerning chitosan biopolymer. Furthermore, a detailed analysis of the patentability by using the "chemical compounds search" feature of the Patentscope database, has been provided regarding publication dates, jurisdictions, and patent classifications. As a research service of the WIPO, this database offers searches of international patent applications filed under the Patent Cooperation Treaty.

Keywords: chitosan; biopolymer; chemical compounds search; patentability; patent data.

Introduction

Chitosan is a linear amino-polysaccharide of $\beta(1\rightarrow4)$ -linked D-glucosamine and N-acetyl-D-glucosamine residues. Also called poly- $\beta(1-4)$ -2-amino-2-deoxy- β -D-glucose, it is a natural heteropolymer obtained by alkaline deacetylation of the amino acetyl groups of chitin, which is the main component of the exoskeleton of insects, crabs, shrimp, and krill [1].

The non-toxic, biocompatible and biodegradable characters, pH-sensitive, the cationic biopolymer based-chitosan represents a promising candidate for their employment in design and fabrication of biocompatible and biodegradable hydrogels used in medicine, tissue engineering, pharmaceuticals, cosmetic and other industrial applications within the biomedical and environmental fields [2]. The formulation of chitosan-based hydrogels is based on the association with glycerophosphate salt. The mixture remains liquid at room temperature, and it gels quickly when heated to body temperature [3-5].

This work, in the form of patent analysis, presents the state by introducing what has been innovated and patented concerning chitosan biopolymer. Furthermore, a detailed analysis of the patentability, by using the “chemical compounds search” of the Patentscope database, has been provided regarding publication dates, jurisdictions, and patent classifications.

Methods

The patent documents of chitosan biopolymer studied hereinafter were based on the “Chemical Compounds Search” of the Patentscope database [6]. It is a search service provided by the World Intellectual Property Organization (WIPO). It offers searches of international patent applications filed under the Patent Cooperation Treaty (PCT) [7].

The chemical structure search recognizes the names of chemical compounds in patent texts and their structures from the embedded drawings. Briefly, this tool standardizes all the different representations of chemical structures into the International Chemical Identifier (InChI). This is a textual identifier developed to make it easy to perform web searches for chemical structures. Also, InChIKey is another parameter that could be used for the chemical structure search. An InChIKey is a fixed-length (27-character) condensed digital representation of an InChI. It provides a precise, robust, and approved structure-derived tag for a chemical substance [6]. The chitosan biopolymer information used in this study is shown in Table 1.

Results and Discussion

The date on which a patent is published, thereby making it part of the state of the art [8,9]. Through the chemical structure search, 1169 patent documents concerning chitosan biopolymer were found. They concern patent documents published until 2021. The year 2016 saw the publication of 122 patent documents. However, the pre-2012 years (i.e., 1997–2011) saw the publication of 304 patent documents (Figure 1).

This lower number of patent documents found on the Patentscope compared to other databases could be explained by the difference in the services offered by each database. In fact, the Patentscope, as a research service of the WIPO, offers searches of international patent applications filed under the Patent Cooperation Treaty (PCT), as well as access to some national and regional collections, while other databases could be considered as a multicountry research service that has access to all patent applications at the international, regional, and national levels through databases provided by WIPO, regional offices, and national offices, respectively.

Table 1. The queries used in this study: InChI and InChiKey.

Molecule	poly-β-(1-4)-2-amino-2-deoxy-β-D-glucose
InChI	1S/C56H103N9O39/c1-87-56(86)65-28-38(84)46(19(10-74)96-55(28)104-45-18(9-73)95-49(27(64)37(45)83)97-39-12(3-67)88-47(85)20(57)31(39)77)103-54-26(63)36(82)44(17(8-72)94-54)102-53-25(62)35(81)43(16(7-71)93-53)101-52-24(61)34(80)42(15(6-70)92-52)100-51-23(60)33(79)41(14(5-69)91-51)99-50-22(59)32(78)40(13(4-68)90-50)98-48-21(58)30(76)29(75)11(2-66)89-48/h11-55,66-85H,2-10,57-64H2,1H3,(H,65,86)/t11-,12-,13-,14-,15-,16-,17-,18-,19-,20-,21-,22-,23-,24-,25-,26-,27-,28-,29-,30-,31-,32-,33-,34-,35-,36-,37-,38-,39-,40-,41-,42-,43-,44-,45-,46-,47-,48+,49+,50+,51+,52+,53+,54+,55+/m1/s1
InChiKey	FLASNYPZGWUPSU-SICDJOISSA-N

An applicant, or first mentioned applicant in the case of joint applicants, can apply for a patent at the appropriate patent office (e.g., United States Patent and Trademark Office, Moroccan Industrial and Commercial Property Office, Canadian Intellectual Property Office, etc.) under whose jurisdiction he normally resides or has his domicile, has a place of business, or the place from where the invention originated. In addition, a patent application must be filed in each country where an inventor is interested in obtaining patent protection. If patent protection is sought in a number of countries worldwide, an applicant may consider filing an international application under the PCT. It's a global system for filing patent applications administered by the WIPO [10].

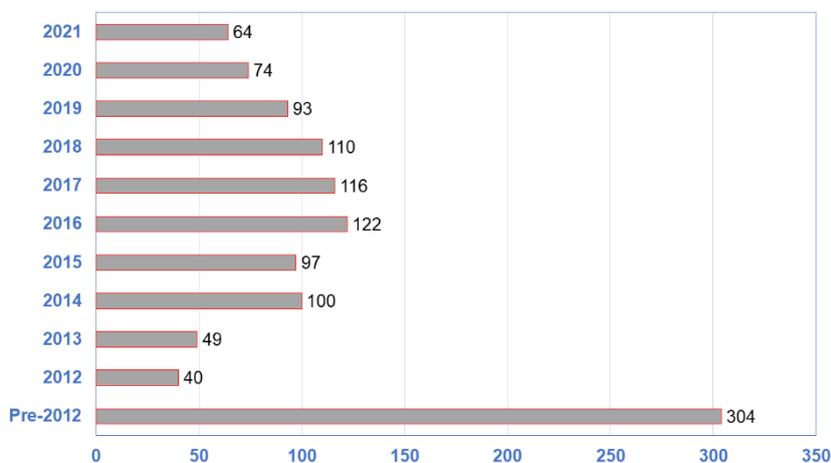


Figure 1. Evolution of the resulting patent documents of chitosan biopolymer as a function of the published date.

The jurisdictions of filed patents are presented in Figure 2. The global system for filing patent applications, known as PCT and administered by WIPO, encompasses 423 patent documents with a higher patent contribution per total of 36%. The United States, through the USPTO (United States Patent and Trademark Office), encompasses 402 patents with a higher patent contribution per total of 34%, as well as China, through the CNIPA (China National Intellectual Property Administration), encompasses 207 patent documents with a patent contribution per total of 18%.

In addition, the EPO (European Patent Office), where patent applications are filed regionally (i.e., Europe), encompasses 77 patent documents with a patent contribution per total of 7%. Finally, a lower patent contribution per total of 4 and 1% was registered in Japan through the JPO (Japan Patent Office), and the Republic of Korea through the KIPO (Korean Intellectual Property Office), respectively.

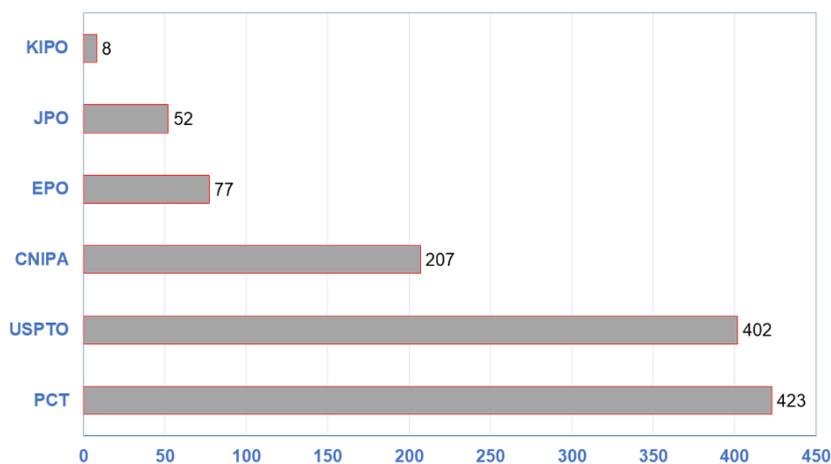


Figure 2. Jurisdictions of resultant patent documents of chitosan biopolymer.

The International Patent Classification (IPC) is a hierarchical system in the form of codes, which divides all technology areas into a range of sections, classes, subclasses, groups, and subgroups. It is an international classification system that provides standard information to categorize inventions and evaluate their technological uniqueness [11].

Concerning chitosan biopolymer, the top 10 IPC codes are presented in Figure 3. These IPC codes concern only patent applications under the PCT global system. In this case, the most IPC code corresponds to A61K which is a subclass that means preparations for medical, dental, or toilet purposes, such as devices or methods specially adapted for bringing pharmaceutical products. This subclass has recorded 1056 patent documents alone. Secondly, the subclass A61P that defines the specific therapeutic activity of chemical compounds or medicinal preparations has recorded 749 patent documents. Thirdly, the subclass C07D which means heterocyclic compounds such as macromolecular compounds, has recorded 722 patents.

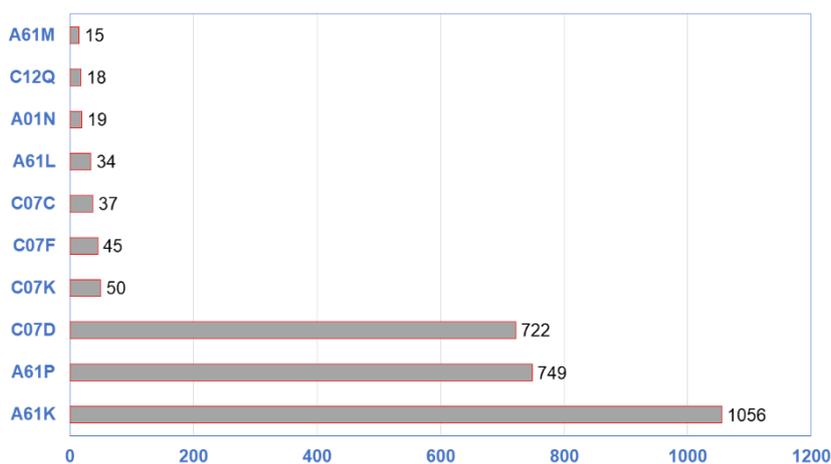


Figure 3. IPC codes (top 10) of resultant patent documents of chitosan biopolymer.

Conclusions

The chemical structure search recognized the name of the chitosan compound in patent texts and its structures from the embedded drawings. Thanks to the used queries (InChI and InChiKey) 1169 patent documents concerning chitosan biopolymer were found. The United States leads the patent race in the chitosan biopolymer sector. The innovation and improvement of chitosan concerned the raw materials,

synthesis and methods of preparation, formulations and fabrication processes, as well as applications. Based on the IPC codes, all filed patents concerned heterocyclic compounds (macromolecular compounds) and specific therapeutic activities of chemical compounds or medicinal preparations. In addition, this study demonstrated that the inventions included in the patents concern preparations for medical, dental, or toilet purposes, as well as devices or methods specially adapted for bringing pharmaceutical products.

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