

Bioethanol under the BRICS and the Brazilian scenario in view of the national strategy for science, technology and innovation (2016-2022)

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Abstract — Bioethanol is recognized as a potential alternative to petroleum-derived transportation fuels, with several advantages such as high octane number, low cetane number, and high heat of vaporization. The bioethanol production in Brazil uses sugarcane as feedstock and employs first-generation technologies based on the use of the sucrose content of sugarcane. In this sense, the present paper outlines the current bioethanol technology scenario based on the analysis of databases of patent documents filed at the main industrial protection offices. For this purpose, the Lens platform was used to search and analyze patent documents using keywords, according to the search stages. In this sense, the present paper outlines the current scenario of bioethanol technology in the BRICS based on the analysis of databases of patent documents filed at the main industrial protection offices. For this purpose, the Lens platform was used to search and analyze patent documents using keywords, according to the search stages. As a result, 1471 documents were related to patents and patent applications granted between 1989 and 2019. Regarding the BRICS, China ranks first in the number of registered documents, followed by Brazil and Russia. India and South Africa made no deposits during the study period. From the results, one can observe a trend of growth in the number of patent registrations in Brazil between the years 2016 and 2018, coinciding with the launch of the targets for the "energy" theme of the National Strategy for Science, Technology and Innovation of the Brazilian Government.

Keywords—Bioethanol, Brazil, BRICS, Technology.

1 INTRODUCTION

The indiscriminate use of fossil fuels by the mankind, especially since the dawn of modern civilization has led the world to a unique situation at present. In this sense, the concern for the environment has figured in the public policies of several nations. Inserted in these policies is the search of sustainable production, with the use of renewable energy matrices. The progressive depletion of fossil carbon sources has been causing increasing concern regarding both the security of their supply and greenhouse gas (GHG) emission and global warming. Therefore, the need of the use of renewable, sustainable, cost effective and environmental friendly energy source is at its peak (SOCCOL et al., 2010)

Some countries have promoted strategies to develop incentive policies for non-fossil energy, with the financing of sustainable projects. The economic bloc formed by Brazil, Russia, India, China and South Africa (BRICS) has this type of financing through the New Development Bank (NDB). The NDB was created in 2012 by this block with the objective of financing infrastructure and sustainable development, having approved until 2016, 05 (five) renewable energy projects, with a financial contribution of US\$ 911 million (BATISTA JUNIOR, 2016)

In a more singular perspective, Brazil has made efforts in the development of technologies focused on

the use of renewable energy sources. This statement can be corroborated by one of the strategic themes of its National Strategy for Science, Technology and Innovation 2016-2022 (ENCT&I) which deals with "Energy". The theme aims to "foster research, technological development and innovation in energy production chains, aiming to strengthen competitiveness and increase the diversification of the energy matrix, ensuring safety and efficiency" (BRAZIL p.108, 2016). ENCT&I lists some strategies to achieve the proposed objective, including the creation, expansion and strengthening of research, development and innovation (RD&I) networks and the promotion of public-private partnerships in the themes of gas oil and bioenergy.

Bioenergy is energy derived or obtained from any fuel that is derived or originated from biomass, which includes recently living organisms and their metabolic by-products. Similarly, biofuels are defined as fuels made from biomass resources, or their processing and conversion derivatives (ANP, 2018). Biomass is defined as all plant and animal matter on the Earth's surface. Therefore, harvesting biomass such as crops, trees, or dung and using it to generate heat, electricity, or motion, is bioenergy.

One of the most important biofuels over the years is bioethanol (BNDES, 2018). Bioethanol has been recognized as a potential alternative to petroleum-derived transportation fuels, with several advantages such as high octane number, low cetane number, and high heat of vaporization (BALAT, 2007). According to Balat (2008), bioethanol feedstock can be classified into three types: (i) lignocellulosic materials such as woody biomass, herbaceous perennials, and various wastes; (ii) starch-rich crops such as maize and grain sorghum; and (iii) sucrose-rich crops such as sugarcane and sugarbeet.

In Brazil, the sugarcane was chosen as the feedstock to produce ethanol and, as a consequence, agricultural and technological studies were greatly intensified, leading Brazil to a very favorable position in terms of bioethanol production in the world. With an average productivity of about 6000L/ha, the Brazilian sugarcane system of agroenergy represents the most efficient system (GOLDEMBERG, 2007). In 2018, for instance, the global production of bioethanol reached 28.57 million gallons (Table 1). Among the BRICS, Brazil leads the bioethanol production ranking, accounting for about 27.7% of the world bioethanol production and producing 5-fold more fuel than China and India together.

Table I
World Fuel Ethanol Production in 2018

Country	Millions of Gallons
United States	16.061
Brazil	7.920
Europe Union	1.430
China	1.050
Canada	480
Thailand	390
India	400
Argentina	290
Rest of World	549
Total	28.570

Source: Data from Renewable Fuels Association (<https://ethanolrfa.org/statistics/annual-ethanol-production/>, accessed August 9th, 2019).

The major advantage of the production of bioethanol from sugarcane bagasse in Brazil is the use of a residue, almost 10% of the total generation, which is usually rejected and cause environmental problems. Most of this production is directed to provide energy for automobiles, either in addition to gasoline or in its exclusive use, considering that the majority of Brazilian cars have engines with flexfuel technology, allowing the use of

any mixture of these fuels. (SOCCOL et al., 2010; BNDS, 2018)

In the 1970s, Brazil started a program, named as National Program of Alcohol (PróAlcool), to substitute gasoline by ethanol in order to decrease the dependence from politically and economically variable periods. PróAlcool was initially described as the answer to the first oil crisis as well as a solution to the problem of the fluctuation of sugar prices in the international market (Moreira and Goldemberg, 1999). However, the current agricultural, industrial, academic and technological scenario is quite different from that of the 1970s. Currently, some countries are producing ethanol from cellulosic feedstock at different development stages, and several public/private international projects have been developed in the biorenewable sector to promote a bio-based economy.

Therefore, the Brazil's challenge in developing technological solutions to improve bioethanol production processes and quality is clear and in line with the existing legal framework and ENCT&I. In this context, This paper describes an academic-technological prospection on bioethanol, presenting an overview of this topic in the BRICS framework, with emphasis on the Brazilian reality. In addition, this research will identify the alignment between the Brazilian scenario in terms of patents and the goals established in ENCT&I (2016-2022).

2 METHODOLOGY

The methodology adopted for the construction of the article was based on the mapping of information in order to identify the patent documents related to the Bioethanol theme filed at the main industrial protection offices in the world between 01/01/1970 and 10/08/2019. The interval was chosen in view of the beginning of the development of the PróAlcool in Brazil in the 1970s. To this end, the *Lens* (lens.org) technology-prospecting platform was used. The Lens is an open global cyberinfrastructure to make the innovation system more efficient and fair, more transparent and inclusive. The Lens is building an open platform for Innovation Cartography. Specifically, the Lens serves nearly all of the patent documents in the world as open, annotatable digital public goods that are integrated with scholarly and technical literature along with regulatory and business data.

The system allows searching by means of keywords, bibliographic fields, patent classification, citations, patent families, legal status, among others. The patent query was based in the keyword "bioethanol prod*", located in the title, or in the abstract or in the claims. As a filter, only the patent application and granted patent were used as document type.

3 RESULTS AND DISCUSSION

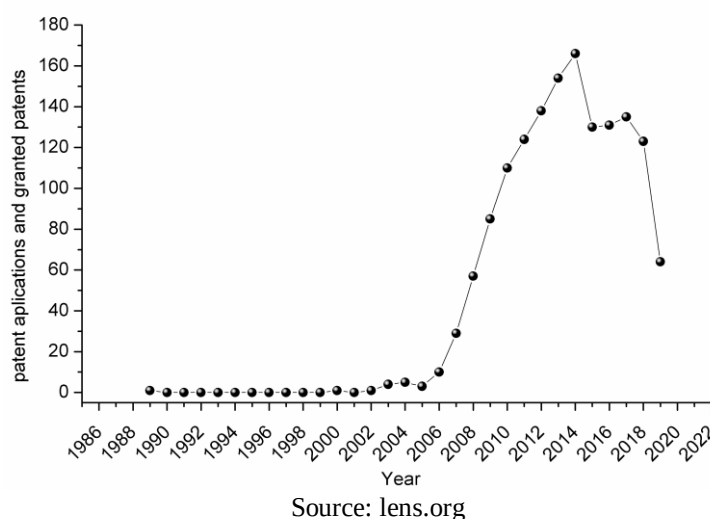
The search carried out at Lens platform with the terms previously described, resulted in 1471 patents of which 1076 patent applications and 395 granted patent (Figure 1). The first patent was granted in 1989 it is a motor-fuel in that the ethanol component consists of a mixture of bioethanol with more water than the water content of the ethanol/water azeotrope (at normal pressure), pure ethanol and/or ethanol with a water content. Conversely, the most recent patent is related to a method for producing bioproducts, such as bioethanol, comprising the use of a host (*Myceliophthora thermophila*) cell. From the data of Figure 1, we can observe that between the years of 1989 and 2005, the number of applications for patent deposits, as well as the patents granted, remained practically constant, although there were few variations. However, as of 2006, there was a relevant increase in this number.

It is well known that the twentieth century has seen phenomenal growth in the global economy and a continuous improvement in the standard of living in industrialized countries. However, as a form of environmental counterpart, the chemical industry, in this same period, began the search for the design, development and implementation of chemicals and processes to reduce or eliminate the use or generation of

substances harmful to human health and the environment. This was the guiding principle for the development of so-called *green chemistry*. The *green chemistry* movement received a boost in 2005 when three scientists – Yves Chauvin of France, and Robert Grubbs and Richard Schrock of the U.S. – won the Nobel chemistry prize for simplifying the process of synthesizing carbon compounds. Another green chemistry milestone occurred in 2008, when California’s governor, Arnold Schwarzenegger, backed legislation to tighten restrictions on toxic chemicals in household goods. The state’s Safer Consumer Products law took effect in 2013, and an initial 164 chemicals were targeted for scrutiny in 2014.

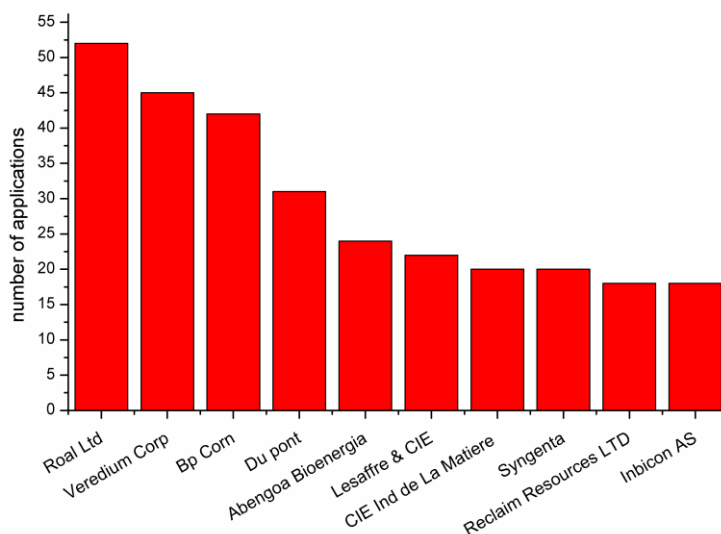
In this sense, it is reasonable to affirm that the increase in the number of patents observed between 2007 and 2014 may be due to the advent of green chemistry and the development of new synthesis technologies for the production of environmentally friendly substances.

Figure 1. Patent applications and granted patents among 1989-2019.



From the data extracted of the Lens Platform, it is noted that the largest patent applicant is the Finnish company Roal Ltd (Figure 2). The Roal Ltd is one of the world’s largest enzyme companies and produce enzymes for different industrial applications, e.g. for bioethanol production. The second major applicant is the Verenium Corporation with 45 patents, followed by BP Corp North America Inc. and Du pont® with 42 and 31 patents, respectively.

Figure 2. Top 10 patent applicants.



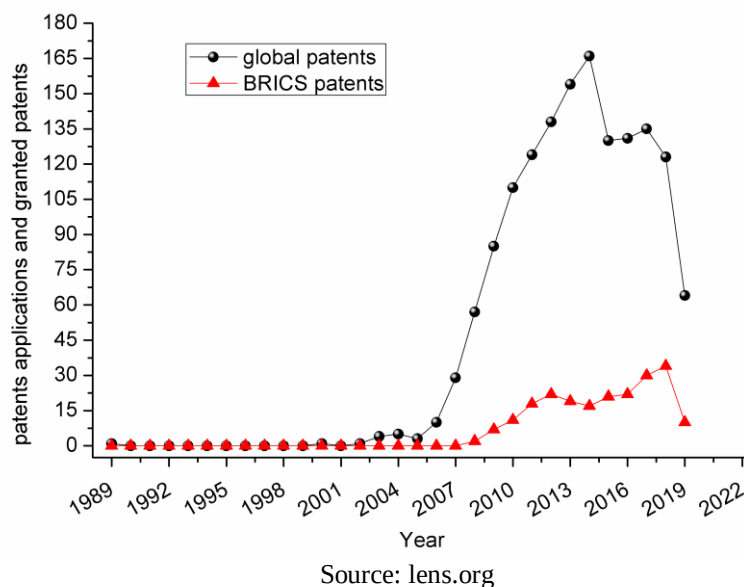
Source: lens.org

Concerning to the International Patent Classification (IPC), we observed that 55.36% of the results are related to the following IPCR codes: C12P7/06 (366 results), C12P7/10 (308 results) and C12P7/08 (140 results). The IPCR codes are related, respectively with the following descriptions: Ethanol, i.e. non-beverage; substrate containing cellulosic material and produced as by-product or from waste or cellulosic material substrate.

As already pointed out, the BRICS, an acronym for Brazil, Russia, India, China and South Africa, is the first multilateral group created and run by off-axis countries of developed and western nations. The primary objective of the group is to influence world geopolitics and the market, from the alleged importance of large developing countries with a crucial role in the economy. Therefore, a good metric for inferring the effectiveness in achieving the initial objectives of the BRICS is the number of patents.

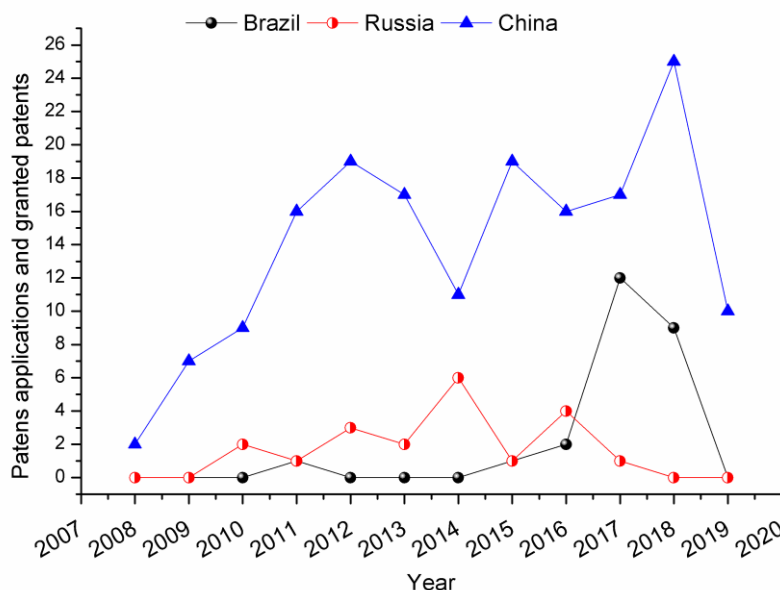
Therefore, the BRICS is responsible for 14.47% of the world's patents in the last 30 years, being China's first patent registration in 2008 (Figure 3). Similarly to the global results, there is a small but continuous growth in the number of patents as of 2007, corroborating the assumptions previously made regarding the global behavior observed in Figure 1.

Figure 3. Global x BRICS patent applications and granted patents among 1989-2019.



Analyzing the BRICS in detail, there is a discrepancy between the countries in terms of the number of patents. China leads the way with 168 patents, representing 78.8% of the total number of patents registered with the BRICS. Brazil ranks second with a modest 25 patent applications, 11.73% of the total, followed by Russia with 20 applications (Figure 4). Surprisingly, for the period studied, both India and South Africa did not register patents, being the fact most likely linked to social issues and which will not be addressed in the present work.

Figure 4. BRICS patent applications and granted patents among 1989-2019.



Source: lens.org

According to REN21, the top five nations in terms of existing biomass power capacity in 2011 are the United States, Brazil, Germany, China, and Sweden in order of one to five. The top two nations of this list are also the top two nations in bioethanol production, not coincidentally. However, as already mentioned, the number of Brazil patent applications and granted patents are still much lower than the China amounts. This observation can be explained from the population and geopolitical point of view, however, the deepening of these issues is beyond the scope of the present work.

The most important fact is that Brazil has increased the number of deposits between 2016 and 2018. The data coincides with the launch of ENCT&I (2016-2022) and may be strongly associated with the joint efforts of the business sector, research and development and the Brazilian authorities in terms of increasing the competitiveness of ethanol and making new biofuels viable, especially bioethanol.

4 CONCLUSION

Given the data, it is reasonable to say that the BRICS has been contributing to the development of clean and green energies, as well as to bioethanol production on the world stage. Although the number of patents is modest within the BRICS group, it can be seen that Brazil has increased its production in relation to other members over the years. In particular, it is clear that the increase in the number of Brazilian patents coincides with the launch of targets for the ENCT&I "energy" theme and that, therefore, it is expected that by the end of 2022 there will be a considerable increase in Brazilian intellectual protections in the bioethanol theme.

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