An analysis of overlapping terms to define articles key words: The use of VOSviewer tool applied to technology transfer in fuel cells

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Abstract

Several ways of structuring sources of innovation have been provided in order to achieve competitiveness and reduce the impacts during a crisis time. The use of renewable technologies that also reduce global carbon dioxide emissions and dependence on fossil fuels has been encouraged. The objective of this study was to identify the main groupings of terms through the VOSviewer tool, related to technology transfer in fuel cells found from searching in the Scopus database repository. The structuring of relationship networks of the terms of greater co-occurrence of technology transfer in fuel cells enabled a verification based on clear definitions, providing a synthesis of the most researched devices, or potentially found in the Scopus database. The search provided a number of 170 articles in an unbiased way presenting an overview of the main understanding of selected articles from 2015 up to the present, indicating central operators to be considered, as well as innovation perception to support future economic growth, focusing on most significant terms on the searched parameters.

Keywords: Knowledge transfer, Decarbonized Energy, Bibliographic Mapping.

1. Introduction

In the globalized world, economies are becoming increasingly competitive, investments in technological innovation are deeply related to development. Kloosterman et al. (2015) mentioned that the added value of science is materialized through technology, allowing society to benefit from new discoveries. Such benefits are diverse (such as health, economy, commerce, transport, communication, sustainability, conservation of cultural and historical heritage, security and justice), but they have in common the demand for increased quality of life and the possibility of progress and prosperity in societies. The science cycle, innovation and development are the reasons behind the massive and structural investment in scientific programs in developed countries (Fukuda, 2020).

Technologies development from intensive knowledge innovations can be described as strategic for companies and has been encouraged to provide alternative techniques capable to achieve decarbonization

goals (ASONGU et al., 2017 and SILVA et al., 2017). According to Malta and Pereira (2018) sustainable technology production is an articulated process based in ecological potential, environmental conditions and socio-cultural values. Garrone et al, (2018) stated that the concept of sustainable innovation is broad, focusing on the reduction on the effects that cause negative impact to the ecosystem.

In this scenario of sustainable innovations, the development and improvement of fuel cells is an excellent alternative to energy generation. Being a knowledge-intensive technology, fuel cells is reported when investigating the location where research was carried out, are primarily at the heart of researches conducted by the research centers (Su et al., 2020; Staffell et al., 2019; Dwivedid, 2020; Ouyango et al., 2020; Messing; Kjeang, 2020; Wang et al., 2020).

Technology transfer is directly linked to know-how, i.e. technological development of production. This perspective is supported by the ongoing global trends of technological, economic and social changes, those the companies struggle to keep following (Fukuda, 2020). Thus, in order to provide technology transfer, contracts and/or agreements must be signed, after negotiations, with the elaboration of well-defined and transparent clauses to meet legal agreements and effective knowledge transfer in an environment of legal security, leading to a positive influence on the quality of the outcome, i.e., success in commercialization (Santos et al., 2015) and (Sun; Zhang; Kok, 2020).

It is noticeable that the performance of an analysis to obtain indicators related to technological innovation processes that involve the transfer of technologies related to fuel cells is very important to the guidance of a more sustainable energy matrix, not only from the theoretical point of view but also from the pragmatic point of view of the tool use which allows the visualization of research of overlapping terms what express the market interest. The objective of this study was to identify the main groupings of terms through the VOSviewer tool, related to technology transfer in fuel cells found from searching in the Scopus database repository.

2. Methodology

The literature search was performed using a procedure of term network formation and data visualization about what is more relevant in order to simplify the study (Treinta et al., 2014). Then, an article folder was generated containing 170 peer-reviewed articles. The search task was conducted considering a cautious, pluralist and flexible approach, according to the following criteria (Gallart, 2018): first, only articles focused on fuel cell technology transfer were chosen. Secondly, a restriction was applied to the search for academic literature to define economically viable fuel cells with a potential to be produced in a commercial way. Finally, an exploratory assessment was carried out to define the most recurrent keywords with promising aspects.

The procedure of analyzing overlapping terms in order to define keywords began after the following activities were completed:

Step 1: Choose the data repository, define search terms and time horizon;
Step 2: Choose the overlapping term viewing tool;

2.1 Regarding the data repository, definition of search terms and time horizon

The preparation of the manuscript folder was possible after the database choice, onsidering the digital environment in which ideas were shared and examined by pairs. This decision was based on the data repositories of World Wide Web-based platforms that synthesize researchers' ability to securely access and manage research information remotely (Gallart, 2018). The quality of scientific information is guaranteed, since the content has usually been examined by qualified professional members of scientific committees.

This work used the Scopus databases, focusing on aspects related to the storage of abstracts and citations from books, scientific journals, thus providing an approach at an international level of researches production, eliminating repeated works among the platforms. It is important to consider literary contribution which state that to analyze the state-of-the-art reviews of scientific productions of researcher's interest, limitations of the specialized research system should be observed and should be used citation information from major platforms, thus providing a minor margin of error and avoiding crossing citations (Gusenbauer, 2020) and (Guimarães; Araújo; Sousa, 2020).

Due to the determination of the data repositories, the establishment of the terms to be used was initiated, in such a way that they were intrinsically related to the research goals. Considering that the objective of the research is to discuss two central themes, technology transfer and fuel cells, the descriptors ("technology transfer" and "fuel cell") and ("fuel cell" and "viable cost") were defined in order to verify the research profile in fuel cells that have the potential to be economically viable. Furthermore, when using Boolean research logic, it is important to note that the connective logic operators "and" and "or" were used, because this expedient of usage of the connectors explains the existence of many or few manuscripts located (Tavares; Rodrigues; Filho, 2012).

In this sense, it should be pointed out that the most common search operators are the "AND", "OR", "NOT" and they are used respectively: to locate documents containing all the distinct subjects by the operator; to locate documents containing one of the distinct subjects by the operator and to exclude documents containing certain words from its search. (Scopus Reference Guide, [n. d.]).

Thus, a search based on titles, abstracts and keywords in the Scopus database was performed, selecting recent scientific publications from the last 5 years to build visual maps of keywords using the software applied to co-occurrence data. It was found respectively a number of 27 articles for the search based on the logical structure ("technology transfer" and "fuel cell") and 143 articles for the search based on the operator ("fuel cell" and "viable cost") and the files were exported according to the CSV Excel extension.

2.2 Regarding to the viewing tool

The used tool to build networks of terms for the overlap visualization was the VOSviewer software (Jan and Ludo, 2010), adjusted to visualize bibliometric data, selecting the compatible option with the searched databases, choosing the saved CSV Excel file, based on the determined operators and later defining the co-occurrence analysis, complete counting and keyword index.

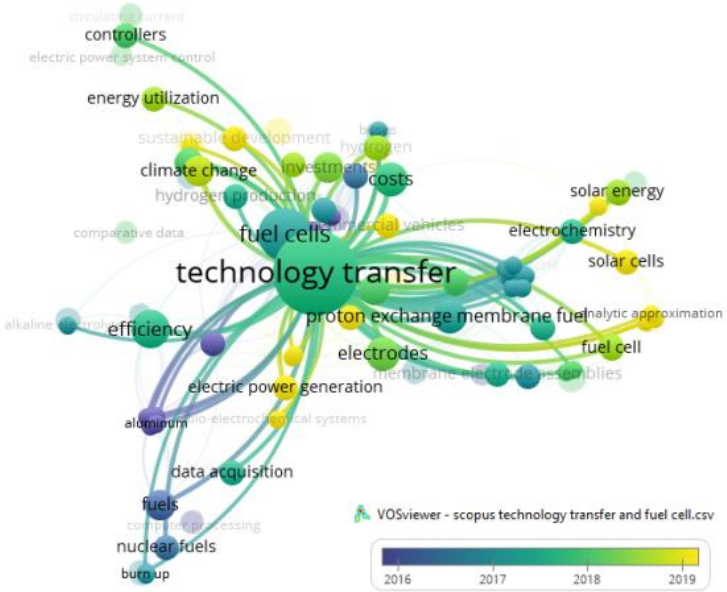
Two types of maps were used. A map that links terms over time in a network, and the other map to check the general distribution of co-occurrence regarding to the activity intensity verified by color and size variation. The colors vary from blue to red. Where blue represents low intensity activity and red represents

high intensity activity. The size of the grouping sphere indicates the number of publications per subject (Zahedi; Eck, 2014). In fact, these maps helped to analyze the information formed by the main terms of the research field over time and the most and least active terms.

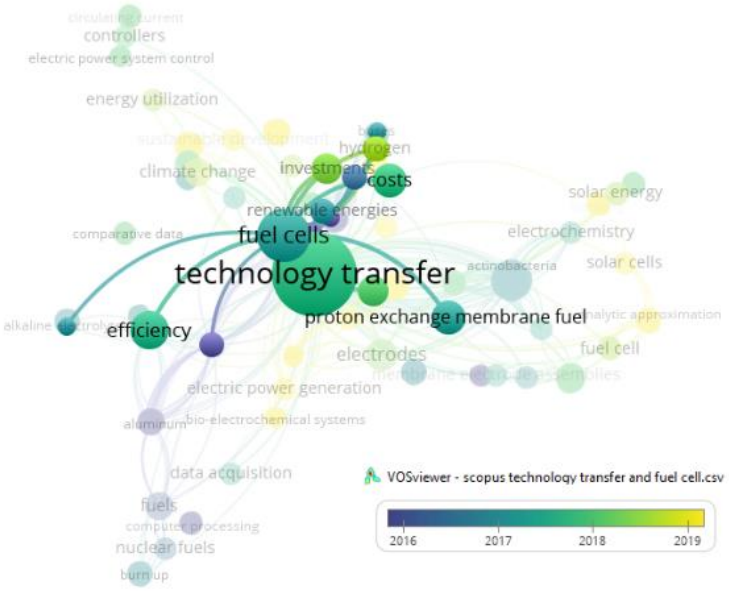
3. Results

The overlapping terms views applied to the logical structure of search ("technology transfer" and "fuel cell") is shown in Figure 01 (a and b) which provides an overview of the interconnection among the term grouping spheres of the network composed by the central terms respectively ("technology transfer") and ("fuel cell"). As far as the grouping spheres are located in positions further apart, there will be a lesser correlation among the grouped terms.

Also in Figure 1 is possible to notice that the terms technology transfer and fuel cells are strongly related to each other, not only as a priority, but also as a main network of terms with: (*microbial fuel cells, electrodes, proton exchange membrane fuel cells, efficiency, costs, electrode, electrolytic reduction, climate change and oxygen*). It is also noticeable that since 2018 the groupings of publications with the terms (*investiments and hydrogen*) have been highlighted.



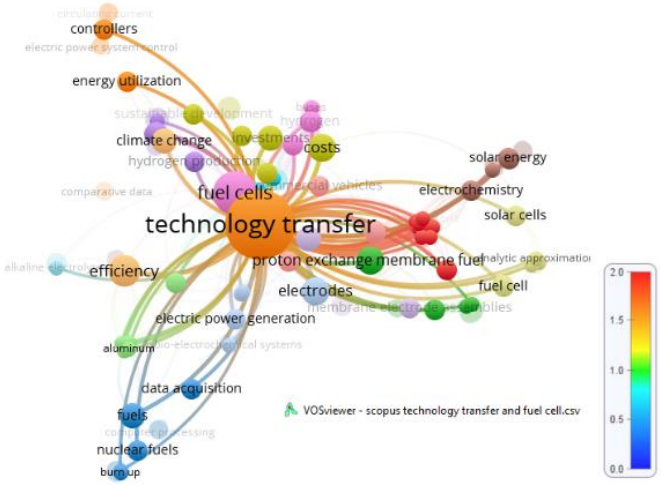
(a)



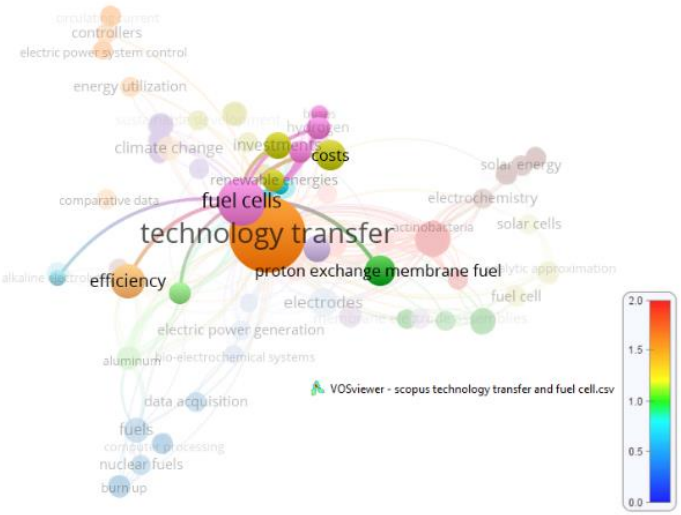
(b)

Figure 1- map terms display related to time: (a) technology transfer and (b) fuel cells, through the VOSviewer tool to logical operators (*"technology transfer"* and *"fuel cell"*).

Considering the analysis regarding the groupings geometrical feature, as well as the activity intensity through the search (*"technology transfer"* and *"fuel cell"*) (Figure 2), it seems that the term "technology transfer" is object of intense publication activity represented by the orange color. Regarding to the used parameters, the term "fuel cells" is represented by a lower intensity color and smaller volume of the grouping sphere compared to the term technology transfer. On the other hand, Figure 2 lists the subjects (*investments, efficiency and cost*) with more intense color representation and similar size which indicates that the publications for the researched terms may respresent something to the keywords choice consideration.



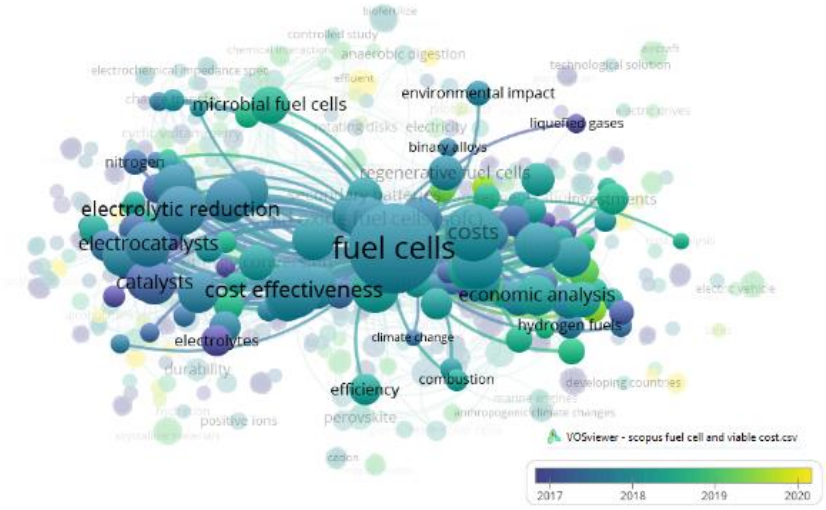
(a)



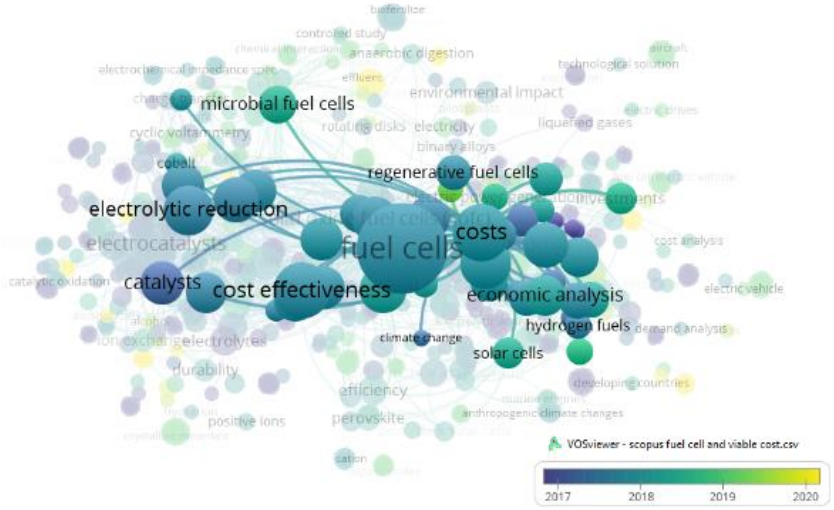
(b)

Figure 2- Map terms display related to activity intensity: (a) technology transfer and (b) fuel cells, through the VOSviewer tool to logical operators ("*technology transfer*" and "*fuel cell*").

Figure 3 shows the matching groups of terms forming co-occurrence networks applied to the logical utilized operator ("*fuel cell*" and "*viable cost*").



(a)



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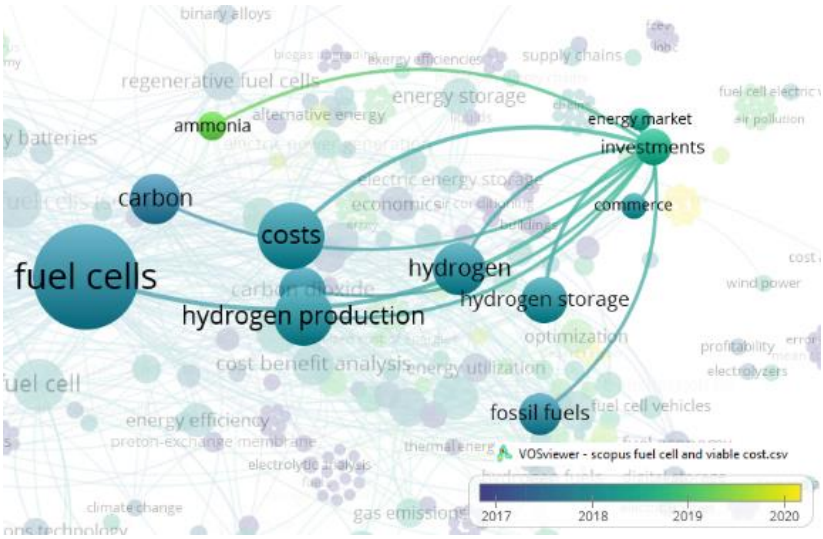
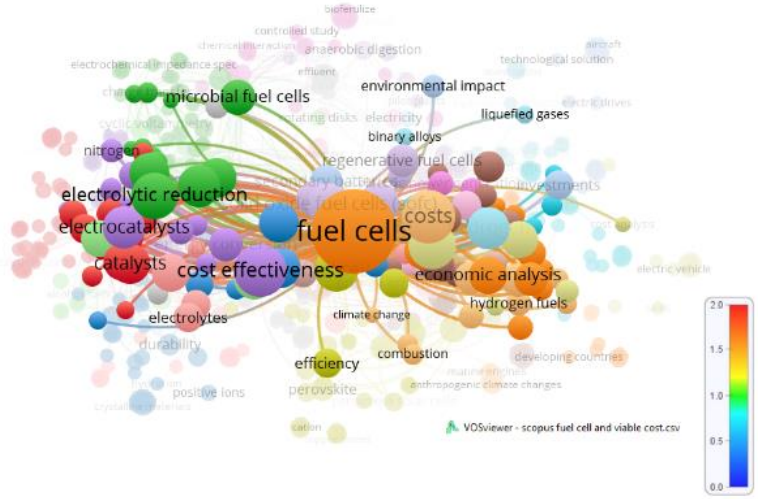


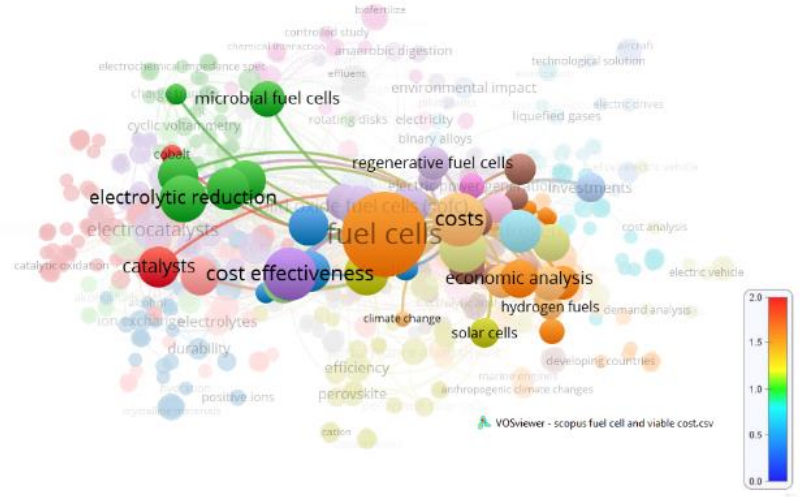
(c)

Figure 3- Map terms display related to time: (a) fuel cells, (b) cost and (c) investment through the VOSviewer tool to logical operators ("*fuel cell*" and "*viable cost*").

The observation of the networks allows provides an understanding that the integrated terms of the logical operator used in the searches (a) and (b) are quite similar positions, which indicates a strong relationship between them. Also in (c) a network built based on the term *"investments*" can be considered by the representation of the location of the spheres of terms (*hydrogen, carbon, and ammonia*). The network has been established in a dominant way from published terms from 2018, as follows: (*fuel cells, costs, cost effectiveness, hydrogen production, hydrogen, electrolytic reduction oxygen, catalysts, carbon, próton exchange membrane fuel cells, platinum, solid oxide fuel cell, microbial fuel cells, methanol e cathodes*). The Figure 4 presents networks formed by the terms "*fuel cells*" (a), "*costs*" (b), "catalysts" (c) and "methanol" (d). The groupings terms associated with the fuel cell operating mechanism are positioned far from the cost related grouping, indicating a weak relationship.


microbial fuel cells
environmental impact
liquefied gases
binary alloys
nitrogen
regenerative fuel cells
electrolytic reduction
electrocatalysts
fuel cells
costs
catalysts
cost effectiveness
economic analysis
hydrogen fuels
electrolytes
climate change
durability
combustion
efficiency
perovskite
positive ions
developing countries
VOSviewer - scopus fuel cell and viable cost.csv

(a)


microbial fuel cells
environmental impact
liquefied gases
binary alloys
cobalt
regenerative fuel cells
electrolytic reduction
costs
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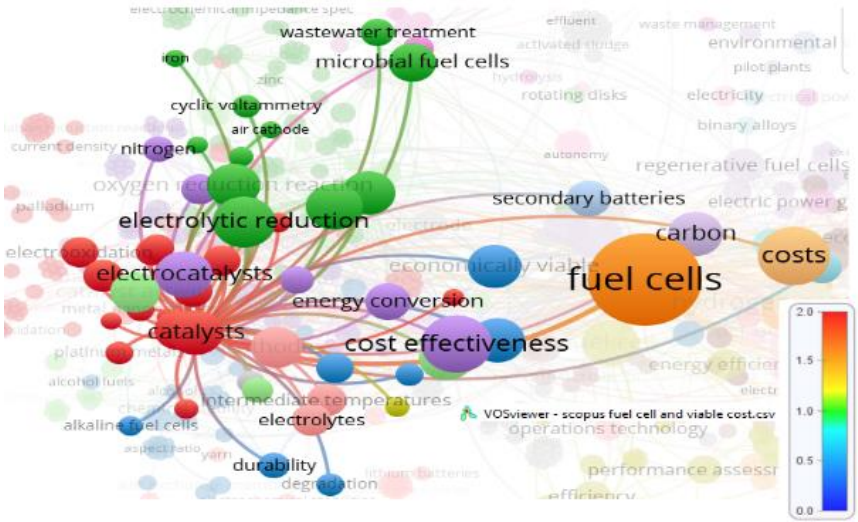
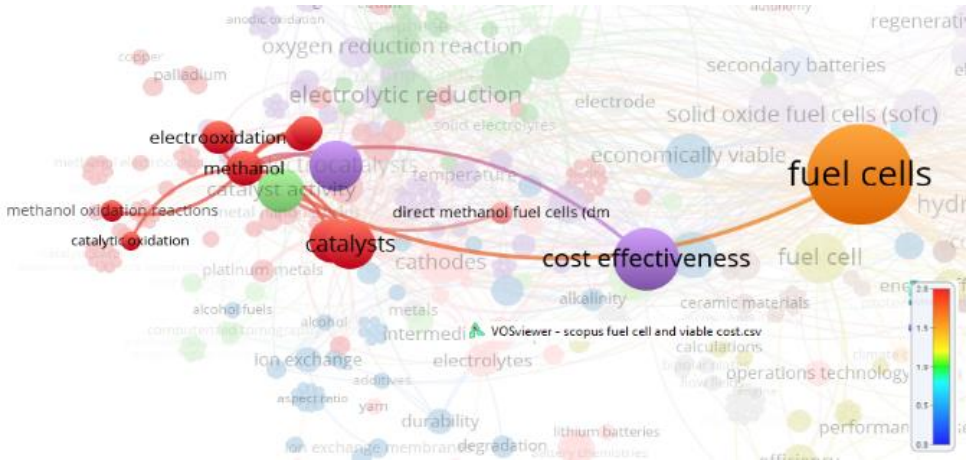
fuel cells
catalysts
cost effectiveness
economic analysis
hydrogen fuels
climate change
solar cells
electrolytes
durability
efficiency
perovskite
developing countries
VOSviewer - scopus fuel cell and viable cost.csv

(b)


wastewater treatment
microbial fuel cells
cyclic voltammetry
air cathode
nitrogen
secondary batteries
electrolytic reduction
carbon
costs
electrocatalysts
fuel cells
energy conversion
catalysts
cost effectiveness
intermediate temperatures
electrolytes
alkaline fuel cells
durability
degradation
VOSviewer - scopus fuel cell and viable cost.csv

(c)

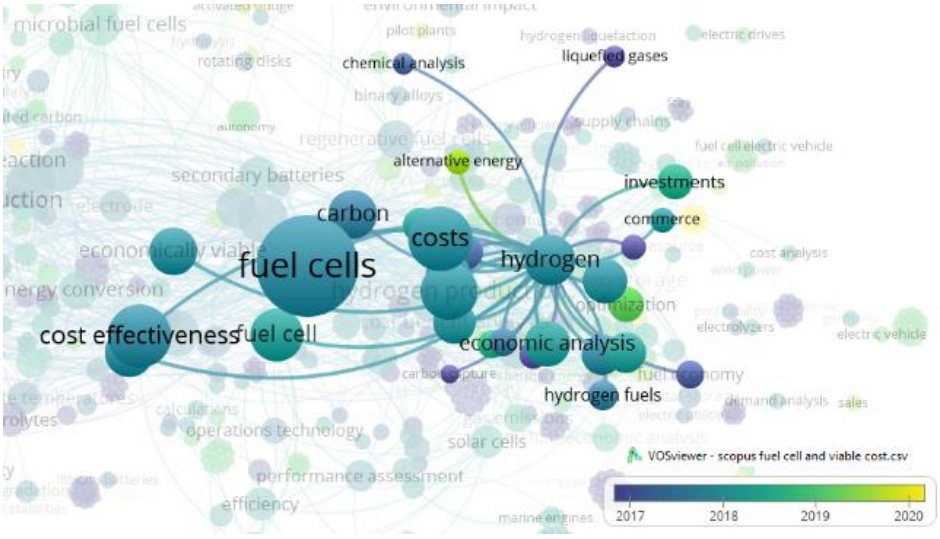


(d)

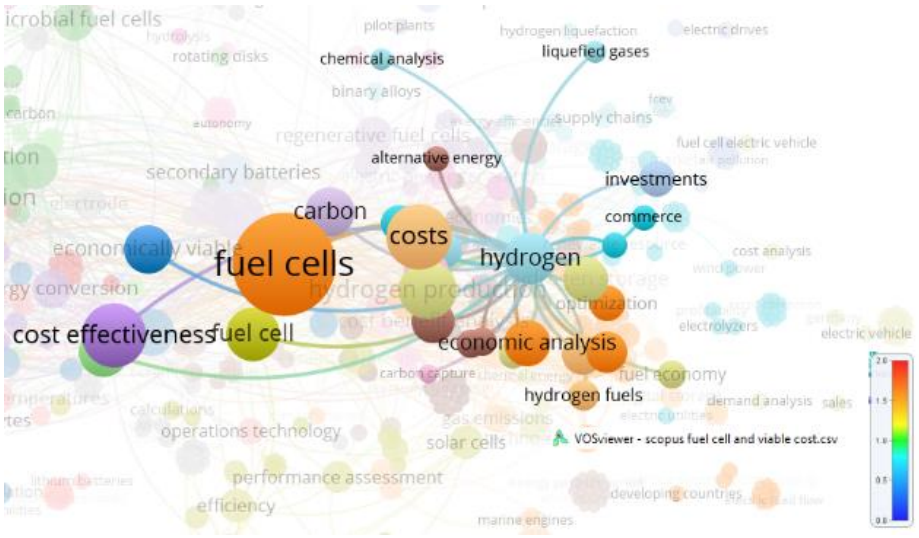
Figure 4- Map terms display related to activity intensity: (a) fuel cells, (b) cost and, (c) catalysis and (d) methanol through the VOSviewer tool to logical operators ("*fuel cell*" and "*viable cost*").

The groupings of terms linked to the conversion principle that were represented by the color red, i.e. the ones that showed high research interest by the scientific community was analyzed. Thus, the groupings networks of terms, Figure (c) and (d) were selected, where was verified that the terms groupings spheres present similar dimensions and equivalent distance to the used terms. Therefore the visualized groupings as (electrocatalysts, electrolytic reduction, microbial fuel cells, methanol and eletctro oxidacion) have a weak relation regarding to the cost.

On the other hand, in the analysis of the grouping network related to the term "hydrogen" (Figure 5), it is possible to observe a predominant composition of terms for publications established from 2018, a close position to the search structure, meaning a strong relationship between the terms. It was noticed that the representation by the blue color, provides an assunption that this term has low scientific research activity. Also it seems that the 'carbon' grouping is always in a high reference position considering the applied terms.



(a)



(b)

Figura 5- Map terms display through time of (a) the activity intensity and (b) for the network generated for the term hydrogen through the VOSviewer tool to logical operators ("*fuel cell*" and "*viable cost*").

In order to synthesize the choice plan, the terms for the composition of the logical structure were established, as presented in Figure 6 - Synthesis of the terms groupings. The term ("*hydrogen*") was chosen for the keywords composition of the Boolean structure, to integrate close spatial relationship with the searched terms and searched intensity, showing what seems to be a low explored search field.

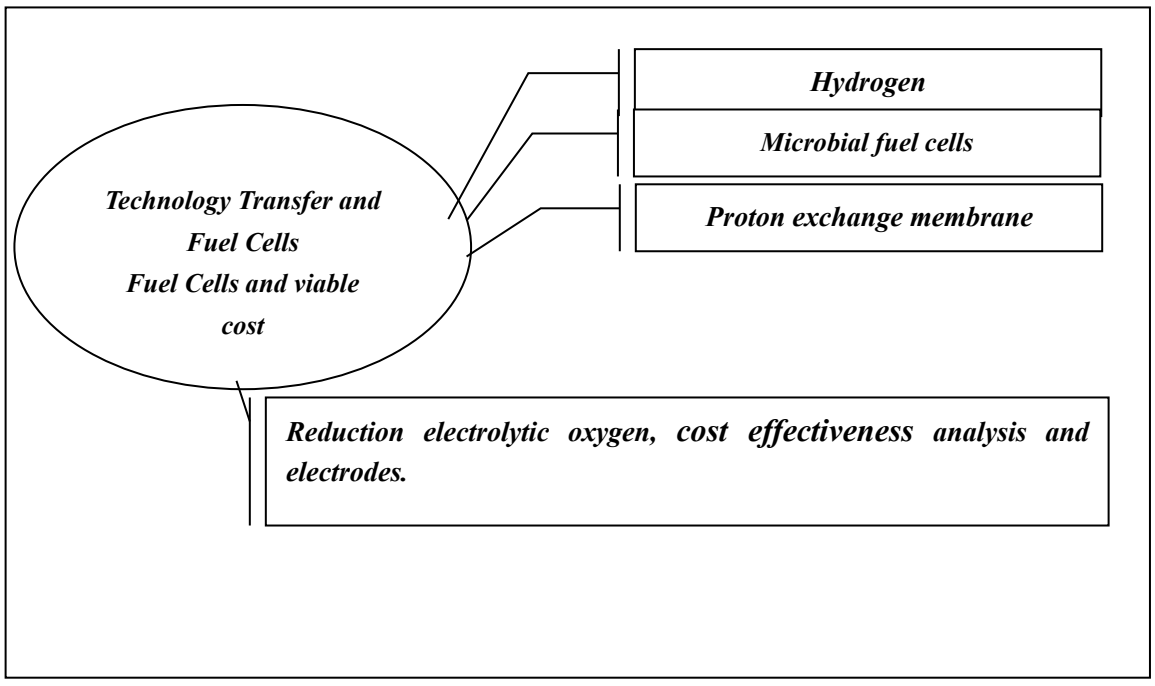


Figure 6- Synthesis of the terms groupings.

The formed groupings by *("cost effectiveness", " Microbial fuel cells", " electrodes ", "proton exchange membrane fuel cells", "electrolytic reduction oxygen"*) were presented as relevant operator terms, either because they had been researched intensively or because they hold a promising relationship for further research. Finally, the visualization and analysis of the overlapping of groupings of terms proved to be

important in view, indicators related to the improvement of devices associated with the functioning mechanism in order to seek more economical means that can be applied to fuel cells, that is, to an efficiency ratio between the costs incurred and the benefits arising, adapting as support for the choice of articles.

4. Final Considerations

The analysis of the overlapping of grouping terms using VOSviewer tool, allowed anetwork visualization, and therefore the choice of indicators related to technological innovation processes applied to the fuel cell technologies transfer which present promising scientific evidence to the market.

The need for investigation and interpretation through a structured procedure seems appropriate, once there has been no search of literature on the subject, and also because the categorization of the research using the applied methodology proved to be relevant, as it offered direction and structure for the most recurrent terms found in the specialized and peer-reviewed literature described when used the Scopus database in the last 5 years.

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