International Journal of Design & Nature and Ecodynamics
Vol. 17, No. 1, February, 2022, pp. 1-8
Journal homepage: http://iieta.org/journals/ijdne

Mapping Research Trends in Publications Related to Bio-Jet Fuel: A Scientometric Review

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https://doi.org/10.18280/ijdne.170101

Received: 12 December 2021
Accepted: 18 February 2022

Keywords:
fighter aircraft, biofuels, bio-jet fuel, biofuels jet, VOSviewer, bio-aviation

ABSTRACT

It is a fact that society has increased the need for mobility throughout the world. In that regard, it has become aware of the problems associated with the use of fossil fuels such as jet-fuel. As alter-natives, the use of bio-jet fuel has been proposed, which is a biofuel that researchers have evaluated and developed as an environmentally friendly alternative. The development of research on the topic of biofuels has generated a growing number of alternatives in the methods, technologies and raw materials for the production of bio-jet fuel. In this work, a bibliometric study has been developed to analyze the evolution of publications, the contribution of authors, countries, in terms of citation productivity on the topic of bio-jet fuel. Scientific publications were searched in the Scopus database for the period 2001 to 2021. The results showed that the publications have grown exponentially in the last 10 years. The most influential institution and country are from China. "Renewable and Sustainable Energy Reviews" is the most cited journal in the field of bio-jet fuel. The growth rate of publications was estimated using the Gompertz model, the rate was 0.2232 y^{-1}. Most of the documents were published in journals Q1.

1. INTRODUCTION

Today´s society´s need for comfort has resulted in a shortage of petroleum resources, as well as pollution issues related to petroleum extraction, refining, transportation and use. Since the Paris-Agreement was approved in 2015, there has been an increasing awareness of climate change and its catastrophic impacts throughout the world [1]. The transport sector is a major consumer of oil resources, the requirement for fossil fuel is forecasted to grow 1.3% each year up to 2030, whereas the carbon emission from the transport system would likely increase to 80% [2].

Biofuels (advanced) are one of the possible options for decarbonizing transportation at least in the short term, particularly for aircraft, marine, and heavy/duty vehicles, which lack quick alternatives [3]. The use of biofuels for the transportation system has proved to be effective in reducing soot [4]; specially in the recent decade, the aviation industry has been the largest investor in more efficient and environmentally friendly technologies to reduce greenhouse emissions considerably [5]. Using sustainable and renewable aviation fuels, known as bio-jet fuels, is proposed as a viable alternative for achieving long-term reductions in air pollutants by 2050 [6].

Bio-jet fuels also called bio-kerosene are a group of renewable aviation fuels with high-performance hydrocarbons (C8-C16), and these biofuels have similar properties to jet-fuel that are generated from oil [1, 7, 8]. The feedstocks used in the manufacture of jet fuel are diverse and can be divided into 3 generations. The first generation is based on edible crops (wheat and corn); the second generation can be produced from lignocellulosic biomass and non-edible oil crops and animal fats; the third generation is typically based on macroalgal and algal feedstocks [9].

Several researchers have investigated conditions, feedstocks, simulations, risks and factors associated with the bio-jet topic. This development has an important economic, environmental and social impact. Although a variety of documents on bio-jet fuel are published, the society, the government and the scientific community need to know the main countries, authors, citations, universities, journals and areas that have the greatest influence on the topic analyzed. For this reason, the application of bibliometric indicators is necessary to know and predict future research [10].

Bibliometric analysis allows to identify international research activity in all areas of knowledge [11], the analysis of bibliometric indicators to facilitate to know the direction of the topic and the impact of the publications in the academic, government and social context.

Although the topic of bio-jet fuel has high relevance in the international context, nowadays there are no bibliometric studies that describe the evolution of scientific publications. Therefore, it is necessary to cover this area of knowledge for the above reasons.

The aim of this publication is to determine the evolution of the publications on the topic of bio-jet fuels through a bibliometric analysis and mapping of research. In this work, the Gompertz model was proposed to determine the growth rate of publications and to estimate the global evolution of the bio-jet fuels topic in the world.

The rest of the present study is organized as follows. In section 2, the materials and methods describe the database, period, equations and software. Then it is followed by the results and bibliometric indicators, in addition to the discussion of results. Also, the description of conclusions and limitations on the topic of bio-jet fuels. Finally, the contributions and references are presented.

2. MATERIALS AND METHODS

The bibliographic database has a key role in bibliometric research to analyze the development of scientific activity of researchers, organizations, countries and co-workers [12]. This work adopted a bibliometric study of the topic of bio-jet fuel. The data were obtained from the Scopus database, which is one of the largest and most comprehensive databases [13-15]. In addition, the Scopus database has an international scope, it has a wide coverage of time, metadata are downloadable and of quality in the process of reviewer and publications [16].

This study was divided into four phases: search criteria definition, data collecting, export and standardization of data, finally data analysis, as proposed by previous works [17, 18].

The set of words or search criteria and Boolean-operators were defined in the section. It was implemented a query string with the word “jet fuel”, “aviation jet”, “aviation jet fuel”, however the criterial was generic and disperse. The next step to define the criterial was added the word “bio” due the objective of this study, finally in database was defined: “Title-Abstract-Keywords” and the keywords used were “bio-jet” AND “fuel*”. The signs (“ ” and *) were used in the search to extract the exact phrase and the variation in the singular or plurals of the words. The documents considered are only published in the English language and between the period time from 2001 to 2021. The information download was carried out on September 1st, 2021 and it was placed in Microsoft Excel software. A total of 211 items were also downloaded in csv format to convert into .xls format.

The data were sorted and classified in the Microsoft excel software. The bibliometric analysis was developed under descriptive conditions (quantitative and qualitative) of evolution of publications, most influential journals, most cited publications, authors and affiliations, subjects and countries.

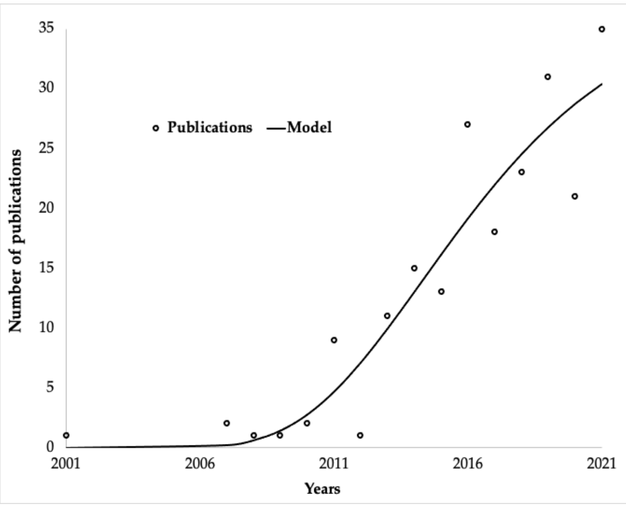

Figure 1. Evolution of publications of bio-jet fuel in the Scopus database, growth rate 0.2232 y^{-1}, R^2=0.8754

The growth curve of publications can be fitted using the Gompertz model (Eq. (1)) with Microsoft excel [19] and the solver function (2) [20].

$$P(y) = ae^{-be^{-\mu t}} \tag{1}$$

$$\left[P_{(y)scopus} - P_{(y)model}\right]^2 \tag{2}$$

Visualization is a key technique for extracting information from a database, it is a tool that helps to understand patterns and trends [21]. VOSviewer software is a tool that builds networks and provides clustering of information. The VOSviewer software was used in the map network analysis for the visualization of indicators related to the bio-jet fuels topic.

3. RESULTS

3.1 Evolution of publications of bio-jet fuels

A total of 211 publications fulfilled the search criteria. The type of publications shows that most of them are Articles (86.88%), followed by Conference Paper (15.64%), Review (10.9%), Book Chapter (1.9%) and others (5.6%). The most influential language is English (94%) and Chinese (5.6%). English is the global language in the scientific community and coworker authors prefer the universal language.

The results of publications initiated a significant growth from 2010 to 2021. The growth exponential shows that the scientific community has interest in the subject of bio-jet fuels and the relationship with climate change. Figure 1 reports the evolution of publications considering the best fit to specific data obtained in the Scopus database.

The Gompertz model was used to determine the growth rate and the coefficient of determination (R^2) was determined using the regression function of Microsoft excel. The rate of publications of the scientific community on the topic of bio-jet fuel was 0.2232 y^{-1} with a coefficient R^2=0.8754; this data can be used in the Gompertz model to determine the evolution of publications in the next years on the same topic.

Different models have been used to represent the trends of the growth pattern of the publications, the main models are exponentials [22] with a rate of 0.2439 years^{-1} in the topic of adoption of water systems to climate change uncertainties, rate of 0.0728 years^{-1} ($R^2=0.87$) in the topic of wastewater management [17]; other models are logistic with a rate of 0.1898 years^{-1} ($R^2=0.9132$) in the topic of sugar beet to biofuels [23]. In this context, the quadratic model was used to estimate the rate of corporate social responsibility social [16].

3.2 The most influential countries in bio-jet fuels

Table 1 shows the top 15 rankings of countries with influence on bio-jet fuels in this study. It is noteworthy that although China has the first rank of publications, the total number of citations is higher in the United States. Also, the most influential Latin-American country in this ranking is Brazil, followed by Mexico, however the number of citations is much lower than the top 2 in Table 1. When exploring the influence of publications in the field, it is necessary to determine the ratio of total citations and total publications. In this case, it is evident that South Africa has a high ratio (35.6), followed by India (31.50) and the United States (26.98). Note that although Taiwan is part of China, it has been considered separately derived from the fact that the consulted database handles it that way.

Table 1. Ranking of the most influential countries in the bio-jet fuels topic

Ranking	Country/Territory	TP	TC	TC/TP
1	China	69	1001	14.51
2	United States	45	1214	26.98
3	Brazil	12	88	7.33
4	Malaysia	11	296	26.91
5	Taiwan	10	250	25.00
6	South Korea	9	76	8.44
7	United Kingdom	8	62	7.75
8	Germany	6	76	12.67
9	India	6	189	31.50
10	Japan	6	93	15.50
11	Mexico	6	42	7.00
12	Australia	5	51	10.20
13	Indonesia	5	34	6.80
14	South Africa	5	178	35.60
15	Sweden	5	25	5.00

Abbreviations: Total of Publications (TP), Total of Citations (TC).

3.3 Most cited bio-fuel jet documents

The most frequently cited documents indicate their importance or strong relevance as reference material [24]. The top 3 documents with more than 100 citations are the review titled "Bio-jet fuel conversion technologies", which has received a large number of citations (182), followed by another review titled "Aviation biofuel from renewable resources: Routes, opportunities and challenges" (170) and the article titled "Life cycle assessment of bio-jet fuel from hydrothermal liquefaction of microalgae" (119).

In Table 2, it was observed that the authors published on bio-jet fuel in high impact and quality journals, where 9 out of 10 journals have quartile 1 (Q1). The distribution of documents are 6 articles and 4 reviews (from the journal Renewable and Sustainable Energy Reviews). Wang et al. [25] reviewer the main technologies for the production of renewable jet fuels from feedstock to commercialization. Kndaramath et al. [26] follow the same pathway of describe the bio-aviation biofuel considering the opportunities and challenges of the production of jet fuels. Fortier et al. [27] described the analysis of life cycle of two pathways related to production of bio-jet fuel of the hydrothermal process of microalgae. Zhang et al. [28] review the status of synthetic jet fuel and bio-jet including the properties evaluations, engines test and flight test. Cheng and Brewer [29] resume the production of jet fuel using lignin, in this review was reported the pretreatment, depolymerization, hydrodeoxygenation and alkylation to transform lignin into jet-fuel. Zhang et al. [30] described the enhanced carbon yields to jet fuel using plastic and biomass such as feedstock, they also evaluated the catalyst to production of jet fuel that potentially can be used blending it. Zhang et al. [31] reported the production of bio-jet and diesel fuels derived from sawdust. Diederichs et al. [32] developed the simulation with Aspen Plus of three feedstocks for the production of biojet fuel, the materials were lignocellulose, vegetable oil and cane juice. Be et al. [33] demonstrated the conversion of lignin into jet and diesel fuel under a controlled reaction pathway and Dunn [34] evaluated the fuel properties of bio-jet fuel blends.

Table 2. Ranking of the most influential countries in the bio-jet fuels topic

Title of document	Authors	Source/type	TC	Organizations/countries or regions	Reference
Bio-jet fuel conversion technologies	Wang, W.C., Tao, L.	Renewable and Sustainable Energy Reviews/Review	182	National Cheng Kung University; National Renewable Energy Laboratory/Taiwan-USA	[25]
Aviation biofuel from renewable resources: Routes, opportunities and challenges	Kandaramath Hari, T., Yaakob, Z., Binitha, N.N.	Renewable and Sustainable Energy Reviews/Review	170	Universiti Kebangsaan; Sree Neelakanta Govt. Sanskrit College Pattambi, Kerala, India/Malaysia	[26]
Life cycle assessment of bio-jet fuel from hydrothermal liquefaction of microalgae	Fortier, M.O.P., Roberts, G.W., Stagg-Williams, S.M., Sturm, B.S.M.	Applied Energy/Article	119	The University of Kansas/ USA	[27]
Recent development in studies of alternative jet fuel combustion: Progress, challenges, and opportunities	Zhang, C., Hui, X., Lin, Y., Sung, C.-J.	Renewable and Sustainable Energy Reviews/Review	98	Beihang University; University of Connecticut/China-USA	[28]
Producing jet fuel from biomass lignin: Potential pathways to alkyl-benzenes and cycloalkanes	Cheng, F., Brewer, C.E.	Renewable and Sustainable Energy Reviews/Review	90	New Mexico State University/USA	[29]
Enhancement of jet fuel range alkanes from co-feeding of lignocellulosic biomass with plastics via tandem catalytic conversions	Zhang, X., Lei, H., Zhu, L., (...), Wu, J., Chen, S.	Applied Energy/Article	78	Washington State University/USA	[30]
Production of jet and diesel biofuels from renewable lignocellulosic biomass	Zhang, Y., Bi, P., Wang, J., (...), Zhou, X., Li, Q.	Applied Energy/Article	78	University of Science and Technology of China/China	[31]
Techno-economic comparison of biojet fuel production from lignocellulose, vegetable oil and sugar cane juice	Diederichs, G.W., Ali Mandegari, M., Farzad, S., Görgens, J.F.	Bioresource Technology/ Article	71	University of Stellenbosch/South Africa	[32]
From lignin to cycloparaffins and aromatics: Directional synthesis	Bi, P., Wang, J., Zhang, Y., (...), Wang, T., Li, Q.	Bioresource Technology/ Article	69	University of Science and Technology of China; Guangzhou Institute of Energy Conversion, Chinese Academy of Sciences/China	[33]

Title of document	Authors	Source/type	TC	Organizations/countries or regions	Reference
of jet and diesel fuel range biofuels using biomass					
Alternative jet fuels from vegetable oils	Dunn, R.O.	Transactions of the American Society of Agricultural Engineers/Article	63	USDA Agricultural Research Service/USA	[34]

Abbreviations: Total of Citations (TC)

3.4 The most published journals contributing to the biojet-fuel biofuels topic

Table 3 gathers the top 15 journals with publications on bio-jet fuels. As shown, most of the relevant journals show a high quartile Q1 (11 journals), Q2 (2 journals) and 2 journals that have not yet been assigned. This result is indicative of the quality and relevance of the topic in the main journal and the scientific community.

In terms of productivity, the journal "Fuel" has the highest number of publications (15) and it is followed by "Renewable and Sustainable Energy Reviews" and "Applied Energy". The total number of citations was also analyzed, again highlighting "Renewable and Sustainable Energy Reviews" with 662 citations, followed by "Applied Energy". Finally, the total of citations/total of publications ratio also favors the journal "Renewable and Sustainable Energy Reviews" (60.18), followed by "Bioresource Technology" (48.25) and "Applied Energy" (44.5).

Table 3. Journals that publish on the bio-jet fuels topic

Source	TP	TC	TC/TP	SJR (2020)	Quartile
Fuel	15	284	18.9	1.56	Q1
Renewable and Sustainable Energy Reviews	11	662	60.18	3.522	Q1
Applied Energy	8	356	44.5	3.035	Q1
Green Chemistry	8	197	24.6	2.221	Q1
Biotechnology for biofuels	6	133	22.16	1.44	Q1
Catalyst	5	42	8.4	0.8	Q2
Bioresource Technology	4	193	48.25	2.489	Q1
Energy Conversion and Management	4	46	11.5	2.74	Q1
European Biomass Conference and Exhibition Proceedings	4	1	0.25	-	No yet assigned
Renewable Energy	4	33	8.25	1.825	Q1
Rsc Advances	4	72	18	0.746	Q1
AIAA Propulsion and Energy Forum and Exposition, 2019	3	7	2.33	-	No yet assigned
Chemical Engineering and Technology	3	29	9.66	0.403	Q2
Chemical Engineering Research and Design	3	24	8	0.788	Q1
Energies	3	27	9	0.598	Q2

Abbreviations: Total of Publications (TP), Total of Citations (TC), SCImago Journal Rank (SJR), Quartile (Q)

Figure 2 shows the most influential journals in bio-jet fuels using the VOSviewer mapping tool. The Journal "Fuel" is ranked first, followed by "Renewable and Sustainable Energy Reviews", both journals are preferred by authors to publish as the first option.

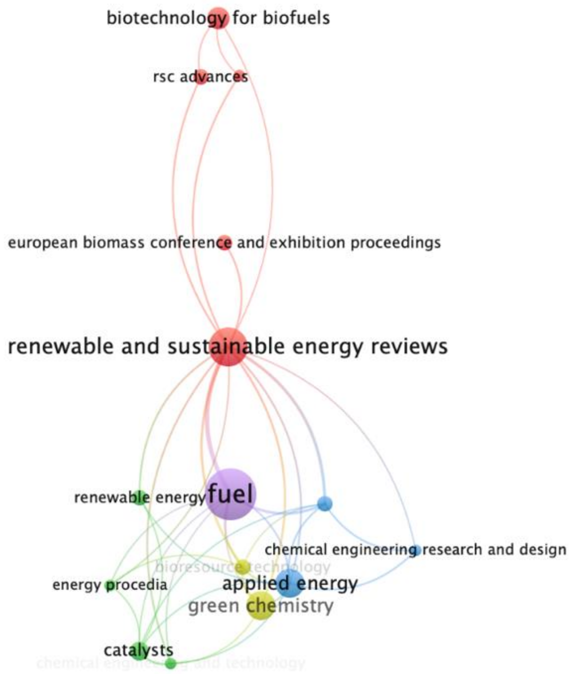

Figure 2. Citation-based map of leading journals in bio-jet fuel publications

3.5 The most influential authors

The scientific impact evaluated with bibliometric indicators of the number of documents and citations determines the quality and influence of each publication [24, 35-37]. In this context, based on the total number of publications, Table 4 shows the top 10 most productive authors. For example, Xu Zeng Fu is the most productive author in bio-jet fuels research with 7 publications and 198 citations. From the total citation indicator, Wang Wei-Cheng has the highest number of citations with 249. In Figure 3, it is evident that China is the country with the most researchers in the field of bio-jet fuels, information that coincides with Table 1. In addition, the Dalian Institute of Chemical Physics working group with three collaborators ranked in the top 10.

3.6 Subjects categories

The Scopus database has 19 subject areas for publications on bio-jet fuels. Regarding subject category, "Energy" leads the ranking with 107 documents, followed by "Chemical Engineering" with 80 documents, "Chemistry" with 54, "Environmental Science" with 50 and Engineering" with 47.

The contribution of the rest of the subjects is less than 50 or it is low, Figure 3. Due to the nature of the topic, the subject category "Energy" will always be related to power generation, in this case to biofuels.

Table 4. Authors that publish on the bio-jet fuels topic

Author	TP	TC	Affiliation	Country	H-Index
Xu, Z.F.	7	198	Guangxi University, Nanning	China	26
Wang, T.	6	108	Guangdong University of Technology, Guangzhou	China	48
Wang, W.C.	6	249	National Cheng Kung University, Tainan	Taiwan	16
Chen, L.	5	39	Guangzhou Institute of Energy Conversion of the Chinese Academy of Sciences	China	20
Cong, Y.	5	133	Dalian Institute of Chemical Physics Chinese Academy of Sciences	China	29
Lei, H.	5	167	Washington State University Tri-Cities	USA	27
Li, G.	5	133	Dalian Institute of Chemical Physics Chinese Academy of Sciences	China	24
Li, N.	5	133	Dalian Institute of Chemical Physics Chinese Academy of Sciences	China	32
Ma, L.	5	39	Southeast University, School of Energy and Environment	China	51
Qu, H.	5	3	Research Institute of Petroleum Processing	China	3
Xu, Z.F.	7	198	Guangxi University, Nanning	China	26
Wang, T.	6	108	Guangdong University of Technology, Guangzhou	China	48
Wang, W.C.	6	249	National Cheng Kung University, Tainan	Taiwan	16
Chen, L.	5	39	Guangzhou Institute of Energy Conversion of the Chinese Academy of Sciences	China	20
Cong, Y.	5	133	Dalian Institute of Chemical Physics Chinese Academy of Sciences	China	29

Abbreviations: Total of Publications (TP), Total of Citations (TC)

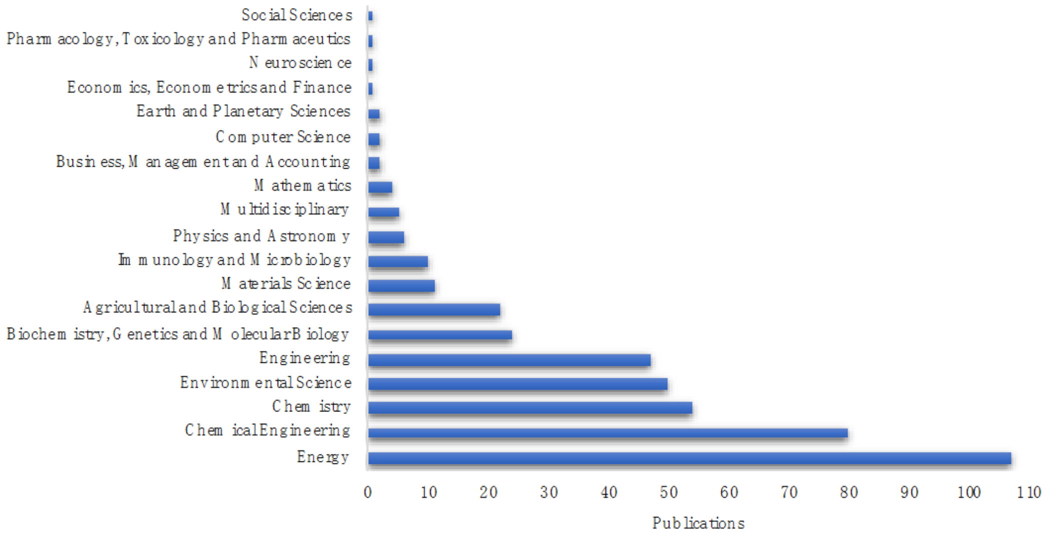

Figure 3. Subject categories related to bio-jet fuels

3.7 Keywords of the publications of bio-jet fuels

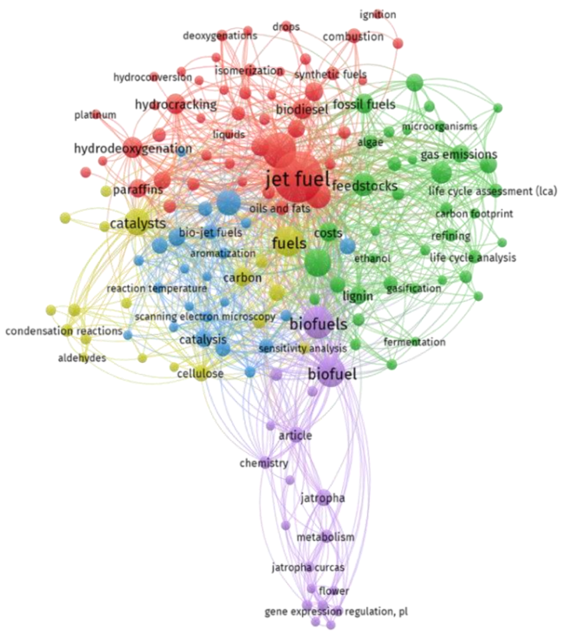

Figure 4. Keywords that appear in bio-jet fuel documents in the Scopus database

The co-occurrence analysis of keywords allows to identify the emerging themes associated to the field of knowledge [38]. In a network, each node represents an entity [39]. In Figure 4 each keyword is represented by a circle and the size represents the number of publications [40, 41]. The color in each item is defined by the cluster in which the item is obtained [42, 43]. The thickness in the lines shows the strength of the association between keywords [44] and the position of the keyword represents its co-occurrence in publications [45].

Figure 4 shows five clusters (red, green, blue, yellow and purple), where the most frequent keyword is jet fuel, followed by biofuels, fuels, biofuel, biomass, bio-jet fuel, catalyst, hydrocarbons, fighter aircraft, feedstocks, greenhouse gases and others. The keywords used in different documents are indicatives of the relevance of the topic of bio-jet fuel in the environmental, social and technical context. The keyword will be useful for other authors or students to define search criteria in a particular field in the future.

4. DISCUSSIONS

A diverse range of technologies related to a more environmentally friendly transport sector are being developed [46]. This review analyzed the progress of bio-jet fuels research with the help of bibliometric analysis. The data of publications from 2001 to 2021 can be possibly interpreted under sigmoid function, specifically, from 2010 to 2021 the results show a major growth of the publications. This behavior can be a result of the regulatory mechanisms that promote the use of sustainable fuels. In this regard, the scientific community and air transport companies have a special interest in developing bio-jet fuels that meet technical and commercial requirements. In this analysis, it was also possible to determine the growth rate of scientific publications, which allows to determine the future behavior of publications in the field of bio-jet fuels.

China leads the publications on bio-jet fuels due to the policies promoted by governments around the world such as the "Carbon Offsetting Reduction Scheme for International aviation", where China has a special interest in reducing the emissions to achieve the goal [47]. However, one of the main limitations and challenges for the implementation of biofuels in general is the economic disadvantage compared to traditional fuels [48]. Despite the fact that bio-jet fuel prices have declined drastically in recent years, they are still twice that of fossil jet fuel, raising concerns about the economic feasibility of bio-jet fuel production [48-50]. Thus, the cost of bio-jet fuel in the end will be determined by biomass costs, refinery technology, and logistics costs [51]. On the other hand, in addition, a more viable feedstock must be explored, as well as the development of new catalysts capable of producing a larger amount of bio-jet fuel within a single step process [52].

The number of citations in documents received is a key indicator of the impact and contribution to the research community [53]. In terms of document type, in this work "reviews" are cited more than articles. In Table 2, the top 5 documents have 4 "reviews" in the journal "Renewable and Sustainable Energy Reviews/Review". This can be due to the fact that it is easier to cite the review that understands, judges, reads or sorts the original data [54]. The journal impact factor has frequently been linked to the impact of a publication on the scientific community [55]. In this work, it was identified that authors prefer to publish in high impact journals.

Most of the works that consider the energy subject are related with the development of jet fuel and bio-jet fuel keywords. In Figure 3, the central role is identified with the word "jet fuel" (red color), in a strong proportion of the word "biofuels" (violet color), followed by the words catalyst and feedstocks. The trends in bio-jet fuels publications consider the development of catalyst and feedstocks as central research topics.

5. CONCLUSIONS

This paper completes a bibliometric analysis of the research on bio-jet fuels from 2001 to 2021. The bibliometric indicators were determined using the number of publications, countries, authors, subjects, institutions and keywords.

The Gompertz model has been proposed to determine the growth rate of the evolutions in publications. The number of publications on bio-jet fuels reflects a significant increasing trend with a growth rate of 0.2232 y^{-1}.

Multidisciplinary scientific disciplines (Energy and Engineering) have development studies in catalyst, feedstocks, production and synthesis of bio-jet fuels. China and USA are leaders in the bio-jet fuels topic, this result is derived from international policies.

The scientific community related to bio-jet fuels published in journals with quartile 1 (Q1), which represents a greater scope for consultation of documents and represents a greater number of citations.

The limitations that have been identified in this work in further research should considerer patents. Also, data from other databases can be used to determine the evolution of publications.

For future research, an analysis of technologies associated with the development of innovations of bio-jet fuels is recommended and a comparison of publications to determine the correlations between databases. Finally, the growth rate of publications for each country can be evaluated using the Gompertz model proposed in this work.

ACKNOWLEDGMENT

The authors are also very grateful to the anonymous referees for their comments and suggestions which have considerably improved this paper.

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NOMENCLATURE

P(y)	documents by years
“a”	asymptotic publications
“b”	integration constant
t	time
P(y)Scopus	publications reported on Scopus database
P(y)model	publications estimated by model

Greek symbols

μ	specific growth rate of publications, years^{-1}