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Assessment of the growth and structure of Organic Chemistry: A Scientometric view

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ABSTRACT

This present scientometric assessment of organic chemistry research publications based on a web of science database, a total number of 7151 publications were collected for the study. This study revealed that the number of publications is increasing gradually, the Annual growth rate (AGR) is 41.72 , major document type was article 4491 (62.8%), It also revealed that the most preferred language for publication is English 6895 (96.4%), Most Productive Institution in the field of Organic Chemistry Research is Chinese Academy of Science with162 (2.3%) Publications, the most productive country is USA with 2454 (34.1%), Stephenson GR is the most productive author having 30 publications, and Bradford's law does not fit for the publication. Most productive keyword is chemistry 2003 (27.8%), followed by organic with 1996 (27.7%).

KEYWORDS: Scientometrics, Annual Growth Rate, Bradford's law, Zipf's law, Organic Chemistry, , VOS Viewer, Hiscite**.**

1. INTRODUCTION

Organic Chemistry has developed as an important field of research mainly due to its role in drug discovery and the chemical industry. Organic chemistry is the study of the structure, properties, composition, reactions, and preparation of carbon-containing compounds. Most organic compounds contain carbon and hydrogen, but they may also include any number of other elements (e.g., nitrogen, oxygen, halogens, phosphorus, silicon, sulfur, etc.

2. LITERATURE REVIEW

Sab, M. C., Kumar, P. D., & Biradar, B. S. (2018) studied chemical science research in India over the span of fifteen years based on the Web of Science database. The main objective is to study the Scientometric output of all chemical science scientists and studied the growth of research output and citations, relative growth rate and doubling time, sub-discipline-wise distribution of publications and citations, activity index, citation index, national and international collaboration, highly productive institutions, highly productive authors, highly preferred journals and highly cited publications. India has produced 1,31,212 papers, and received 12,70,317 citations during the period 2002-2016, in the same manner, the world has produced 24,04,444 publications in chemical science and had increased its publications from 1,14,912 in 2002 to 1,93,822 in 2016

Dwivedi, S.,et al. (2015) in their article discussed Indian scientists and their publications. A Total number of publications retrieved from the Web of science core collection (WoSCC) was 17,344 papers during 2004 -2013. They used different scientometric parameters to analyse the publications.

Kumari, G (2009) in their article attempted to present an analysis of the research output and impact in Synthetic Organic Chemistry (SOC) during 1998–2004. This study used different scientometric parameters like Adopting relative indicators-Absolute Citation Impact,and Relative Citation Impact (RCI), a cross-national comparison is attempted at three levels of aggregations-global, Asian and Indian. Based on this analysis, it is concluded that G7 nations, being leaders for the volume of literature published and citations attracted showed a decreasing trend over the years. Netherlands credited with only 1.12% world share of publications has recorded the highest absolute citation impact and recorded higher than the world average Relative Citation Impact

Karki, M. M. S., Garg, K. C., & Sharma, P. (2000) This paper investigates Indian organic chemistry research activity during 1971–1989 using *Chemical Abstracts*. It attempts to quantification of national contribution to world efforts and identifies areas of relative strengths and weaknesses. Also models the growth of Indian organic chemistry output to world organic chemistry output as a whole and in sub-fields where the activity index for the world and India are similar.

Karki, M. M. S., & Garg, K. C. (1999) in their article provide the making use of scientometric techniques, the paper attempts to assess the performance of Indian organic chemistry research during the 70s and 80s, Identifies the significant work and its impact using mainstream connectivity, surrogate measures of quality and relative impact indicators. It is observed that the organic chemistry research performed in India during the later period (80s) has improved slightly as compared to the previous period (70s).

3. OBJECTIVE OF THE STUDY

The main major objectives of the study are as follows:

- ✓ To study the annual growth rate of organic chemistry from the year 2013 to 2022.
- ✓ To find out the type of documents..
- ✓ To identify the language-wise distribution of the publication.
- ✓ To examine the most productive institution in the field of organic chemistry research publication.
- ✓ To study the county-wise distribution of publications.
- ✓ To examine the most prolific authors in the field of organic chemistry research publication
- ✓ To apply Bradford’s law of scattering journals and articles in the field of organic chemistry research publication.
- ✓ To apply the zip's Law identify the word of occurrence
- ✓ To determine the most cited reference in the field of organic chemistry research publication.

4. METHODOLOGY

The present study is a scientometric analysis of organic chemistry for 10 years during 2013-2022. The data was collected from the Web of Science database maintained by Clarivate Analytics. The data on organic chemistry was extracted by using the keyword Topic "Organic Chemistry "Publication Year "2013 to 2022. For interpreting the data, Hiscite and MS-Excel were used to analyze data and VoSviewer was used to the mapping and visualization.

5. DATA ANALYSIS AND INTERPREDATION

5.1. Annual growth rate of organic chemistry research publication

Table 1: Annual growth rate of publication

Sl. No.	Year	Total No. of Publication	AGR
1	2013	539	0
2	2014	569	5.56
3	2015	580	1.93
4	2016	690	18.96
5	2017	715	3.62
6	2018	728	1.81
7	2019	768	5.49
8	2020	936	21.87
9	2021	847	-9.5
10	2022	779	-8.02
	Total	**7151**	**41.72**

Table 1 and Fig 1 show the Annual growth rate of Publication on "Organic Chemistry" during the period 2013 to 2022. It is found that the highest number of 21.87 AGR was recorded in the year 2020, followed by 18.96 AGR during the year 2016 and the lowest number of -9.5 AGR in the year 2021. The overall AGR is 41.72 data is shown in Table 1.

The annual growth rate (AGR) is calculated on the formula given (Kumar and Kaliyaperumal, 2015) below:

AGR = <u>End Value – First Value</u> × 100

First Value

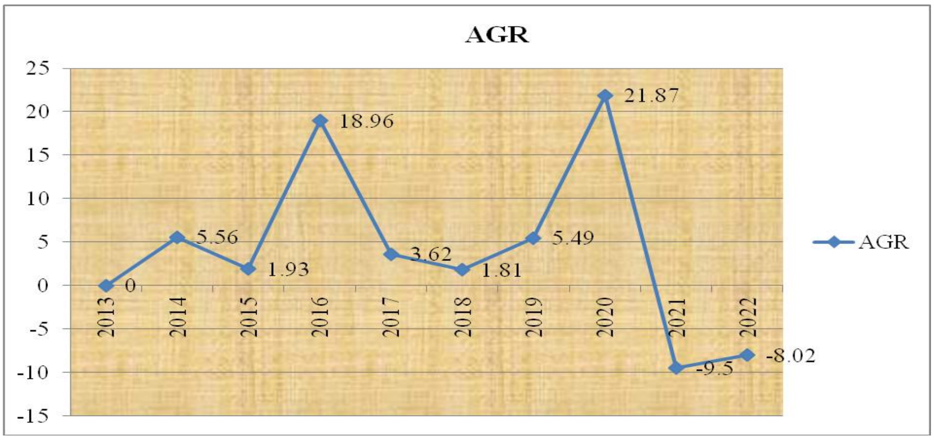

Fig. 1 Annual growth rate of Publications

5.2. Document Types

Table 2: Document wise distribution of publication

SL.No.	Document Type	Total No. of Article	%	Local citation Score	Global Citation Score
1	Article	4491	62.8	7267	106482
2	Review	1583	22.1	1816	83589
3	Meeting Abstract	545	7.6	0	3
4	Editorial Material	292	4.1	103	1330
5	Review; Book Chapter	50	0.7	30	923
6	Article; Early Access	43	0.6	0	35
7	Article; Proceedings Paper	43	0.6	75	1039
8	News Item	28	0.4	5	64
9	Biographical-Item	20	0.3	2	13
10	Letter	16	0.2	12	24
11	Review; Early Access	11	0.5	0	59
12	Article; Book Chapter	9	0.1	13	200
13	Editorial Material; Book Chapter	7	0.1	0	1
14	Correction	4	0.1	0	3
15	Book Review	3	0	0	0
16	Editorial Material; Early Access	2	0	0	0
17	Article; Data Paper	1	0	0	29
18	Article; Retracted Publication	1	0	0	5
19	Retraction	1	0	0	0
20	Review; Retracted Publication	1	0	0	195
	Total	**7151**	**100.2**	**9323**	**193994**

Table 2 & Fig 2 illustrate the document-wise distribution of publications on “Organic Chemistry” during the period from 2013 to 2022. There are twenty types of documents in the study period of organic chemistry. The maximum number of 4491(62.8%) publications were Articles followed by “Review “ type of documents with 1583(22.1%) publications. The Article; Early Access, and Article; Proceedings Paper are 43(0.6%). The maximum number of local citations is 7267 score and the global citation score is 106482. The organic chemists preferred their publications as articles.

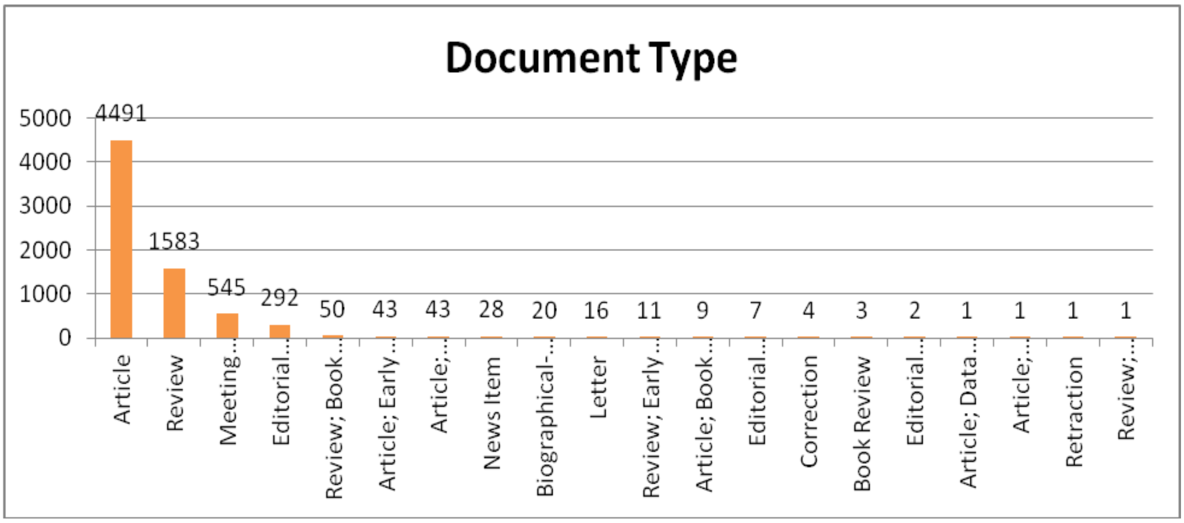

Fig.2 Document of types

5.3. Language wise distribution of Publication

Table 3: Language wise distribution of Publication

Sl.No	Language	Records	%	Local citation Score	Global Citation Score
1	English	6895	96.4	9255	192488
2	Chinese	124	1.73	35	1322
3	Japanese	81	1.13	7	80
4	Portuguese	32	0.44	23	92
5	German	7	0	0	0
6	Polish	5	0	0	2
7	Czech	3	0	1	3
8	Spanish	2	0	0	2
9	Galician	1	0	2	5
10	Hungarian	1	0	0	0
	Total	**7151**	**100**	**9323**	**193994**

From the above Table 3, it was found that among the various language published, most of the publications are in English with 6895 (96.4%) publications and total local citation score is 9255 and a global citation score is 192488 then it is followed by Chinese with 124 (1.73%), Japanese with 81 (1.13%) and Portuguese with 32 (0.44%) It is visible that the language English is predominantly used to publish organic chemistry research publications.

5.4. Most productive institution in the field of organic chemistry research

Table 4: Most productive institution in the field of organic chemistry research top 20

Sl. No.	Institution	Total Publication	%	Total Citation	ACPP	Country
1.	Chinese Academy of Science	162	2.3	6877	42.45	China
2.	Russian Academy of Science	71	1	1932	27.21	Russia
3.	University of Wisconsin Madison	62	0.9	1842	29.70	USA
4.	University of Michigan	55	0.8	1327	24.12	USA
5.	Kyoto University	53	0.7	1852	34.94	Japan
6.	University of Tokyo	53	0.7	1047	19.75	Japan
7.	California Institute of Technology	46	0.6	1953	42.45	USA
8.	University Chinese Academy Science	46	0.6	1391	30.23	China
9.	University of South Florida	45	0.6	656	14.57	USA
10.	University of Illinois	44	0.6	802	18.22	Chicago
11.	Tsinghua University	43	0.6	1233	28.67	China
12.	University of Ottawa	43	0.6	1119	26.02	Canada
13.	Massachusetts Institute of Technology	41	0.6	2409	58.75	USA
14.	NASA (National Aeronautics and Space Administration)	41	0.6	1307	31.87	USA
15.	University of California los Angeles	41	0.6	1508	36.78	USA
16.	University of Minnesota	39	0.5	514	13.17	USA
17.	Nankai University	38	0.5	1285	33.81	China
18.	Peking University	38	0.5	1709	44.97	China
19.	National University of Singapore	37	0.5	1781	48.13	Singapore
20.	University of California Irvine	36	0.5	801	22.25	USA

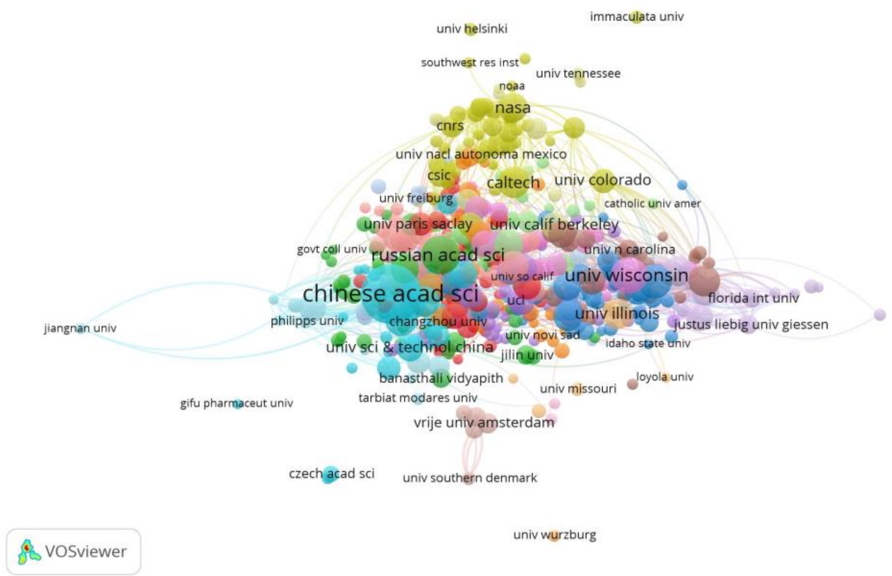

Fig.3 Most productive Institution in the field of organic chemistry research

Table 4 & Fig 3 analyses the top 20 most productive institutions based on organic chemistry research during the study period. According to the Web of Science database, the Chinese Academy of Science, China has published the highest number of publications in the field of organic chemistry with 162 (2.3%) with Citation 6877 and ACPP 42.45. Followed by the second-highest Russian Academy of Science, Russia has 71 (1%) publications with citations of 1932 and ACPP 27.21. The University of California Irvine, USA has the lowest publication with 36, citations 801 and ACPP 22.25. In the study of institutions the constituent countries are analysed and a few dominant countries are identified

5.5. Most productive Countries

Table 5: Most productive top 20 countries with h- index

Sl. No.	Country	Records	%	Global Citation Score	h-index SJR
1	USA	2454	34.1	58904	2280
2	Peoples R China	1070	14.9	34271	1210
3	Germany	557	7.7	29674	1584
4	India	509	7.1	12451	795
5	Japan	458	6.4	13137	1236
6	UK	402	5.6	16313	1815
7	France	289	4	11748	1420
8	Spain	250	3.5	9085	1127
9	Canada	246	3.4	6231	1460
10	Italy	207	2.9	8047	1255
11	Switzerland	160	2.2	5860	1212
12	Brazil	153	2.1	2032	729
13	Russia	152	2.1	3566	702
14	Iran	136	1.9	2477	445
15	South Korea	114	1.6	3422	863
16	Australia	104	1.4	2413	1276
17	Unknown	98	1.4	304	0
18	Poland	95	1.3	1878	687
19	Netherlands	81	1.1	3804	1284
20	Saudi Arabia	71	1	1881	517

Table 5 and Fig 4 identify the country-wise distribution of publications on organic chemistry research during the period of 2013 to 2022. USA has the highest contribution with 2454 (34.1%) publications and a global citation score of 58904 and h-index of 2280, followed by the second highest contribution with Peoples R China 1070 (14.9%), global citation score of 34271 and h –index of 1210, Germany ranked third with 557(7.7%) publications and 1584 h-index. The lowest country contribution has Saudi Arabia 71(1%) followed by other countries, as shown in Fig.4 .

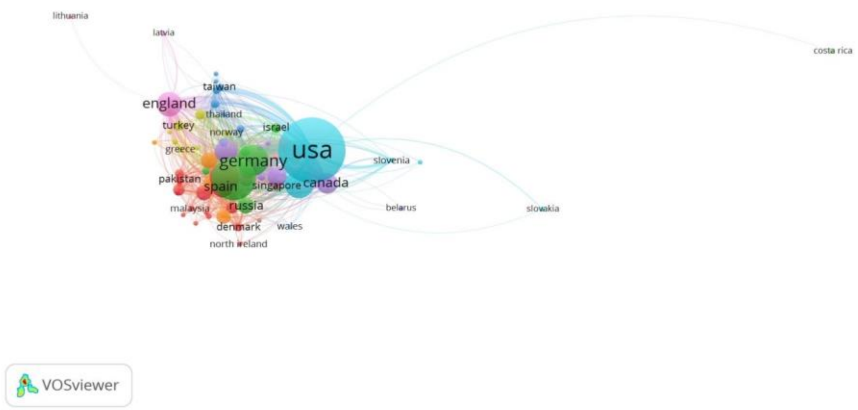

Fig.4 Most productive countries in the field of organic chemistry research

5.6. Most prolific author productivity

Table 6: Most prolific author productivity

Sl. No.	Author	Recs	%	TLCS	TLCSx	TGCS	TLCR	TLCSb	TLCSe
1	Stephenson GR	30	0.4	0	0	0	0	0	
2	Bretz SL	26	0.4	246	202	628	85	75	82
3	Raker JR	25	0.3	149	92	433	182	53	28
4	Wang L	24	0.3	21	16	340	42	1	
5	Flynn AB	22	0.3	396	300	639	185	98	83
6	Reetz MT	22	0.3	154	65	1793	99	56	9
7	Liu Y	21	0.3	1	1	417	24	0	
8	Zhang Y	21	0.3	7	6	451	42	4	
9	Graulich N	20	0.3	205	136	393	207	48	61
10	Anilkumar G	19	0.3	14	11	519	14	2	
11	Kaur N	19	0.3	71	0	401	75	32	1
12	Shultz GV	19	0.3	97	55	240	153	9	
13	Wang Y	18	0.3	9	9	705	33	3	
14	Cooper MM	17	0.2	236	173	603	153	40	34
15	Heravi MM	16	0.2	32	16	697	22	12	0
16	Li Y	16	0.2	13	11	758	15	4	0
17	Houk KN	15	0.2	56	46	1016	18	20	14
18	Wang J	15	0.2	13	10	489	13	4	
19	Gallardo-Williams MT	14	0.2	70	51	213	44	13	
20	Tantillo DJ	14	0.2	24	17	206	28	11	

In this regard, there are 20944 numbers of authors who contributed 855 publications across the globe on organic chemistry research. We have selected only the top 20 author's contributions and analyzed them. The list of authors revealed that there are no dominant authors as the records were scattered, the top contributor has only 30 records by Stephenson GR, followed by other authors, as shown in table 6.

5.7. Bradford's law of scattering

Table 7: Bradford's law of scattering

No. of Journals	No. of Article	Total No. of Article	Cumulative No. of Article	
1	1077	1077	1077	First zone
1	534	534	1611	
1	172	172	1783	
1	143	143	1926	
1	133	133	2059	
1	131	131	2190	
1	124	124	2314	
1(8)	**123**	**123**	**2437(15397)**	
1	120	120	2557	Second Zone
1	115	115	2672	
1	97	97	2769	
1	93	93	2862	
1	88	88	2950	
1	81	81	3031	
1	79	79	3110	
1	77	77	3187	
1	72	72	3259	
1	70	70	3329	
1	69	69	3398	
1	68	68	3466	
1	67	67	3533	
1	64	64	3597	
1	63	63	3660	
1	60	60	3720	
1	54	54	3774	
2	53	106	3880	
2	52	104	3984	
1	49	49	4033	
2	48	96	4129	
2	45	90	4219	

2	43	86	4305	
1	42	42	4347	
1	41	41	4388	
1	40	40	4428	
2	39	78	4506	
1	37	37	4543	
1	34	34	4577	
1	32	32	4609	
2	31	62	4671	
2	30	60	4731	
2(42)	**27**	**54**	**4785(125009)**	
2	25	50	4835	
2	24	48	4883	
1	23	23	4906	
2	22	44	4950	
2	21	42	4992	
1	20	20	5012	
1	19	19	5031	
2	18	36	5067	
3	17	51	5118	
4	16	64	5182	
4	14	56	5238	
5	13	65	5303	**Third Zone**
6	12	24	5327	
13	11	143	5470	
10	10	100	5570	
10	9	90	5660	
16	8	128	5788	
15	7	105	5893	
21	6	126	6019	
20	5	100	6119	
38	4	152	6271	
70	3	210	6481	
113	2	226	6707	
444(805)	**1**	**444**	**7151(132973)**	
855		**7151**		

Bradford's law of scattering describes a quantitative relation between journals and the papers that have published sources. The scientific journals are arranged in order to decrease the productivity of articles on a given sample data.

They may be divided into a nucleus of periodicals more particularly devoted to the subject and several groups or zone containing the same number of articles as the succeeding zone will be 1: n: n2 where n is the multiplier According to Bradford's distribution the relationship between the zone 8: 42:805 which does not fit into Bradford's distribution. This shows that core contributions are given by journals, less than Bradford's formulated and the final zones contain a very large number of journals much more than Bradford's formula. This is a clear indication that the core zone is more concentrated and the other zone is much extended showing the scattering of journals. When this analysis is done for a wider range of periods the extent of scattering can increase. Hence, the analysis of data clearly discounts Bradford's law of scattering.

5.8. Application of zipf's law

Zipf's law states that, "in a long textual matter if words are arranged in their decreasing order of frequency of occurrence of the word"

$$R + F = C$$

Where,

R = is the rank,

F = is the frequency.

C = is constant

Taking on both sides log,

Log (r) + Log (f) =Log C

(or) Log (f) + Log (r) = Log C

To apply this law, the word terms were collected from the title of the articles and ranked according to their frequency of occurrence in decreasing order.

Only those twenty words occupying frequency up to 10840 items are given in the Table 9. On applying this law, it was found that the log of frequency of occurrence of words when added to the log of their rank results are almost the same for each word. The log of frequency of the three most potential words appeared in the titles.

Green is given below:

Word : "Chemistry"

Frequency : 2003

Rank : 1

Log of Frequency + Log of Rank

Log 2003 + Log 1

= 3.30 + 0

= 3.30 Words.

Hence, it is provided that Zips'f law is valid even today.

Table 8: Application of zipf's law

Sl. No.	Word	Records (F)	Rank (R)	Log F	Log R	LogC
1	Chemistry	2003	1	3.30	0	3.3
2	Organic	1996	2	3.29	0.30	3.59
3	Synthesis	1251	3	3.09	0.47	3.56
4	Reactions	575	4	2.75	0.60	3.35
5	Catalyzed	486	5	2.68	0.6	3.28
6	Using	462	6	2.66	0.77	3.43
7	Reaction	432	7	2.63	0.84	3.47
8	Laboratory	385	8	2.58	0.90	3.48
9	Based	364	9	2.56	0.95	3.51
10	Students	321	10	2.50	1	3.5
11	Recent	299	11	2.47	1.04	3.51
12	Metal	288	12	2.45	1.07	3.52
13	Chemical	284	13	2.45	1.11	3.56
14	Undergraduate	274	14	2.43	1.14	3.57
15	Learning	265	15	2.42	1.17	3.59
16	Molecular	261	16	2.41	1.20	3.61
17	Coupling	230	17	2.36	1.23	3.59
18	New	224	18	2.38	1.25	3.63
19	Synthetic	221	19	2.34	1.27	3.61
20	Advances	219	20	2.34	1.30	3.64

5.9. Most cited reference

Table 10: Most cited reference

S. No.	Cited Reference	Records	%
1	Prier CK, 2013, CHEM REV, V113, P5322, DOI 10.1021/cr300503r	161	2.2
2	Becke A. D., 1993, Journal of Chemical Physics, V98, P5648, DOI 10.1063/1.464913	149	2.1
3	LEE CT, 1988, PHYS REV B, V37, P785, DOI 10.1103/PhysRevB.37.785	121	1.7
4	Frisch M. J., 2009, GAUSSIAN 09	103	1.4
5	Bhattacharyya G, 2005, J CHEM EDUC, V82, P1402, DOI 10.1021/ed082p1402	98	1.4
6	Romero NA, 2016, CHEM REV, V116, P10075, DOI 10.1021/acs.chemrev.6b00057	97	1.3
7	Purser S, 2008, CHEM SOC REV, V37, P320, DOI 10.1039/b610213c	88	1.2
8	Zhao Y, 2008, THEOR CHEM ACC, V120, P215, DOI 10.1007/s00214-007-0310-x	88	1.2
9	MIYAURA N, 1995, CHEM REV, V95, P2457, DOI 10.1021/cr00039a007	86	1.2
10	Anastas Paul T., 1998, FRONTIERS, V640	79	1.1
11	Lyons TW, 2010, CHEM REV, V110, P1147, DOI 10.1021/cr900184e	79	1.1
12	Yan M, 2017, CHEM REV, V117, P13230, DOI 10.1021/acs.chemrev.7b00397	75	1
13	Ferguson R, 2008, CHEM EDUC RES PRACT, V9, P102, DOI 10.1039/b806225k	74	1
14	Freeman S, 2014, P NATL ACAD SCI USA, V111, P8410, DOI 10.1073/pnas.1319030111	74	1
15	Narayanam JMR, 2011, CHEM SOC REV, V40, P102, DOI 10.1039/b913880n	73	1
16	Kolb HC, 2001, ANGEW CHEM INT EDIT, V40, P2004, DOI 10.1002/1521-3773(20010601)40:11<2004::AID-ANIE2004>3.0.CO;2-5	72	1

17	Grimme S, 2010, J CHEM PHYS, V132, DOI 10.1063/1.3382344	70	1
18	Grove NP, 2012, J CHEM EDUC, V89, P844, DOI 10.1021/ed2003934	66	0.9
19	Frisch M.J., 2016, GAUSSIAN 16	65	0.9
20	TROST BM, 1991, SCIENCE, V254, P1471, DOI 10.1126/science.1962206	65	0.9

Table 10 shows the most cited reference of organic chemistry research during the study period 327750. Among the cited reference, highly productive is Prier CK, 2013, CHEM REV, V113, P5322, and DOI 10.1021/cr300503r is 161 (2.2%) followed by Becke A. D., 1993, Journal of Chemical Physics, V98, P5648, DOI 10.1063/1.464913 is 149 (2.1%), The lowest cited reference is LEE CT, 1988, PHYS REV B, V37, P785, DOI 10.1103/PhysRevB.37.785 is 121(1.7%), TROST BM, 1991, SCIENCE, V254, P1471, DOI 10.1126/science.1962206 is 65 (0.9%), It s followed by other cited reference, as shown in Table 10.

FINDINGS AND CONCLUSION

The study revealed that increase in the output of publications in the selected field of organic chemistry research during the study period. Hence the progress in organic chemistry is significant, the research output on organic chemistry continuously increasing from 2013 to 2022, the study revealed that the researchers are highly interested in publishing their research in the form of article and in the journal Scientometrics, the highest number of 21.87 AGR was recorded in the year 2020, The maximum number of 4491(62.8%) of publications were “Article” types of documents, most of the publications are in English 6895 (96.4%), Chinese Academy of Science, China has published the highest number of publication in the field of organic chemistry 162 (2.3%). USA has the highest contribution with 2454 (34.1%) publications, Stephenson GR has the highest number of publications with 30. The finding of this present scientometric study will help the researchers, scientists and policymaker who are directly or indirectly involved in the research work in the field of organic chemistry. The intention of this work was to enable the researchers in understanding the nature and evolution of this domain as a starting point for academics, practitioners, and general public to identify some of the main insights behind the existing knowledge.

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