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Review article

A bibliometric survey of research trends in vitrimer

Harsh Sharma [a], Balaji Krishnakumar [b], Tarik J. Dickens [b], Gun Jin Yun [c], Ajay Kumar [a,**], Sravendra Rana [a,*]

[a] University of Petroleum and Energy Studies (UPES), School of Engineering, Energy Acres, Bidholi, Dehradun, Uttarakhand 248007, India
[b] Department of Industrial & Manufacturing Engineering, High-Performance Materials Institute, FAMU-FSU College of Engineering, Tallahassee, FL, 32310, USA
[c] Department of Aerospace Engineering, Seoul National University, Gwanak-gu Gwanak-ro 1, Seoul, 151-744, South Korea

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ABSTRACT

The recent trends of vitrimer studies enhance the thermoset material with superior properties, therefore, it is particularly important to address the critical scientific inquiries in this area using their research metrics. The reported vitrimer systems have been highly required for future real-time applications; however, the inquisitiveness of material exchange mechanisms extends the research studies further. Significantly, more scientific information's are required to achieve the evident prospective outcomes *via* these materials. This article highlights the trends and developments of the most relevant publications, authors, articles, countries, and keywords in the vitrimer research field over the past 10 years. The represented bibliometric survey would elevate the basic understanding of the current vitrimer research stats and also help follow the particular research community to learn and develop insight. To generate bibliometric networks, bibliometric data has obtained from Scopus and visualised in VOS-viewer; as an overview of that, the highest number of publications were from China, United States, France, United Kingdom, and Spain.

1. Introduction

To achieve sustainable development goals, there is a high demand for designing structural materials with recyclable, healable and reprocessable features [1–5]. Several attempts have made in the past to address the issues associated with traditional cross-linked materials [6–9]. Importantly, emphasis has been placed on employing supramolecular interactions at the cross-link sites of polymeric materials, where the materials can exhibit recyclability and healability when subjected to appropriate external stimuli [10–15]. Non-covalent bonds such as hydrogen bonds [16,17], π-π stacking [18], and metal-ligand bonds [19] were added to the thermosetting matrix to achieve recyclability and self-healing in thermosetting materials. However, because non-covalent adaptive bond interactions have weaker bonding energies (usually 1–5 kcal/mol) [20] than covalent bond interactions (50–150 kcal/mol) [21]; they may result in inferior mechanical characteristics.

Dynamic covalent bonds based approaches can be a potential platform to design recyclable and self-healable polymer networks [22–27]. Regardless of the bond exchange mechanism, such systems are known as covalent adaptable networks (CANs), and the

* Corresponding author.
** Corresponding author.
E-mail addresses: akumar@ddn.upes.ac.in (A. Kumar), srana@ddn.upes.ac.in (S. Rana).

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subclass of CANs comprising associative dynamic covalent bonds are known as "vitrimer" as reported by Leibler and co-workers [1]. Vitrimers, a new type of polymeric material, are known to have distinct properties that combine the advantages of thermosets and thermoplastics. Vitrimers offer several advantages over traditional polymers. First, they possess excellent mechanical properties, combining high strength and stiffness with the ability to be reconfigured. This unique combination allows vitrimers to be self-healing, meaning they can repair themselves when damaged or fractured. Additionally, vitrimers can be recycled and reprocessed multiple times without significant loss of material properties, reducing waste and promoting sustainability [28]. At low temperatures, vitrimers behave as a cross-linked thermoset; however, at high temperatures the covalent bonds in the polymer network would exchange the bonds with adjacent free molecules and detach with the old bonds, which can follow the Arrhenius [29,30] and William-Landel-Ferry equation (WLF) [31,32] at their exchanging time. This behaviour allows them to maintain permanent crosslink density, and the same time behaving them as viscoelastic liquids [2,3,33–40]. To effectuate this, various chemical processes, such as transesterification [41], transamination [4,42], alkoxyamine exchange [43,44], olefin metathesis [45], and thiol-disulfide exchange [46,47], have been deployed in the production of vitrimers for various applications in the past decade. In the field of materials science, they can be used in coatings, adhesives, composites, and 3D printing materials. Their reconfigurability and self-healing properties makes them promise for applications in automotive parts, aerospace components, and consumer goods. Furthermore, vitrimers hold potential in biomedical applications, such as drug delivery systems, tissue engineering, and shape-memory devices [48–50]. Thus, it is critical that polymer researchers are made aware of current research trends and directions in vitrimer processing.

Expert evaluation and research metrics have gradually been used to address critical scientific inquiry in a specific field. To overcome manual review deficiencies in engineering studies [51] and other fields, bibliometric analysis has given a profound, quantitative, and less skewed linkages to the network between many features of massive bibliometric datasets. Bibliometric analysis is a popular and reliable method for discovering and interpreting vast amounts of scientific data [52].

Intriguingly, bibliometric analysis of the published literature in vitrimer studies is required to keep readers and policymakers up to date on present and emerging research topics. Significantly, prior studies on vitrimer materials reviews/mini-review have qualitatively discussed the material chemistries and properties, however, this is the first report about the quantitative analysis of vitrimers. Hence, the purpose of this research is to highlight the trends and advancement of the most prominent publication sources, keywords, authors, papers, and the nation of origination in vitrimer research over the last 10 years. The bibliometric analysis gives valuable and statistical insight into vitrimer current and future research trends. It also provides a better perspective about the theoretical structure and cluster themes of vitrimer, as well as highlights the major issues and significant contributions of top publications and researchers in the evolving field. Perhaps, in the future vitrimer investigation databases will be abundant; however, it could be a burden to attain the exact vitrimer synthesis and research practice, in that case, this paper needs to be detailed on this occasion. Exploring thriving research trends and, making this milestone data article would effectively promote this field, and benchmark to fascinate the vitrimers system further. In addition, the networks visualisation of bibliometric co-occurrences and co-citations is a critical tool for understanding the relationships and connections between scientific publications. It plays a crucial role in identifying research trends by highlighting clusters of related publications and revealing emerging areas of study. These visualizations allow researchers to explore the overall research landscape, identifying influential works and important research communities. Additionally, they help trace the diffusion of knowledge within the scientific community by visualizing the connections between highly cited publications. It serves as a roadmap for academics and research organisations to share their advanced technologies, collaborate on new research, and launch creative joint ventures. A bibliometric network is created and utilized to show the annual distribution and top growth trends across publication sources, articles, authors, and countries in vitrimer research.

2. Methodology

The bibliometric analysis technique was used in the current study to quantitatively visualise scientific data and generate bibliometric maps [53]. The method could be suited for this evaluation since it uses extensive bibliographic data to highlight and assess the development of vitrimer over a period. While the most popular databases for citation indexing and gathering academic literature are Google Scholar, Scopus, and Web of Science. Although, more excellent bibliometric data coverage, a wider selection of journals, and a quicker indexing procedure have made Scopus is the preferred alternative for researchers over to Web of Science [54–56]. Based on citation data, VOS Viewer produces maps of authors, articles, and journals and provides a map of keywords based on co-occurrence data [57]. The researchers also use a number of other bibliometric mapping tools, including Bibliometrix [58], CitiNetExplorer [59], and Pajek [60]. However, the alternative software offers small bibliometric maps and easy graphical representations, which are inadequately represented in comparison to VOSviewer. Therefore, the current study used Scopus as a data retriever tool and VOSviewer as a network mapping technique. An inclusion criterion was applied to filter relevant publications for this analysis (Table 1).

The authors, abstract, keywords search strings defined to conduct the research were "vitrimer". The applied search string suggests 490 research articles, 37 reviews, 21 conference papers and 24 other publications in preliminary results (2014–2023). The next search was then limited to only English-language publications that resulted in 561 English publications. In January 2023, the data were

Table 1
Inclusion criteria were used for gathering data from Scopus as of 23 Jan 2023.

S. No.	Option	Criteria Applied
1.	Language	English
2.	Publication date	Jan. 2014–2023

retrieved as Comma Separated Values (CSV) files, which were then imported and examined by VOS viewer software (version 1.6.19). The annual distribution and growth trend, keyword co-occurrence, top publication sources, authors, articles, and countries in vitrimer research were examined using a bibliometric network; and each of them provides specific importance and estimation like an emergent and exploration, common presence and close proximity, credible and valuable reproduction, communicate and collaborate, insights and evaluation, cognizant and contribution, respectively.

3. Results and discussion

3.1. Annual distribution and growth trends

For the "vitrimer" search string, the first article was published in 2012, and up to 2013 only 1 article was published. From 2014 to 2023, there was a rise in vitrimer articles to 561, indicating an increase of more than 98%. The rising interest of vitrimer research has occurred due to its sustainable properties, which has resulted in a significant number of publications. Fig. 1 shows the annual distribution and growing trend in vitrimer research.

3.2. Contribution of publication sources

Mapping publication sources is critical for assessing growth in research output. Table 2 shows the top publication sources/journals with at least 10 documents from January 2014 to January 2023. American Chemical Society (ACS) Macromolecules, Elsevier Polymer, ACS Applied Polymer Materials and Multidisciplinary Digital Publishing Institute (MDPI) Polymers are the top four most recommended sources for vitrimer publication having 51, 30, 27 and 23 documents, respectively. These documents were able to receive 2426, 556, 291 and 302 citations, respectively. As indicated in Table 2, the journal impact factor (JIF) was employed to assess the value of journals to the scientific community. Ahmad and co-workers [61,62] adopted a similar approach, stating that the JIF shows a journal's authority and influence. As a result, the top three journals in terms of relevance for vitrimer articles were the Chemical Engineering Journal (JIF = 16.744), the Journal of Materials Chemistry A (JIF = 14.511), and Composites Part B: Engineering (JIF = 11.322). The network representation of the top recommended publication sources for vitrimer is shown in Fig. 2. The size of the circle shows the journal's publishing count, i.e., the larger the circle size, the more papers published, but it does not imply the journal's authority or prestige.

Furthermore, circles of the same colour indicate the association and interconnectedness of the publication sources. By grouping the circles by colour, it is possible to see which publications are most closely related to one another based on their frequency. This information can be useful for understanding the relationships between different research areas and for identifying key publications in a particular field. The two dissimilar shades observed represent two related groups, with 13 and 2 items in red (Group 1) and green (Group 2), respectively. Publication sources of a similar colour that are close together show a stronger relationship than those that are far apart. The majority of the sources cite articles from ACS Macromolecules, ACS Macro Letters, and ACS Applied Materials and Interfaces. Closely connected publication sources form a comparable cluster, and the network edges show citation links.

Co-Occurrence of Keywords; Keywords assists the researcher in interpreting the main information of a document and subject categories and determining the development and trend of study in the field [63]. Table 3 lists the most frequently used keywords in vitrimer publications. The top three terms are vitrimer, crosslinking, and stress relaxation, with 206, 150, and 114 occurrences, respectively.

Figs. 3 and 4 exhibit a keyword co-occurrence network and overlay visualisation, in which the size of the circle represents the frequency of keyword usage, and its position indicates a correlation in publications. VOSviewer identified four groupings, with red (Group 1) having 15, green (Group 2) having 11, and blue (Group 3) having 4. Keywords like "vitrimer", "crosslinking", "stress relaxation", "recycling", and "vitrimers" had more occurrences and larger circle sizes than the other keywords.

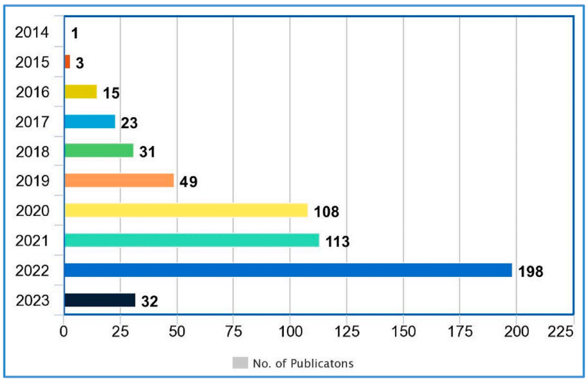

Fig. 1. Number of Publications on topic "vitrimer". Source: http://www.scopus.com (accessed on 25 Jan. 2023).

Table 2
Publication sources with a minimum of 10 documents from Jan. 2014 to Jan. 2023.

S.No.	Sources	Publications	Citations	JIF
1.	ACS Macromolecules	51	2426	6.057
2.	Polymer	30	556	4.432
3.	ACS Applied Polymer Materials	27	291	4.855
4.	Polymers	23	302	4.967
5.	Polymer Chemistry	20	735	5.367
6.	ACS Applied Materials and Interfaces	20	700	10.383
7.	European polymer Journal	18	602	5.546
8.	ACS Sustainable Chemistry and Engineering	18	642	9.224
9.	Chemical Engineering Journal	17	511	16.744
10.	Composites Science and Technology	14	390	9.878
11.	Journal of Applied Polymer Science	14	118	3.057
12.	ACS Macro letters	12	795	7.015
13.	composites Part B: Engineering	10	199	11.322
14.	Journal of Materials Chemistry A	10	404	14.511
15.	Industrial Crops and Products	10	138	6.449

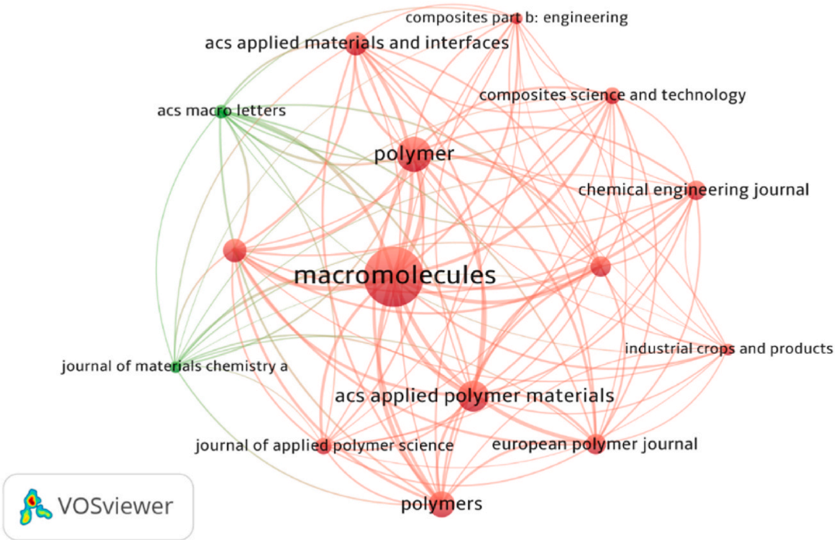

Fig. 2. Visualisation of publication sources with a minimum of 10 documents.

Table 3
Top occurring keywords in "vitrimer" publications.

S.No.	Keywords	Occurrences	S.No.	Keywords	Occurrences
1.	Vitrimer	206	16.	Curing	61
2.	Crosslinking	150	17.	Glass Transition	60
3.	Stress Relaxation	114	18.	Recyclability	60
4.	Recycling	105	19.	Activation Energy	59
5.	Vitrimers	89	20.	Dynamics	58
6.	Esters	87	21.	Reprocessability	52
7.	Self-healing Materials	81	22.	Sulfur Compounds	50
8.	Thermosets	79	23.	Mechanical Properties	48
9.	Tensile Strength	77	24.	Recyclables	46
10.	Self-healing	77	25.	Bio-based	41
11.	Epoxy	75	26.	Polymers	39
12.	Catalysts	71	27.	Property	37
13.	Transesterification	68	28.	Rubber	36
14.	Exchange Reaction	68	29.	Amines	35
15.	Epoxy Resins	63	30.	Transesterification Reaction	35

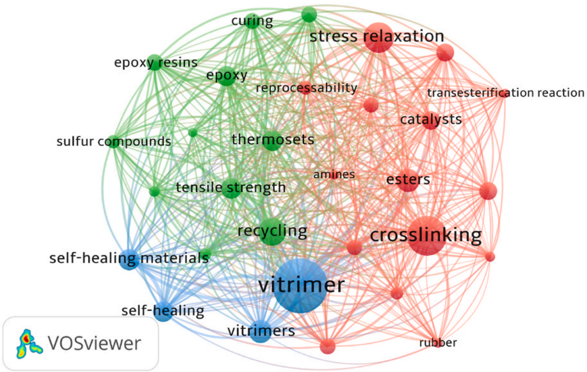

Fig. 3. Keyword co-occurrence network visualisation.

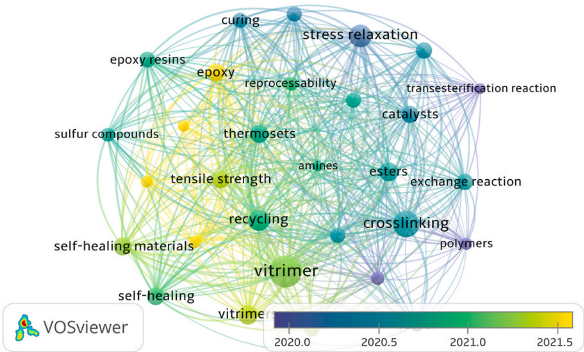

Fig. 4. Keyword co-occurrence overlay visualisation.

4. Contribution of authors

The relationship between authors and co-authors gives important information about the primary research groups working on a specific topic; also, each researcher's individual number of articles and citations help measure their influence in a particular field. As a result, the number of publications and citations indicated in Table 4 evaluates a researcher's contribution and influence. The average citation is calculated by dividing the total number of citations by the number of documents per author. Yang Y., Zhang J., and Zhang S. have 30, 26, and 25 published articles, respectively., J.M. Winne, F.E. Du Prez and L. Leibler have the most overall citations, with 2479, 2442 and 1982, respectively. The leading authors in terms of average citations are Leibler L., Nicolay R., and Winne J.M., with approximately 247, 224, and 206 average citations, respectively. The data reveals that citations in the field of vitrimer connect researchers from various geographical regions.

Figs. 5 and 6 depict eight significant groups (at least three authors in each group) working in the field of vitrimer. Zhang J., Wang Y., Du Prez F.E., and Liu Y. are authors from notable research groups in the vitrimer study field.

4.1. Contribution of publications

The article-citation relationship informs researchers about the familiarity of the published work. A higher citation metric indicates that the article's quality is likely exceptional, and many authors in the research field will cite it. The current analysis chose papers with at least 120 citations, reducing the number of documents to 35 (Table 5). This aided in the study of the most referenced publications and the publications with the greatest impact on vitrimer research.

According to Table 5, the top four most cited publications were "Vitrimers: Permanent Organic Networks with Glass-like Fluidity" by Wim Denissen, "High-performance vitrimers from commodity thermoplastics through dioxaborolane metathesis" by Max Röttger, "Vinylogous Urethane Vitrimers" by Wim Denissen, and "Mechanically Activated, Catalyst-Free Polyhydroxyurethane Vitrimers" by David J Fortman. The increase in citations demonstrates the importance of the papers in advancing vitrimer research. Fig. 7 depicts the articles with at least 120 citations and identified three groups, with red (group 1), green (group 2), and blue (group 3) having 15, 11, and 9 publications, respectively. The data reveals that citations in the field of vitrimer connect experts from various geographical places.

Table 6 reveals that 675 documents from 18 countries were published. The country China had the most publications (286), followed by the United States with 120. France came in third with 57 publications, while the United Kingdom came in fourth with 24.

Table 4
Authors with a minimum of 5 publications and 200 citations in "vitrimer" research.

S.No.	Authors	Publications	Citations	Average Citation	Total Link Strength
1.	Yang Y.	30	1400	46.67	62
2.	Zhang J.	26	1304	50.15	75
3.	Zhang S.	25	1019	40.76	77
4.	Wei Y.	23	1392	60.53	64
5.	Liu T.	22	1245	56.59	71
6.	Ji Y.	19	1176	61.90	59
7.	Liu Y.	17	513	30.18	60
8.	Wang S.	17	584	34.36	53
9.	Wang Y.	17	603	35.48	18
10.	Hao C.	16	1019	63.69	65
11.	Zhang L.	16	664	41.5	19
12.	Zhang X.	15	566	37.73	29
13.	Li Y.	14	698	49.86	30
14.	Wang D.	14	247	17.65	11
15.	Zhao W.	14	365	26.07	7
16.	Hayashi M.	14	200	14.28	2
17.	Du Prez F.E.	13	2442	187.84	23
18.	Guo B.	12	718	59.83	43
19.	Zhang Y.	12	356	29.67	38
20.	Winne J.M.	12	2479	206.58	24
21.	Zhang H.	12	360	30	24
22.	Wang H.	12	215	17.92	21
23.	Zhang B.	12	269	22.42	18
24.	Zhu J.	11	578	52.54	40
25.	Chen Y.	11	332	30.18	22
26.	Qi H. J.	11	608	55.27	22
27.	Li G.	11	225	57.5	5
28.	Wu Y.	10	285	69.5	39
29.	Xu X.	10	564	56.4	38
30.	Tang Z.	10	499	49.9	35
31.	Liu W.	10	575	57.5	32
32.	Liu H.	10	695	69.5	24
33.	Xu Y.	10	298	29.8	21
34.	Wang B.	9	365	40.55	35
35.	Chen Q.	9	383	42.55	21
36.	Zeng J.-B.	9	328	36.44	12
37.	Terentjev E.M.	9	314	34.89	3
38.	Tournilhac F.	9	487	54.11	3
39.	Wang L.	8	769	96.13	29
40.	Chen M.	8	283	35.37	27
41.	Wu S.	8	366	45.75	23
42.	Leibler L.	8	1982	247.75	13
43.	Guerre M.	8	557	69.63	12
44.	Li Y.-D.	8	323	40.37	12
45.	Rana S.	8	238	29.75	11
46.	Zhou Y.	8	272	34	4
47.	Zhao X.	7	280	40	20
48.	Kuang X.	7	513	73.29	12
49.	Nicolay R.	7	1571	224.42	11
50.	Wang T.	7	728	104	11
51.	Li Q.	6	357	59.5	34
52.	Ma S.	6	357	59.5	34
53.	Han J.	6	522	87	28
54.	Zhou L.	6	299	49.83	21
55.	Shi Q.	6	565	94.17	16
56.	Yu K.	6	587	97.83	14
57.	Krishnakumar B.	6	238	39.67	9
58.	Yang X.	5	432	86.4	12
59.	Zhao X.-L.	5	203	40.6	12
60.	Binder W·H.	5	219	43.8	8
61.	Wang W.	5	220	44	8

Following that, eleven countries published documents ranging from 10 to 23, while three countries published documents ranging from 1 to 9. China has received the most citations (7950), followed by the United States (4838), and France (3685). Furthermore, when compared to the other countries, Belgium and France have the highest average number of citations per document (147.36) and (64.65), respectively. These countries exhibit a higher level of research due to key contributing factors such as robust funding and research infrastructure, effective collaboration between academia and industry, and the implementation of supportive policy initiatives. The

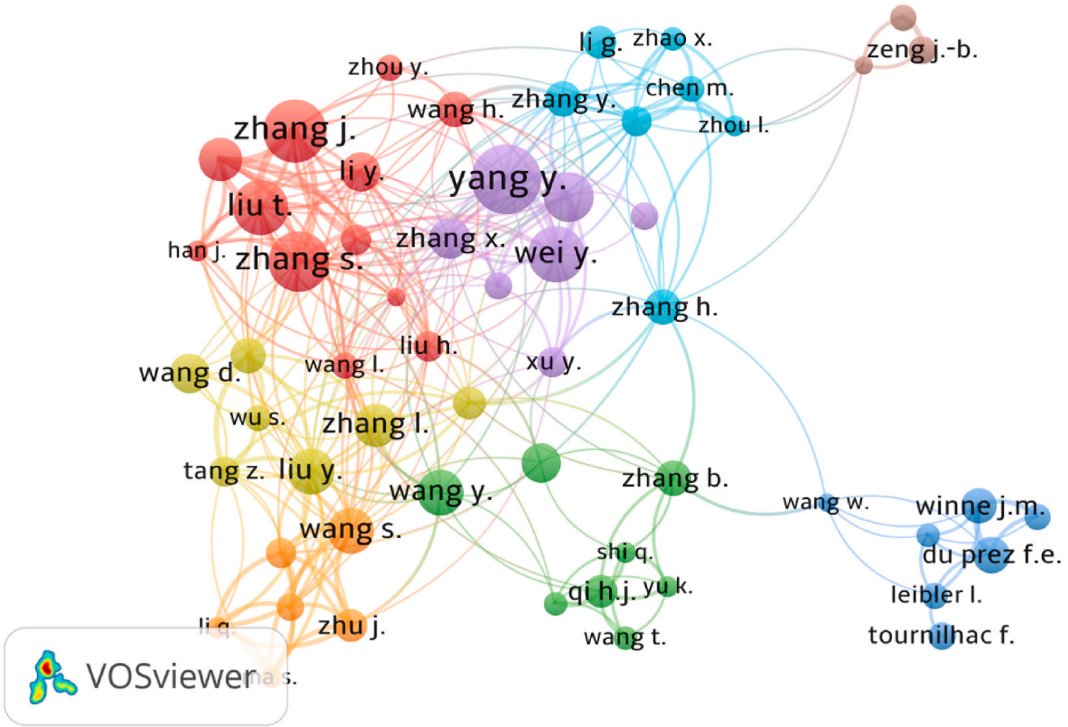

Fig. 5. Author contribution visualisation based on citations and co-authorship.

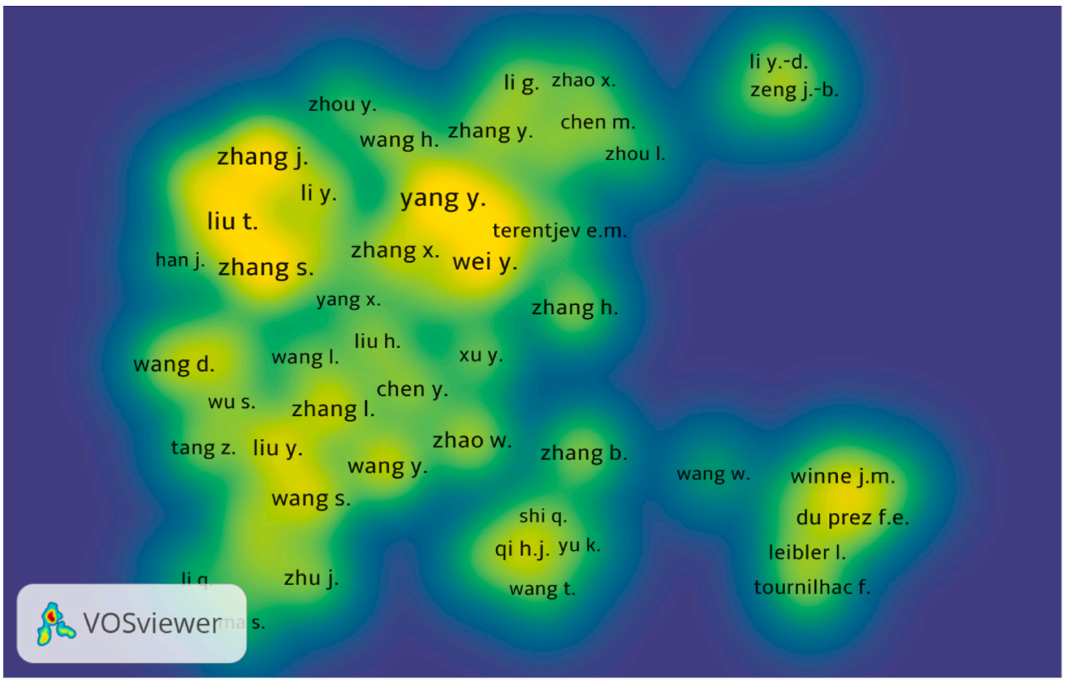

Fig. 6. Author contribution density visualisation based on citations and co-authorship.

Table 5
Publications with a minimum of 120 citations in "vitrimer" research.

S.No.	Publications	Citations	Ref.	S.No.	Publications	Citations	Ref.
1.	Denissen W. (2016)	814	[3]	19.	Liu T. (2018)	161	[64]
2.	Röttger M. (2017)	651	[65]	20.	Chen Q. (2016)	158	[66]
3.	Denissen W. (2015)	572	[4]	21.	Zhang S. (2018)	155	[67]
4.	Fortman D. J. (2015)	472	[68]	22.	Yang X. (2020)	152	[69]
5.	Yang Y. (2016)	283	[70]	23.	Imbernon L. (2016)	150	[71]
6.	Denissen W. (2017)	272	[72]	24.	Krishnakumar B. (2020)	149	[25]
7.	Yu K. (2016)	260	[73]	25.	Chen M. (2019)	146	[74]
8.	Fortman D. J. (2018)	255	[75]	26.	Li L. (2018)	138	[76]
9.	Shi Q. (2017)	254	[77]	27.	Ma Z. (2017)	136	[78]
10.	Liu T. (2017)	243	[79]	28.	Legrand A. (2016)	135	[80]
11.	Yang Y. (2014)	223	[81]	29.	Zhang L. (2017)	134	[82]
12.	Wang S. (2019)	214	[83]	30.	Guerre M. (2018)	133	[84]
13.	Deng J. (2018)	191	[85]	31.	Dhers S. (2019)	128	[86]
14.	Azcune I. (2016)	181	[87]	32.	Liu Y. (2018)	127	[88]
15.	Yang Z. (2016)	168	[89]	33.	Imbernon L. (2016)	123	[90]
16.	Guerre M. (2020)	167	[5]	34.	Liu Y. (2019)	122	[91]
17.	Hendriks B. (2017)	167	[92]	35.	Meng F. (2016)	122	[93]
18.	Han J. (2018)	165	[94]				

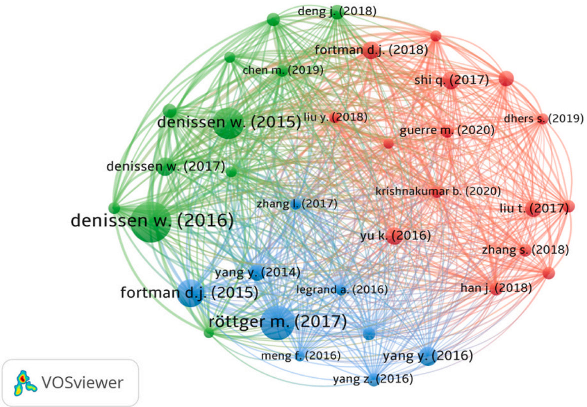

Fig. 7. Visualisation of publications with a minimum of 120 citations.

Contribution of Countries

Table 6
Countries with a minimum of 5 publications in "vitrimer" research.

S.No.	Country	Publications	Citations	Average Citation per Document
1.	China	286	7950	27.80
2.	United States	120	4838	40.32
3.	France	57	3685	64.65
4.	United Kingdom	24	532	22.17
5.	Spain	23	468	20.35
6.	Germany	21	508	24.20
7.	Belgium	17	2505	147.35
8.	Japan	16	288	18
9.	Netherlands	14	464	33.14
10.	Singapore	14	690	49.29
11.	South Korea	14	115	8.21
12.	India	13	272	20.92
13.	Austria	13	187	14.39
14.	Italy	12	186	15.5
15.	Canada	12	324	27
16.	Taiwan	8	163	20.38
17.	Australia	6	84	14
18.	Luxembourg	5	91	18.2

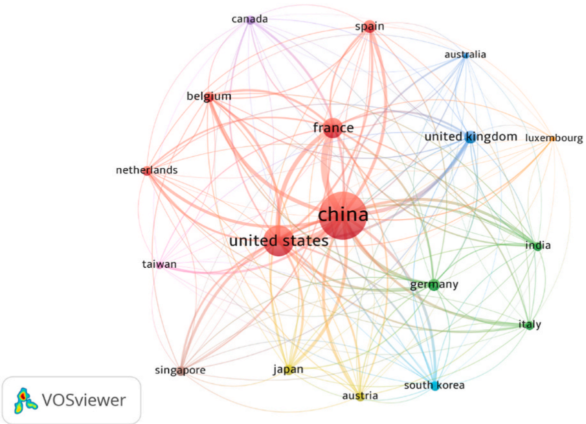

Fig. 8. Visualisation of countries with a minimum of 5 publications.

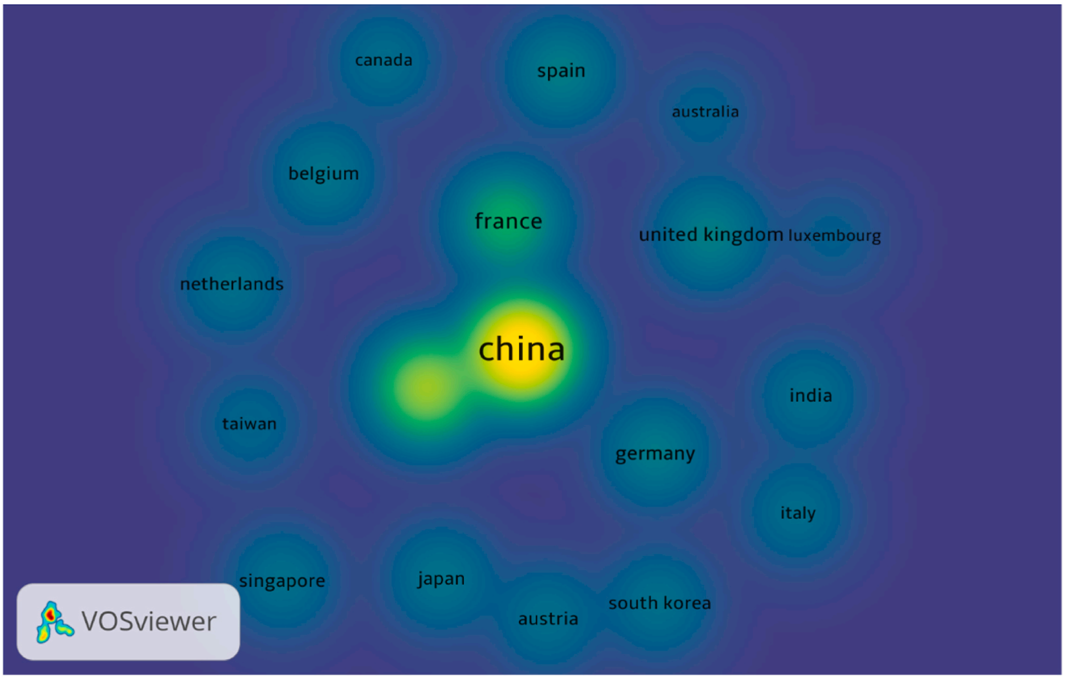

Fig. 9. Density visualisation of countries with a minimum of 5 publications.

network and density visualisation of countries with minimum 5 publications are shown in Figs. 8 and 9.

5. Existing polymers vs vitrimer materials

Conventional polymers have been extensively studied for decades, and they form a mature field of research with a substantial body of literature. This extensive research has led to a significant number of publications and citations. Polymer research has a broad scope, covering a wide range of topics such as polymer synthesis, characterization, processing, and applications [95]. It encompasses various polymer types, including thermoplastics, thermosets, elastomers, and composites [96]. The impact of conventional polymer research is evident in many industries, with numerous practical applications and commercial products derived from polymer science [97]. This impact is reflected in the number of citations and the wide dissemination of polymer research findings. However, as a mature field, the rate of growth in conventional polymer research may have slowed down in recent years compared to emerging areas like vitrimer research [98].

Vitrimer research is a relatively newer and rapidly growing field within polymer science. While it has gained significant attention in recent years, it may not have reached the same level of bibliometric trends and impact as conventional polymers due to its nascent stage. The number of vitrimer-related publications and citations has been increasing, reflecting a growing interest in this area. Researchers are exploring new synthesis methods, understanding the properties of vitrimers, and investigating their applications [51]. Vitrimer materials offer unique properties and capabilities, such as self-healing, reprocessing, and shape memory behavior, which have attracted considerable attention from the scientific community [99–101]. These unique features may contribute to the growing trend of vitrimer research. As the field continues to advance and more researchers contribute to vitrimer studies, it is expected that bibliometric trends and impact will continue to rise, albeit at a different pace compared to conventional polymers. Therefore, the vitrimer bibliometric growing trends are far better than contemporary polymer. However, it requires a detailed analysis of recent data, including the number of publications, citations, and their impact within their respective fields. As bibliometric trends can fluctuate over time, it's essential to consult up-to-date bibliometric databases or conduct a comprehensive analysis to draw specific conclusions on the growth of vitrimer research compared to conventional polymer research.

6. Summary and outlook

This survey performed a bibliometric analysis of vitrimer publications retrieved from the Scopus database between January 2014 and January 2023; and the bibliometric findings from this study would be helpful for academicians and policymakers to exchange research skills and to work together on cutting-edge vitrimeric research including the formation of collaborative ventures. Furthermore, it can assist researchers, governments, and businesses in anticipating future inventive areas, prioritising funding areas, and evaluating the impact of previous collaborations. However, it is important to consider certain limitations when conducting bibliometric analysis for more robust and transparent analysis, including the limited availability of data, inconsistent indexing, language bias, and the time lag in data availability.

The current study discovered that research on vitrimer is quickly advancing, and additional research is required to design advanced materials. Likewise, the studies on exploring new combinations of monomers for vitrimer synthesis, understanding the curing kinetics and healing mechanism of vitrimers, and adopting eco-friendly synthesis routes for long-term durability, stability, and sustainable recycling can be the potential research directions for further investigation in the field of vitrimers.

Following are the key findings from the bibliometric analysis:

1. The top four most popular journals for vitrimer publications in terms of publishing sources are ACS Macromolecules, Polymer, ACS Applied Polymer Materials, and Polymers. ACS Macromolecules, ACS Macro Letters, Polymer Chemistry, and ACS Applied Materials and Interfaces were the publications that the majority of the sources were citing.
2. The most often used keywords in terms of keyword co-occurrence are vitrimer, crosslinking, and stress relaxation. The results may help future researchers to select keywords for a specific research field.
3. Yang Y., Zhang J., and Zhang S. have the most documents in terms of author contribution, whereas F.E. Du Prez has the most citations overall. The analysis demonstrates how citations in the field of vitrimer connect researchers from various geographical locations.
4. Denissen W. (2016), Röttger M. (2017), and Denissen W. (2015) were the top three most cited publications in terms of publication contribution. These documents' bigger network circle diameters than the others suggest that they have an impact on vitrimer research in various geographical areas.
5. The largest number of publications came from the countries like China, the United States, France, and the United Kingdom. According to the country dependent cooperation network, most countries actively collaborate on research with China, France, and the United States.

Author contribution statement

All authors listed have significantly contributed to the development and the writing of this article.

Data availability statement

All publication data on which these studies are based have been drawn from public source, Scopus (http://www.scopus.com/). The search string used for finding vitrimer related documents and the retrieved. CSV file are uploaded in repository (https://github.com/HarshSh22/ResearchTrendsinVitrimer.git). The annual distribution and growth trends plot have been drawn from public source (https://www.meta-chart.com/). The co-citation, co-occurrence and all the bibliometric networks have been created through open-source software: VOSviewer version 1.6.19 (https://www.vosviewer.com), to run VOSviewer java version 1.8.0_361 (Oracle Corporation) have been used.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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