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Research on Lithium Technology Safety Issues: A Bibliometric Analysis

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Abstract: (1) Background: Lithium plays an extremely important role in the national economy. However, the chemical activity of lithium metal leads to many safety problems in the application of lithium technology, which is the bottleneck problem restricting the development of lithium technology. The purpose of this paper is to describe the research status of lithium technology safety issues visually and dynamically, elucidate the pressing issues in this field and reveal future development trends. (2) Methods: In this paper, metrology literature analysis and knowledge graph methods were adopted. With the help of visualization tools, namely, CiteSpace and VOSviewer, literature data exported from the Web of Science were analyzed in a multi-angle and all-round way. (3) Results: The number of papers in the field of lithium technology safety showed an accelerating trend. Close collaboration between authors and institutions. The scope of the research has gradually shifted from the early focus on the medical application of lithium and the resulting safety issues to the health and safety of lithium batteries. (4) Conclusions: Lithium technology safety is a hot topic in the current academic community. Future research trends will continue to focus on the safety problems and solutions of lithium technology, and pay more attention to sustainable development, especially the research on the improvement and optimization of lithium-ion battery performance.

Keywords: safety science; lithium technology; bibliometric analysis

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1. Introduction

With the advantages of a high theoretical energy ratio and low density, lithium has been widely used in batteries [1], ceramics [2], medical treatment [3], nuclear energy [4,5] and other aspects. However, due to the active physical and chemical properties of this metal, the lithium technology around us threatens our own security all the time, which has become an important constraint on the development of lithium technology [6]. For example, after the explosion of the first generation of Li||MoS2 battery products of Moli Canada in late spring of 1989, the panic caused by this battery with real commercial significance at that time made the lithium battery disappear from the public's view for some time afterwards [7]. Therefore, it is very important to pay attention to the safety of lithium for the utilization and development of this technology.

For the last decades, the reviews or discussions about lithium technology safety mostly focus on lithium batteries [8–13]. As a basis, Kalluri et al. [8] discussed an in-depth summary of the significant role of lithium metal oxide-based cathode materials in improving ionic conductivity, electrochemical stability, rate capability and safety. Balakrishnan et al. [9] analyzed the possible conditions that caused the safety problems of lithium-ion battery packs and discussed the safety mechanisms such as pressure relief valves, disposable fuses and chemical shuttles. Hendricks et al.'s work [10] reviewed the physical model state of lithium-ion battery failure and provided a detailed framework for lithium-ion battery reliability assessment. More focused, Chombo et al. [11] reviewed the thermal hazards of lithium-ion batteries and effective safety strategies to eliminate the risk of thermal runaway. In addition, research on safety issues related to lithium-ion batteries has proved the rationality of intensive testing on its value chain, allowing for the development and use of prediction tools to help designers develop safer batteries [12]. Recent research [13] also includes the latest development of ionic liquid-based electrolytes in lithium-ion batteries. These studies summarized the safety problems and improvement directions of lithium batteries from different perspectives in different periods, which are likely to make rapid progress in the application of lithium technology in batteries.

Now, lithium technology has been widely used instead of the battery. One of the early important uses of lithium compounds is used in ceramic products [2], especially in enamel products, to play the role of co-solvent. Lithium is also used as a thickener for grease in the form of lithium stearate, a lubricant with both high water resistance, high-temperature resistance and good low-temperature properties. In the metallurgical industry, the use of lithium can strongly react with oxygen, nitrogen, chlorine, sulfur and other substances of their nature, as a deoxidizer and desulfurizer [14]. At the same time, lithium is also an important component of beryllium, magnesium, and aluminum lightweight alloys. For example, a lithium-lead alloy is a good friction-reducing material. In the military field, 1 kg of lithium can release 42,998 kJ of heat after combustion, and lithium has become a "high-energy metal" and is one of the best metals used to make rocket fuel [15]. Lithium also plays an important role in medical treatment. On the biological necessity and human health effect of lithium, lithium can improve hematopoietic functions and improve human immune functions [16]. Lithium is an effective mood stabilizer, which has a regulatory effect on central nervous activity and can calm and control nervous disorders. Lithium is by far the most effective measure for the preventive management of acute mania and manic-depressive disorder.

In the last decade or so, the demand for lithium has increased exponentially in different application scenarios [17], and the following security risks have gradually increased. It is reported that the demand for lithium has increased dramatically from about 2000 tons in 2005 to more than 14,000 tons in 2020. Global lithium consumption is estimated to be more than double the current levels in 2025 [18]. The safety problems of lithium in different application scenarios are also different. Similar to potassium and sodium, lithium metal has a strong reactivity and needs to be stored separately from the air. Although lithium is widely used in medical treatment, its strong corrosivity to human skin is a problem that cannot be ignored. Most of the safety tests conducted in the laboratory or factory cannot replicate the actual conditions of safety accidents on the site [19]. Therefore, it is necessary to analyze and judge the development of lithium technology safety problems in various fields from the perspective of metrology literature.

As far as we know, there is no research on the safety of lithium technology from the perspective of metrology literature. The method of bibliometrics can intuitively present information in this field through a collation of past research and visualization [20]. Using this method to study the safety of lithium technology can well summarize and analyze the current lithium application scenarios and the existing safety problems, so that researchers can understand the research status of lithium safety in various scenarios, including lithium batteries, and better promote the application and development of lithium technology by solving the corresponding safety problems.

In this paper, we use the methodology of bibliometrics, together with CiteSpace and VOSviewer analysis tools, to analyze and present the literature in the field of lithium technology. By analyzing indicators such as publication characteristics, research hotspots, research institutions and major researchers at different development stages, we provide a quantitative overview of the research profile of lithium technology safety issues, with a view to providing scientific references for the in-depth development of lithium technology. In addition, by way of evolution analysis through CiteSpace and co-occurrence analysis through VOSviewer, we explored the evolution process of research on lithium technology safety issues and predicted future development trends.

The contents of this article will be arranged in the following order. Section 2 introduces the data sources and research methods in detail. Section 3 introduces the analysis results and corresponding enlightenment from the number of documents, citations, journals, topics and other aspects. The discussion and conclusions will be described in Section 4.

2. Materials and Methods

2.1. Data Source

In this paper, we use the Web of Science Core Collection (WOSCC) by Thomson Reuters to search for papers related to our research topic. We chose the WOSCC for two main reasons: On the one hand, the core set database is a collection of high-quality papers representing the field, which can help to grasp more accurate and cutting-edge developments. On the other hand, the data in the core set provides more abundant fields, which facilitates the subsequent construction of a visual analysis of multiple networks in VOSviewer.

In advanced search, we use the search formula "TS = lithium and (risk or safety)" to filter papers related to our research topic. The time range was set to 1972–2021. Export the above literature data in the form of a tab-separated file. The total number of retrieved papers related to lithium safety was 14,262 (web of science core collection), of which 56 were missing in the year column. Excluding the papers missing in the year, there are 14,206 papers left. Before performing visual analysis, we first preprocess the data. Specifically, it is necessary to merge the single and plural forms of some keywords and the full name and short form of some specific keywords. By collecting and analyzing the papers published by global scholars in important international journals in related fields, this paper quantifies the research trend and development trend of lithium technology safety issues and then provides support for exploring the research patterns and future research directions of lithium technology safety issues.

2.2. Research Methods

This paper mainly adopts the bibliometric analysis method and knowledge graph method, taking lithium technology as the main research field. With the help of visualization tools CiteSpace and VOSviewer, the paper conducts a multi-angle and all-round analysis of literature data information exported from Web of Science. As shown in Figure 1, based on the number of articles in the field, citations, mainstream journals, cooperation networks (based on authors, institutions and countries), keywords, etc., we plot citation networks, cooperation networks and topic distribution, visually and dynamically revealing the research status and hot issues of lithium technology, so as to realize the research situation and developments trend of lithium technology safety problems.

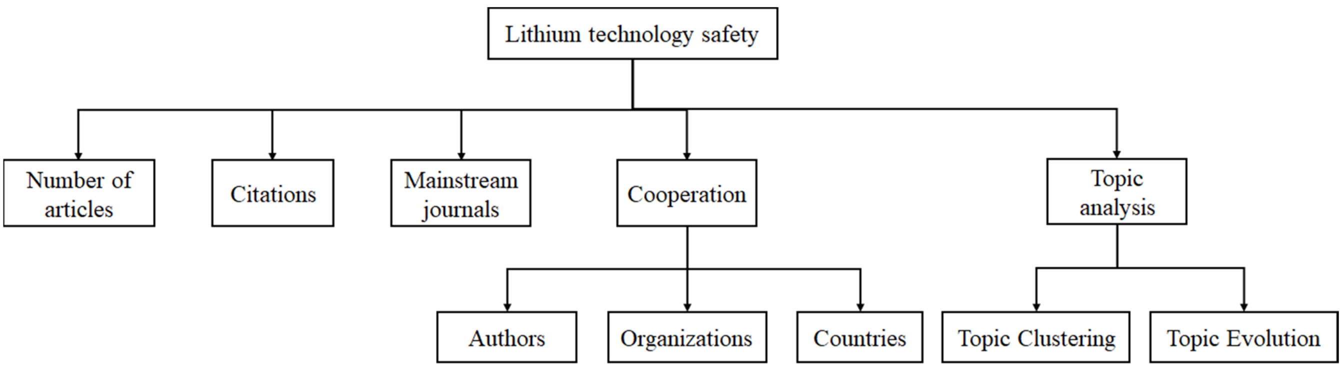

Figure 1. Flowchart of the research methodology.

CiteSpace is a visualization software based on Java language, widely used for field analysis, frontier analysis, scientific evaluation in scientific research, etc. VOSviewer, developed in collaboration with Nees Janvan Eck and Ludo Waltamn, is commonly used for bibliometric analysis and visualization. In this paper, CiteSpace (version 5.7.R2) and VOSviewer (version 1.6.17) are used for visual bibliometric analysis and scientific evaluation.

3. Results

3.1. Number of Articles

By analyzing the year of publication of valid papers, it was found that the number of lithium-related papers peaked in 2021 with 2490 papers. Figure 2 shows the changes in the number of relevant articles published in the last 20 years, showing a yearly climbing trend. It can be clearly seen that the number of relevant articles published increased the most in 2020, with 422 more articles compared to the previous year. The rapid increase in the number of published articles in recent years shows that the safety of lithium technology has been studied more frequently.

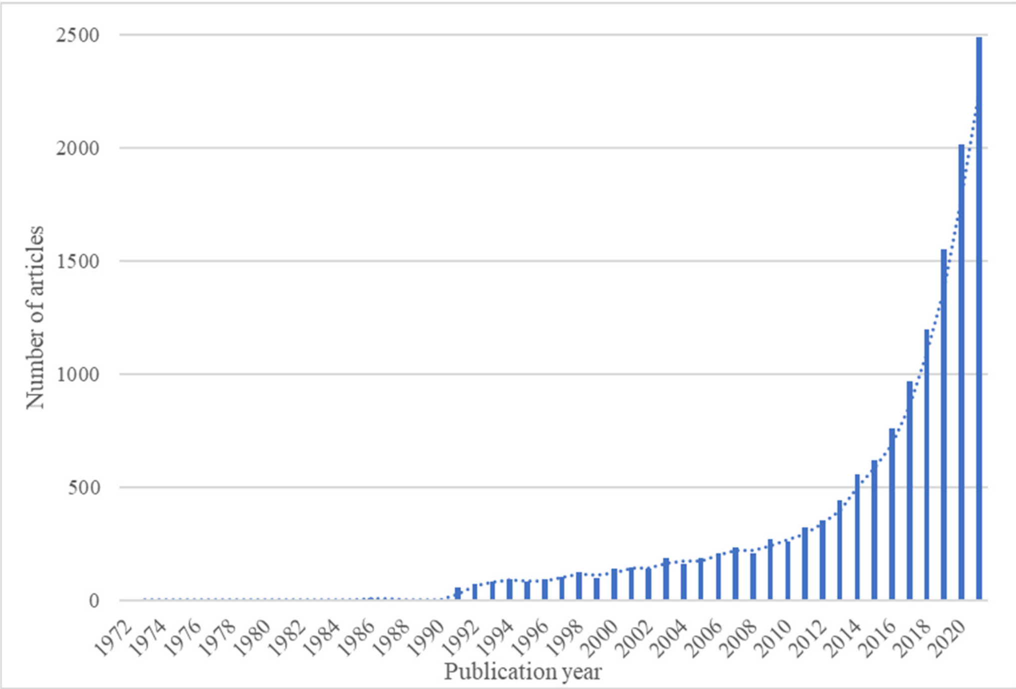

Figure 2. Number of papers published in the field of lithium safety from 1972 to 2021.

As shown in Figure 2, the research on lithium technology security issues is divided into three phases based on annual publication statistics.

1. Budding period (1972–1990): Relevant articles began to appear in 1972 but the number was relatively small, and only 43 articles were published in the field of lithium technology safety issues during this period. This indicates that the research on lithium technology safety issues has not yet been taken seriously and is in the initial period of exploration.
2. Groundbreaking period (1991–2010): The number of articles published in this period shows a fluctuating upward trend, but the growth rate is slow. Some countries started late in this field and even did not publish articles in this period. However, it is clear that the number of papers achieved a double-digit breakthrough in 1991 compared to the previous period, thanks to the first commercial development of lithium batteries in 1991 [21].
3. Developmental period (2011–2021): The number of research results in this period has grown significantly, and the increase has continued to be high, with a rapid rise.

Especially after 2019, there is an unprecedented growth in the number of articles. Notably, 422 more relevant articles were published in 2020 compared to the previous year. This may be related to the fact that John B. Goodenough, M. Stanley Whittingham and Akira Yoshino won the 2019 Nobel Prize in Chemistry for lithium-ion battery research, which has greatly boosted the enthusiasm of researchers.

In recent years, the number of papers published related to the safety of lithium technology has shown an overall increasing trend. The reason for this is mainly because lithium technology is widely used in various industries. Inevitably, there are various safety problems in the application, which cannot be ignored but seriously endanger human life and property safety. In addition, in the context of low carbon, new energy has become the main direction of global development. Large-capacity lithium batteries have been applied to electric vehicles and will become one of the main power sources for electric vehicles in the 21st century. The continuous growth of the production and sales of new energy vehicles has driven up the demand for lithium batteries, while the rapid development of cell phones, electric vehicles, power tools, digital cameras and other industries has also driven the demand for lithium technology applications throughout society. In addition, lithium technology will be applied to artificial satellites, aerospace and energy storage in the future. Such a wide range of application scenarios must primarily address the safety issues of lithium technology in order to make its future development long and sustainable. Therefore, the research on lithium technology and its safety issues will continue to grow in the coming years.

Figure 3 shows the number of articles searched with the search term "lithium", and the time range is set from 1972 to 2021. We can see that the overall trend is increasing. Combined with Figure 2, we can easily find that among the lithium-related research topics, the number of papers on lithium safety issues has been growing rapidly in recent years, faster than the overall number of papers in the lithium field. This indicates that in the process of lithium technology application and development, the topic of lithium safety is of great interest to scholars and has research prospects. This also shows the importance of studying this topic from the side.

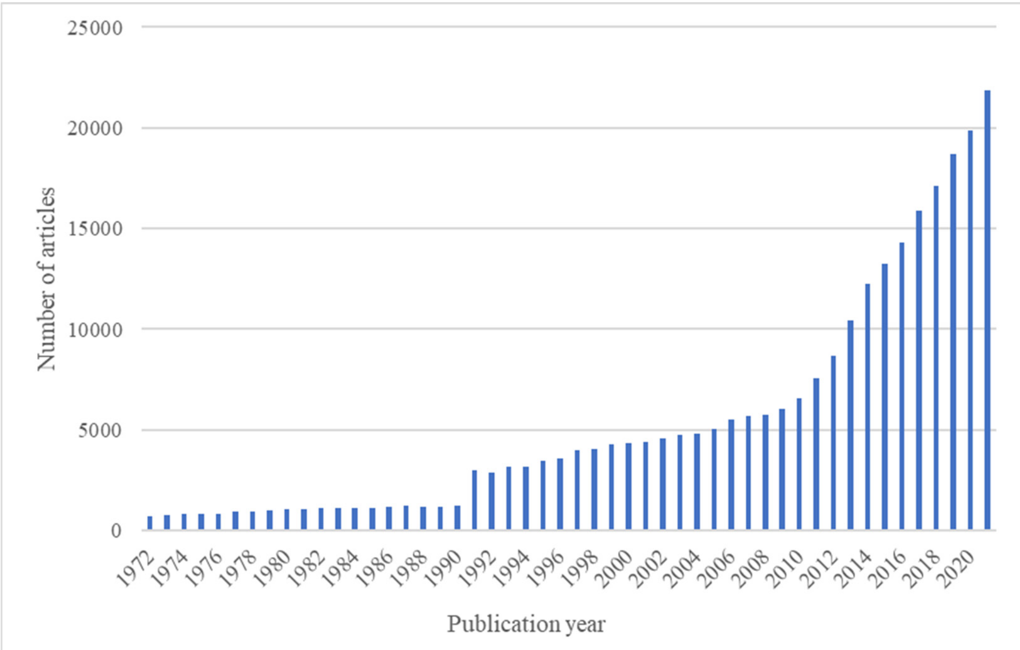

Figure 3. Number of papers published in the lithium field from 1972 to 2021.

3.2. Citations

Citation analysis is a crucial tool for evaluating the caliber of publications since it captures the level of interest that a research issue generates among academics as well as the level of attention that the scientific community accords to an individual researcher's work [22]. Table 1 lists the top 10 highly cited papers in the Web of Science core library on the topic of lithium technology safety from 1972 to 2021, in which the papers are classified according to the title, journal, total citations, and year of publication. Our research shows that most of the most highly cited papers are published in periodicals that are specialized in the field of materials science.

Table 1. List of the top 10 highly cited papers.

Title	Citations	Year	Published Journals
Issues and challenges facing rechargeable lithium batteries	15,789	2001	NATURE
Challenges for Rechargeable Li Batteries	7458	2010	CHEMISTRY OF MATERIALS
The Li-Ion Rechargeable Battery: A Perspective	5808	2013	JOURNAL OF THE AMERICAN CHEMICAL SOCIETY
Li-ion battery materials: Present and future	3897	2015	MATERIALS TODAY
Lithium batteries: Status, prospects and future	3673	2010	JOURNAL OF POWER SOURCES
Reviving the lithium metal anode for high-energy batteries	3386	2017	NATURE NANOTECHNOLOGY
Toward Safe Lithium Metal Anode in Rechargeable Batteries: A Review	2958	2017	CHEMICAL REVIEWS
A review of the key issues for lithium-ion battery management in electric vehicles	2795	2013	JOURNAL OF POWER SOURCES
A lithium superionic conductor	2734	2011	NATURE MATERIALS
Electronically conductive phospho-olivines as lithium storage electrodes	2596	2002	NATURE MATERIALS

3.3. Mainstream Journals

The top five journals in terms of the number of publications are the JOURNAL OF POWER SOURCES, JOURNAL OF THE ELECTROCHEMICAL SOCIETY, JOURNAL OF MATERIALS CHEMISTRY A, ACS APPLIED MATERIALS & INTERFACES, and ELECTROCHIMICA ACTA, as shown in Table 2. These journals are the mainstream journals of materials science, electrochemistry and physical chemistry, which indicate that lithium technology safety-related research has been a hot topic in chemistry.

Table 2. Top 10 Journals by number of publications.

	Journal Name	Number of Articles
1	JOURNAL OF POWER SOURCES	805
2	JOURNAL OF THE ELECTROCHEMICAL SOCIETY	381
3	JOURNAL OF MATERIALS CHEMISTRY A	338
4	ACS APPLIED MATERIALS and INTERFACES	317
5	ELECTROCHIMICA ACTA	289
6	ENERGY STORAGE MATERIALS	230
7	FUSION ENGINEERING AND DESIGN	206
8	JOURNAL OF AFFECTIVE DISORDERS	200
9	JOURNAL OF CLINICAL PSYCHIATRY	198
10	ADVANCED ENERGY MATERIALS	191

In addition, the JOURNAL OF AFFECTIVE DISORDERS and the JOURNAL OF CLINICAL PSYCHIATRY are the mainstream journals in the field of psychiatry, and the published articles mainly focus on the safety issues of lithium technology in medical applications. Lithium is an effective measure for the preventive management of acute mania and manic-depressive disorder. Despite the large number of articles published, they were published earlier, almost a decade ago. Interest in and research on lithium therapy has waned in recent years with the advent of new mood stabilizers.

3.4. Cooperation

3.4.1. Authors

Author collaboration network mapping can show the degree of cooperation, research influence and activity of researchers. The authors of the WOS database were analyzed using VOSviewer, with the analysis type set to co-author, authors as the analysis group, papers with more than 25 authors removed, the counting method set to a full count, and the minimum frequency of author occurrences set to 20, resulting in 136 authors. Some of the 136 items in the network are not connected to each other. The largest set of connected items consisted of 123 items. The set of connected items instead of all items. Notably, 456 connected lines and 12 clusters of authors were formed, see Figure 4. In author collaboration networks, the node size indicates the number of citations. Table 3 shows the top ten highly cited authors in the field of lithium technology security.

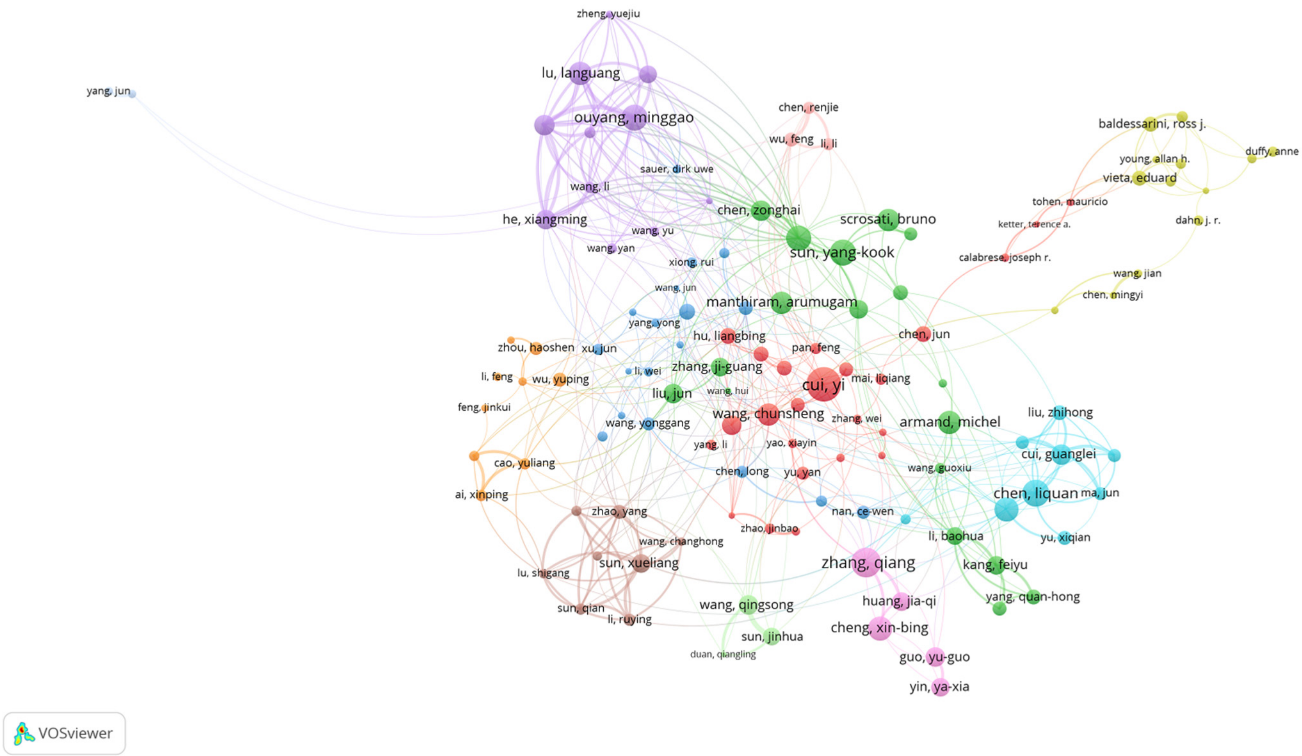

Figure 4. 456 connected lines and 12 clusters of authors were formed.

Table 3. Top 10 highly cited authors in the field of lithium technology safety.

	Author	Documents	Citations	Total Link Strength
1	cui, yi	59	15,729	32
2	zhang, qiang	63	11,445	68
3	chen, liquan	46	9395	86
4	sun, yang-kook	41	9138	35
5	ouyang, minggao	79	8773	264
6	amine, khalil	54	8492	125
7	cheng, xin-bing	23	7840	42
8	li, hong	52	7773	55
9	armand, michel	38	7214	16
10	lu, languang	49	6969	195

3.4.2. Organizations

Figure 5 reflects the cooperative relationships of research institutions in this field. The VOSviewer was used to analyze the institutions in the WOS database and the type of analysis was set as co-authorship and organizations were set as the analysis group. Papers with more than 25 institutions were excluded, the counting method was full counting and the minimum frequency of institutions was set as 20. There are 262 institutions, 3719 connecting lines, and 9 institutional clusters. The cooperation within and between institutional clusters is relatively close. Among them, the institution with the largest number of articles was the Chinese Academy of Sciences, with a total of 847 articles. Detailed results are shown in Table 4. In post number in the top 10 institutions, there are seven are research institutions and universities of China, Chinese Academy of Sciences, Tsinghua University, University of Science and Technology of China, University of Chinese Academy of Sciences, Beijing Institute of Technology, Shanghai Jiao Tong University, Huazhong University of Science and Technology. Harvard University, Argonne National Laboratory and Stanford University, all of which are from the United States, ranked 6th to 8th in that order.

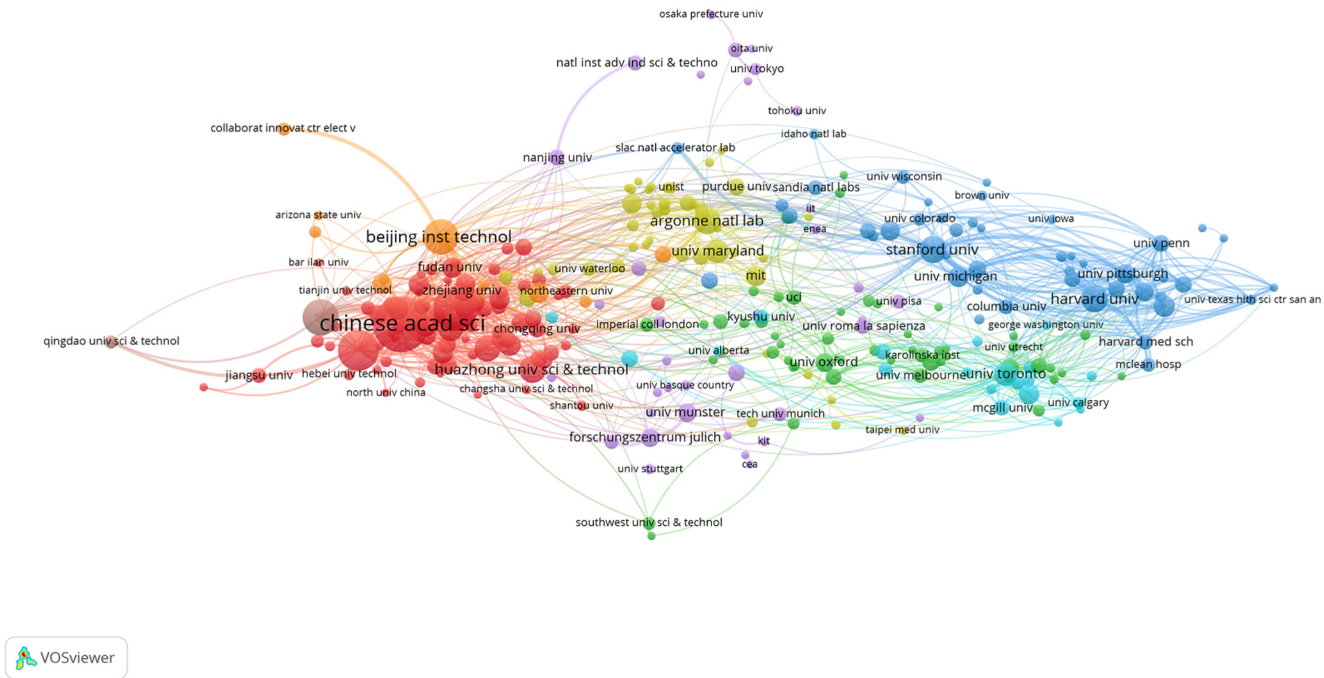

Figure 5. Organizational cooperation network diagram.

Table 4. Top 10 published institutions.

	Organization	Country	Documents	Citations	Total Link Strength
1	Chinese Academy of Sciences	China	726	39,250	928
2	Tsinghua University	China	459	34,458	485
3	University of Science and Technology of China	China	369	17,281	311
4	University of Chinese Academy of Sciences	China	295	17,604	439
5	Beijing Institute of Technology	China	268	12,199	247
6	Harvard University	America	199	16,531	356
7	Argonne National Laboratory	America	195	21,849	259
8	Stanford University	America	193	25,965	436
9	Shanghai Jiao Tong university	China	156	4168	112
10	Huazhong University of Science and Technology	China	155	9064	107

3.4.3. Countries

The country co-occurrence map reflects the collaboration of countries in this research area. The analysis type was set to co-authorship, and country was the analysis group. Papers from more than 25 countries were excluded, and the minimum number of country publications was set to 5. The counting method was full count, resulting in 921 connecting lines for 69 countries. As shown in Figure 6, they are divided into seven clusters. The thickness and length of the connecting lines indicate the closeness of the relationship between countries. Table 5 lists the top ten countries with the number of submissions. In the past 20 years, China ranked first in the world in terms of the number of articles published, with 5184, which is as much as 1.3 times more than the second-ranked United States.

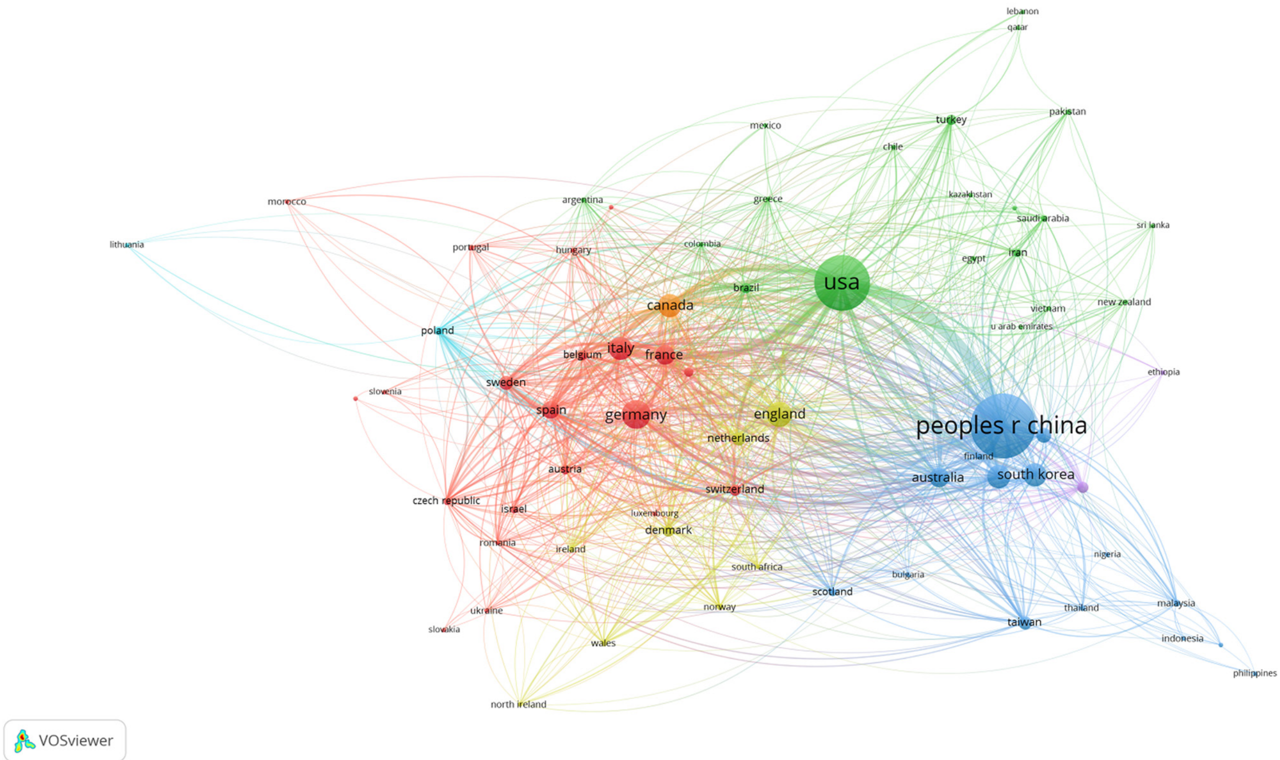

Figure 6. National cooperation network diagram.

Table 5. Top 10 countries by number of publications.

	Country	Documents	Citations	Total Link Strength
1	China	5184	220,985	1647
2	USA	3780	259,443	2187
3	Germany	1043	45,644	1022
4	England	762	34,903	862
5	Canada	697	58,138	796
6	South Korea	690	35,879	342
7	Italy	685	31,963	795
8	Japan	685	34,271	430
9	Australia	478	23,087	664
10	France	471	39,471	617

3.5. Topic Analysis

3.5.1. Topic Clustering

In the keyword co-occurrence network, some keywords exist as singular and plural, but the software does not automatically process them. Therefore, we first build word sets for merging and processing singular and plural words. The analysis type was set as co-occurrence, the analysis group was set as all keywords (author keywords + keywords plus) and the counting method was set as full counting. The minimum occurrence frequency of keywords was set as 20. After human error correction and screening, 879 keywords were formed, and 67,612 complex association network lines were formed between each keyword. The larger the keyword circle is, the higher the frequency of its appearance.

The thickness of the network line indicates the strong and weak connection relationship between keywords.

As can be seen from Table 6, the top 10 keywords with the highest frequency are Lithium-ion battery, lithium, performance, safety, battery, bipolar disorder, anode, cell, stability and behavior.

Table 6. Top 10 keywords with occurrences.

	Keyword	Occurrences	Total Link Strength
1	lithium-ion battery	3282	20,310
2	lithium	2465	15,340
3	performance	1717	12,104
4	safety	1360	9210
5	bipolar disorder	1160	8285
6	battery	1027	6467
7	anode	862	6174
8	cell	830	5543
9	cathode material	749	5274
10	behavior	737	5253
11	stability	720	5367
12	risk	714	4217
13	electrochemical performance	713	5166
14	cathode	690	4860
15	electrolyte	625	4485
16	double-blind	621	4862
17	mechanism	598	4392
18	polymer electrolyte	586	4108
19	electrode	555	3715
20	challenges	542	3799

Figure 7 shows the keyword co-occurrence label map, respectively. Five clusters were obtained by keyword clustering, and the keyword clusters corresponding to each research hotspot and some words with high weight in each cluster were summarized in Table 7. From each keyword cluster, it can be seen that the keywords in each cluster are correlated, and the clustering results have high credibility. The keywords were summarized and clustered into the following topics: lithium medical applications, electrolytes, electrochemical performance, battery health and management, and sustainability technology.

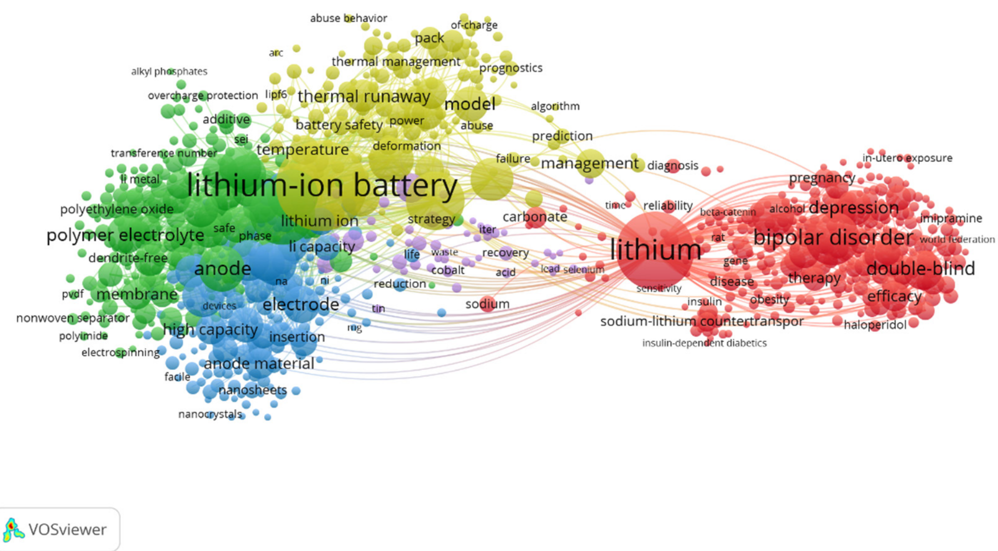

Figure 7. Keyword co-occurrence network diagram.

Table 7. Five types of research topics in the field of lithium technology safety.

Research Topic		Main Keywords
1	Medical applications of lithium	bipolar disorder, double-blind, depression, schizophrenia, efficacy, mania, mood stabilizer, antidepressant, therapy, suicide, placebo, risk factor, mood disorders
2	Electrolyte	stability, electrolytes, polymer electrolytes, conductivity, electrolytes, separators, deposition, membranes, ionic conductivity
3	Electrochemical property	cathode material, electrochemical performance, cathode, electrode, composite, electrochemical properties, high-capacity, anode material
4	Battery Health and Management	lithium-ion battery, thermal runaway, electric vehicle, temperature, state of charge, battery safety, management system, cycle life, overcharge
5	Sustainability	circular economy, drinking water, recycling, renewable energy, sustainability, renewable energy, contamination, corrosion

3.5.2. Topic Evolution

Keyword co-occurrence mapping can analyze the research hotspots and their evolution during the period. The frequency of key occurrences is indicated by the size of the nodes, and the thickness of the connecting lines between the nodes intuitively reflects the sparseness of the connections between the keywords, which are positively correlated.

In Figure 8, the color changes from dark to light as time goes on. As can be seen, the application of lithium technology in the medical field is an early research topic. In recent years, the hot spots of research in related fields have focused on the performance and safety of lithium-ion batteries.

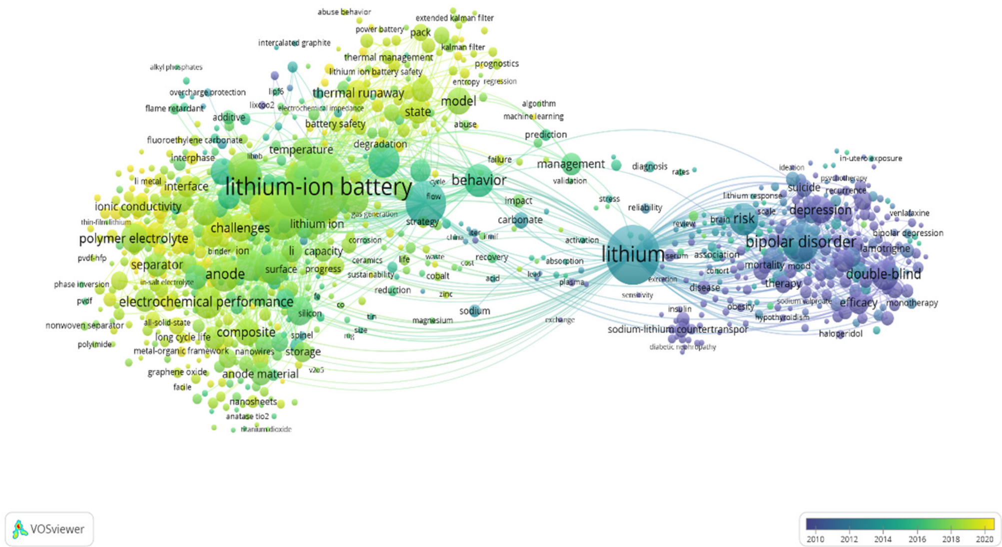

Figure 8. Keyword clustering density map.

CiteSapce software was used to count the frequency of keywords appearing in papers at different stages of development. The keyword emergent mapping can demonstrate the phenomenon of word frequency surge, and the highlighted keywords are often considered to have a popular-oriented function in the research field. Based on this, the lithium security keyword emergent mapping was conducted: the emergent mapping parameters were set to $\gamma = 0.5$, and the default Minimum Duration was set to 2. The 106 emergent words were obtained, and the top 30 were taken, as shown in Figure 9. The keywords clustering density map was combined with the keywords clustering density map to obtain keyword and topic profiles in different periods.

Figure 9. 1972–2021 lithium technology safety issues keywords emergent map.

The results showed that the earliest publication was in 1972, and the number of articles during the budding period was 43, with an annual average of 2.26 articles/year, and the research theme was not yet obvious. The number of articles increased significantly in this phase of the foundation period, and the research themes gradually became obvious. The keywords "depression", "bipolar disorder", and "lithium carbonate" are the hot keywords, mainly in the medical application of lithium technology and lithium battery safety issues related to research. The number of literature in this period increased to 2955, with an average annual number of 147.75 articles/year. The development period is the most productive period, with 11,264 articles and an average annual publication volume of 1024 articles/year. The research topics are clearly distributed, with "composite", "energy storage" and "electrode" as the hot keywords. Among them, the hot keyword in the past three years is "ion battery", which indicates that scholars have gradually shifted their research focus to the safety performance improvement of lithium-ion batteries and other related topics.

The development of the lithium safety field is shown in Figure 10.

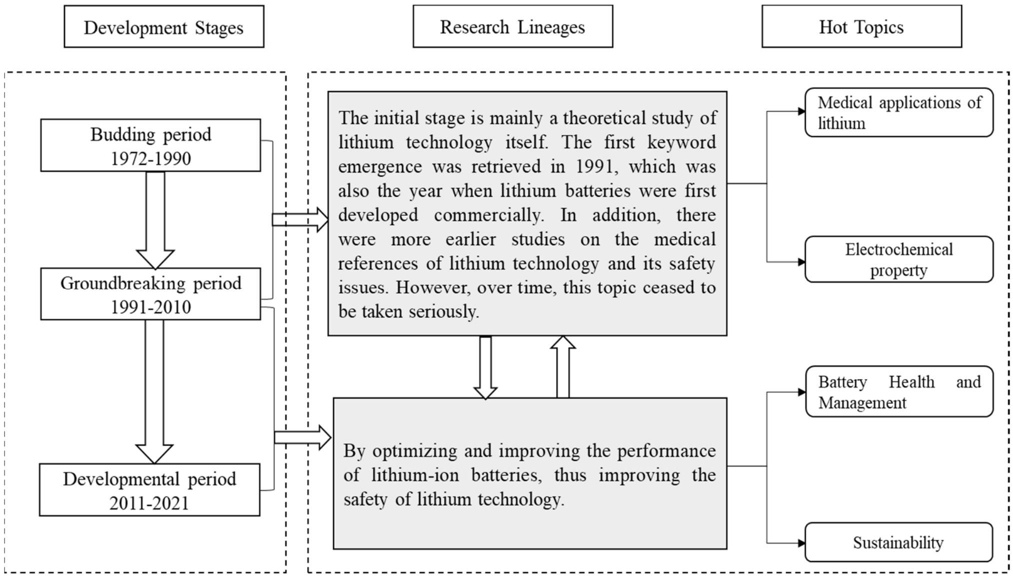

Figure 10. Lithium technology safety theme development pulse chart.

4. Discussion

Based on bibliometric, we used CiteSpace and VOSviewer software to analyze the volume of postings, collaboration analysis, keyword co-occurrence and emergence analysis, as well as to map the visual knowledge graph in the field of lithium security from 1972 to 2021. The results of the study are as follows.

1. The number of publications on lithium technology safety issues is in a steady upward trend throughout the study period, especially in the last 3–5 years. The overall number of publications has increased at a significant rate. It is worth mentioning that China leads the world in the number of published articles and far exceeds other countries. In terms of the mainstream journals published, the research topics are highly interdisciplinary, involving materials science, electrochemistry, physical chemistry, etc. Early related research also involved the medical field, which was attributed to the prevalence of lithium technology for medical applications.
2. The analysis of cooperation and exchange among authors, institutions, and countries that publish articles using VOSviewer clearly shows that there is closer cooperation and more extensive exchange among international institutions. The degree of contact between domestic institutions in each country is also relatively high. However, in terms of the nature of institutions, most of them are universities and research institutes, and enterprises account for a relatively small number. Of course, this may be due to the fact that corporate R&D results are more often published in the form of patents rather than academic papers.
3. Based on the keyword clustering hotspot analysis at each stage, the lithium safety field is more concerned with the safety and risk of lithium-ion batteries. Lithium battery is the most important application of lithium. Safety is the most important issue of lithium-ion batteries, especially for large lithium-ion batteries. The scope of research from the early focus on lithium in medical applications and thus the safety issues caused by the gradual shift to the health and safety of lithium batteries, such as based on electrochemical materials to improve the safety of lithium batteries, more focus on the performance optimization and sustainability of lithium batteries. Lithium technology and other technologies coupled with treatment effects, lithium battery performance optimization, and sustainable development, lithium technology involved in or mediated by the relevant modeling research should be the current and future research hotspots for quite some time.

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