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Knowledge Graph of Safety Production Research in CCUS

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ABSTRACT

CCUS (Carbon Capture, Utilization and Storage) is one of the key technologies to address global climate change. Both in China and internationally, research and development on CCUS has been on the rise in recent years. In the process of CCUS implementation, safety issues are naturally inevitable. In this paper, the knowledge graphs of CCUS safety technology are drawn based on Web of Science database with the help of CiteSpace. The analysis of the countries of publication shows that the United States and China account for most of the publications. The analysis of article co-occurrences demonstrates that CCUS technical safety research is mainly concentrated in the field of energy fuels and engineering, and the development status is obtained accordingly. The co-occurrence analysis of the subject terms yielded the most frequently used terms in this field. The results show that there is a large gap in the safety research on CCUS technology, with fewer articles published and the rigor and reliability of some articles still open to question. The research on CCUS safety technology still needs to be paid attention to, both in depth and breadth, so as to provide more stringent safety for CO2 resource utilization.

Keywords: Knowledge Graph; CCUS; Safety Technology Information Visualization; CiteSpace

1. INTRODUCTION

Carbon Capture, Utilization and Storage (CCUS) technology is the key technology to reduce CO2 emissions. In the process of promoting CCUS, the safety issue should not be taken lightly. The academic research on how to strengthen the safety technology has also attracted much attention.

Knowledge Graph, which shows the process of knowledge development and structural relationships of a series of different graphs, using visualization techniques describing knowledge resources and its carriers, mining, analyzing, constructing, mapping and displaying knowledge and their interconnections. It brings together the complex knowledge domain through data mining , information processing, and knowledge measurement and graphing to reveal the dynamic development of the knowledge domain.

Based on the Web of Science database, this paper summarizes the articles in the field of related safety technologies and makes a preliminary knowledge map in this field, in order to provide a reference for related research.

2. DATA ACQUISITION

In order to ensure that the data involved in the knowledge graph were as comprehensive and accurate as possible, a variety of search formats were used in the data acquisition process. After eliminating irrelevant articles and duplicate articles, a total of 1173 articles were obtained from 2010 to the present.

3. ANALYSIS OF RESEARCH RESULTS IN THE FIELD OF CCUS SAFETY TECHNOLOGY

3.1 Analysis of article publication year

According to the relationship between the number of articles published and the year, it can be concluded that research in related fields was almost at a standstill before 2013, and after 2013, the number of related articles published gradually increased, and the number of articles published in 2021 and 2022 even surged, with the number of articles published in these two years occupying nearly half of the total number of articles published. This year (2023), the number of articles published by March 1 has exceeded the total number of articles published each year before 2017. This reveals

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that the research on the field of CCUS safety technology is gradually gaining attention, and the research fever will continue to rise now and in the future for some time, and the safety issues in this field will gradually gain attention.

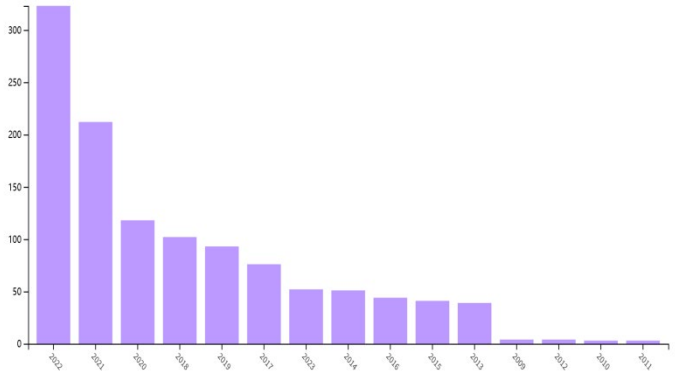

Fig.1.Annual trends in the number of papers in CCUS safety, 2009-2023

3.2 Analysis of article publication countries and regions

The number of articles published shows that the articles are mainly concentrated in China (395), USA (237) and India (101). From the figure, it can be concluded that the academic cooperation among countries is relatively close, and there is full cooperation among the national regions to study the safety technology of CCUS.

Fig.2. Distribution of national issuance and centrality

1	395	0.17	2010	PEOPLES R CHINA
2	237	0.09	2010	USA
3	101	0.04	2016	INDIA
4	75	0.23	2013	ENGLAND
5	55	0.23	2014	NORWAY
6	54	0.01	2013	SOUTH KOREA
7	52	0.08	2011	CANADA
8	51	0.07	2013	AUSTRALIA
9	46	0.05	2013	SCOTLAND
10	44	0.03	2014	GERMANY

Tab.1. Distribution of national issue volume and centrality

According to the centrality analysis, China, the UK, and Norway are important countries in the field and are important publishers. The UK and Norway have the highest centrality, although they have fewer publications, they are more closely associated with other countries and play an important role in the field.

3.3 Article publication Research institution analysis

According to the results of the study, the institution with the highest number of publications is Chinese Acad Sci with 64 publications, which far exceeded other research institutions. The results of the centrality analysis reflects that Chinese Acad Sci and Univ Texas Austin have the largest centrality and are closely associated with several research institutes. It has a significant impact in the field of safety technology research at CCUS.

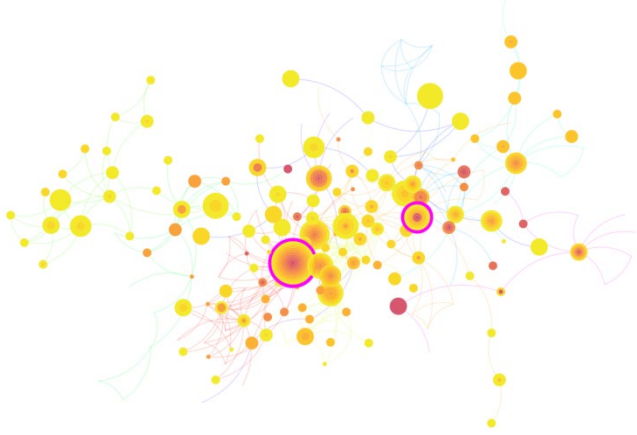

Fig.3. Distribution of national issuance and centrality

64	0.25	Chinese Acad Sci
39	0.06	China Univ Petr
25	0.02	Sichuan Univ
23	0.03	Peking Univ
22	0.03	China Univ Petr East China
21	0.22	Univ Texas Austin
18	0.05	Tsinghua Univ
17	0.05	Univ Edinburgh
16	0.04	China Univ Min & Technol
16	0.01	Dalian Univ Technol

Tab.2. Distribution of national issue volume and centrality

3.4 Author co-citation analysis

The authors were analyzed for co-citation along with cluster analysis. According to the results, it can be obtained that among the relevant studies, the research focus is relatively concentrated and the authors are more closely connected with each other, while at the same time there are some authors who are less connected with other authors and whose research directions are more unique. After excluding the anonymous authors, the individual authors who made outstanding contributions to this field were BACHU S (83 times) and Li Q (77 times), who were not only cited more often but also had stronger connections with others.

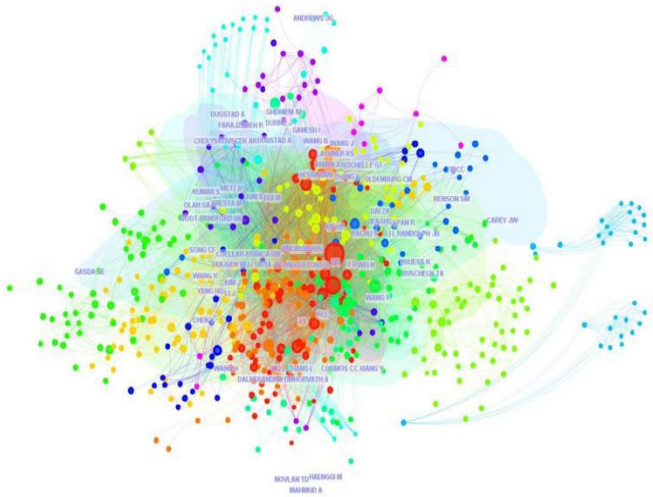

Fig.4. Analysis of authors' co-citations

167	0.09	IEA
88	0.04	IPCC
87	0.01	BUI M
83	0.14	BACHU S
77	0.13	LI Q
68	0.04	GLOBAL CCS INSTITUTE
66	0.09	MIDDLETON RS
65	0.07	RUBIN ES
63	0.01	INTERNATIONAL ENERGY AGENCY
57	0.04	ZHANG X

Tab.3.Frequency ranking of cited authors

3.5 Keyword co-occurrence analysis

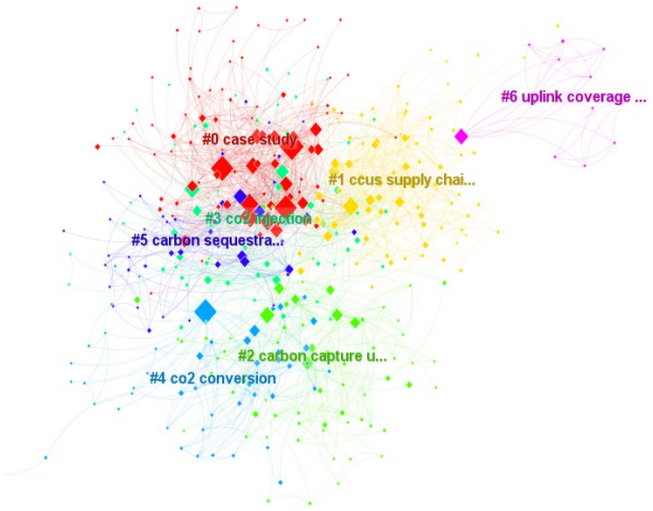

Fig.4. Keyword co-occurrence analysis

According to the keyword co-occurrence analysis, the main research directions in this field are currently storage, capture, and sequestration aspects of safety. In my opinion, these three areas are indeed the focus of research on CCUS safety technology, but the total amount of research and research results are not significant. There are still many blind spots in the research, and more in-depth research is needed.

157	storage
141	carbon dioxide
141	co2 capture
140	carbon capture
107	sequestration
93	capture

Tab.5. Keyword co-occurrence analysis

3.6 Analysis of historical development of research themes

A timeline analysis of keywords and subject terms shows that the capture and collection of CO2 and the safety issues in this process have been of great concern.

Based on the timeline, it can also be concluded that new methods and materials have emerged in recent years in the related field of research, which will play a huge role in the development of the field.

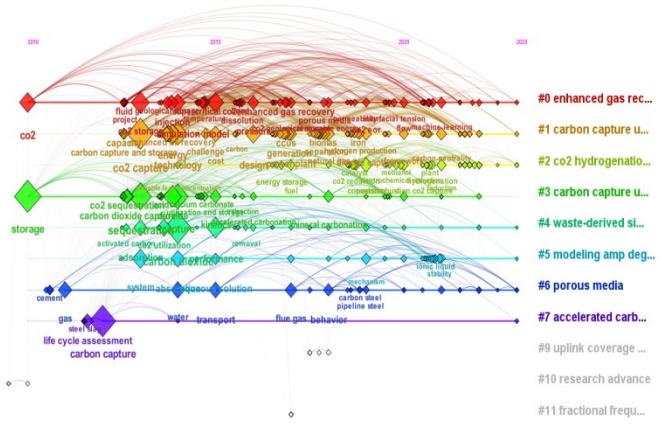

Fig.6.Analysis of historical development of research themes

3.7 Analysis of journal co-citations

The analysis of journal co-citations shows that the journals cited in the field of CCUS security are quite scattered, and there is no more authoritative journal to collect articles in this field centrally, which also brings inconvenience to the research in this field and easily leads to some new and valuable research being ignored. There is an urgent need for an authoritative journal to collect articles in this field.

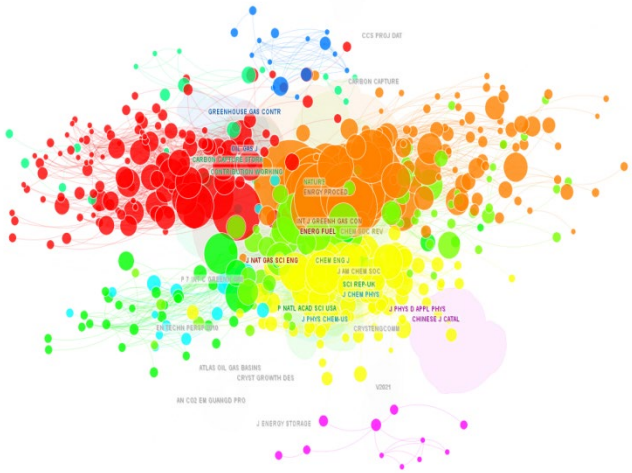

Fig.7.journal co-citations analysis

4. SUMMARY AND DEVELOPMENT PROSPECTS

Currently, there are still some aspects of security research in the CCUS field that are lacking.The research area is mainly focused on energy fuels and engineering, with the goal of securing the safety of capture, transport, storage and utilization processes.

Research on new materials and technologies has also started to emerge. It is believed that in the future, more and more research will be conducted in this area.

Safety of carbon capture technologies: Although a variety of carbon capture technologies have been developed, there may be potential safety risks in practical applications. For example, chemical absorbents may have adverse effects on the environment and human health, while the long-term stability and reliability of new materials still need further verification. Future research on these potential risks needs to be strengthened to ensure the safety of carbon capture processes.

Inadequate risk assessment methods for carbon storage: The current risk assessment methods on underground reservoirs are not yet perfect, and it is difficult to comprehensively predict and assess the possible leakage and crustal changes during storage. In the future, more accurate risk assessment methods need to be developed and validated with actual monitoring data to improve the safety of carbon storage.

As mentioned above, there are still some gaps in the safety research in the field of CCUS. In order to meet these challenges, we need to strengthen research and cooperation in several aspects in the future, including the safety of carbon capture technology and carbon storage risk assessment methods, and we expect researchers to work together to overcome the challenges so that CCUS technology can contribute to human life more safely.

REFERENCE

[1] J. Li and Chaomei Chen. CiteSpace technology text mining and visualization [M]. Beijing: Capital University of Economics and Business Press, 2016.01.

[2]Chen T,Li G-P,Wang S-M. Optimizing scientific knowledge mapping methods for mapping domain-wide scientific structures[J]. Library and Information Work,2022,66(21):107-119.DOI:10.13266/j.issn.0252-3116.2022.21.012.

[3]Siyuan Chen, Jiangfeng Liu, Qi Zhang, Fei Teng, Benjamin C. McLellan,A critical review on deployment planning and risk analysis of carbon capture, utilization, and storage (CCUS) toward carbon neutrality,Renewable and Sustainable Energy Reviews,Volume 167,2022,112537,ISSN 1364-0321

[4Hu Jinqiu,Zhang Laibin,Ma Xi et al. Research on knowledge mapping in the field of offshore oil and gas safety production[J]. Safety,2019,40(12):15-20.DOI:10.19737/j.cnki.issn1002-3631.2019.12.003.