Visual Analysis of Zeolite Adsorption from January 2015 to July 2021

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Abstract. The CiteSpace software was used to visually analyze the literature on zeolite adsorption from 2015 to July 2021 in CNKI database. The results show that at present, various hotspots of zeolite adsorption research coexist, and the focus is mainly sorption and heavy metal, showing a diversified development trend. Many excellent authoritative scholars have issued papers, and some key authors have preliminarily established a large-scale literature cooperation network and are closely linked. Department of chemical engineering and Department of chemistry are the document issuing institutions with core outputs. The research force is relatively concentrated, and the in-depth cooperation and exchange between institutions are strengthened, so as to provide guidance for the rapid development of zeolite adsorption research.

1. Introduction
As an excellent physical adsorbent, zeolite has the advantages of wide application range, low cost, simple operation and convenient adsorbent recycling. So it is favored in the field of carbon capture [1]. There is a lot of water in the internal void of natural zeolite, which will boil when heated, so it is named. Zeolite is widely used in various fields because of its rich resources, wide distribution and low cost. Scientific knowledge atlas is an image that combines the bibliometric method and the principle of information visualization, takes the knowledge domain as the research object, and shows the relationship between the development process and structure of a scientific knowledge, so as to make the research progress more comprehensive and objective [2].

2. Data sources and methods
In order to ensure the scientific and comprehensive data, all samples are from CNKI database. They are searched through advanced search journals. Zeolite is set as the subject search term and adsorption as the keyword. The publication time is limited from January 2015 to July 2021. Considering the value and validity of research and analysis, 2659 effective literatures were finally retrieved after manually excluding non-academic literatures.

This paper uses the time-sharing, dynamic and diversified citation visualization software CiteSpace [3] developed by Professor Chen Chaomei for visual map analysis, and truthfully reflects the internal connection between the research and development process and the knowledge structure system in the form of representation. Select the LLR algorithm, set the time slice to one year, Top N=50%, and set keywords, institution and author for node types to generate the corresponding knowledge map.
3. Quantitative Analysis of Communications

It is of great significance to predict the development trend and dynamics of this field to grasp the development trend of zeolite adsorption and understand the development speed of this field in academic research from the perspective of the relationship between time and document volume [4]. Figure 1 shows the number of research articles published in each year. In recent six years, the research on zeolite adsorption has continued, and the number of articles published has generally increased slightly, indirectly indicating that the heat and attention of the research during this period have also increased. The number of articles published from 2017 to 2020 is the same, more than 400, and the maximum number of articles published is 451.

![Fig.1 Statistical chart of documents issued on zeolite adsorption research from 2015 to July 2021](image)

3.1 Keywords and Emergent Words Analysis

The frequency of keywords directly reflects the hot topics in this field [5]. Use CiteSpace to draw the keyword co-occurrence diagram. As shown in Figure 2, set the node shape to circular, the size of the node indicates the occurrence frequency of keywords, and the lighter the color of the node, the closer the occurrence year. There are 71 nodes (n = 71), 125 connections (E = 125), and the network density is 0.0503. The results show that the field of zeolite adsorption mainly focuses on the topics of sorption and heavy metal. At the same time, adsorption, zeolite, natural zeolites and other words are high-frequency keywords, which are also hot topics in recent six years. At the same time, the modified zeolite prepared by chemical and physical methods can greatly improve the decolorization rate and carbon dioxide adsorption rate of natural zeolite. Therefore, how to modify natural zeolite to have more efficient adhesion performance can be a direction of future research.
3.2 Core Author Analysis

By analyzing the authors and cooperation, we can deeply grasp the breadth and depth of discipline scientific research activities, which is of positive significance to the organization, management and coordination of scientific research activities [6]. In the author cluster view, we can understand the distribution of scholars and research teams in this field and the cooperation between scholars and teams [7]. Figure 3 is a co-occurrence diagram of the author of the document, and the meaning of its nodes and connections is consistent with the keyword map. There are 602 nodes (N = 602), 1059 connections (E = 1059), and the connection density is 0.0059. It can be seen that in the field of zeolite adsorption, Qing Wang, Yucai Qin, Yingshu Liu and other scholars are high-yield authors in this field, and the number of papers published is more than 5. Through further analysis of the cooperation among authors, some authors have initially formed a cooperation network with close contact. The cooperation between different teams is conducive to the further development of zeolite adsorption technology, and the research force is relatively concentrated.

Fig.2 Key words map of zeolite adsorption research from 2015 to July 2021

Fig.3 Contribution of authors in zeolite adsorption field from 2015 to July 2021
3.3 Analysis of Posting Mechanism

Set node types to institution and run the software to get the co-occurrence diagram of research institutions, as shown in Figure 4. The nodes in the figure correspond to the mechanism one by one, and the color values of the time axis determine the unique year, which corresponds to the contour color of the nodes in the cooperative co-occurrence network. The map contains 585 nodes (N = 585), 773 connections (E = 773), and the node density is 0.0045, indicating that there is a close relationship between the sending institutions. Based on the analysis of document volume, Department of chemical engineering, Department of chemistry and Department of Environmental Engineering published 141, 114 and 35 articles respectively, with outstanding document volume, which is the backbone of research in this field. At the same time, the research network formed by Department of chemical engineering, Department of chemical and biological engineering, School of chemical engineering and other organizations has wide and dense branches and comprehensive coverage, which is conducive to fine and scientific research, and also represents the current situation of collaborative experiment in this field to a great extent.

4. Conclusions

In this paper, CiteSpace software is used to deeply analyze and evaluate the research hotspots, research frontiers and research institutions in the field of zeolite adsorption at home and abroad, and the following conclusions are obtained:

(1) The results show that the research on zeolite adsorption has been carried out continuously in recent six years. At present, phased research results have been obtained, which is of great significance for chemistry and environment. From 2017 to 2020, more than 400 papers were published, indicating the importance of zeolite adsorption in China in the past six years, and the increasing importance of Chinese scholars and scientific research institutions in this field.

(2) From the observation of research content, the research focus of researchers mainly focuses on the adsorption performance of zeolite, including its adsorption treatment effect on heavy metals and chemical dyes. In the later stage, the modification of natural zeolite has become the focus of research, so as to promote the more efficient and cost-effective application of zeolite.

(3) From the observation of author group and output organization, the author mostly focuses on the output of research group. The authors of core papers have formed a close cooperative network and are closely related to each other. As the hubs of cooperation and communication, Department of chemical
engineering, Department of chemistry and other institutions have contributed important forces to the research and promoted the active application of zeolite in the field of adsorption.

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