Visualization analysis of adsorption of diatomite resources in China

Mengxin Zhang, Hui Huang*, Jia Zhang, Ru Li
School of Materials and Chemical Engineering, Ningbo University of Technology, Ningbo, Zhejiang, 315211, P R China
*Corresponding author’s e-mail: huihuang@nbut.edu.cn

Abstract: Objective: Diatomite is widely used in food safety, energy saving, environmental protection, health, biochemical and other fields because of its superior performance. With the help of CiteSpace software, this paper makes a visual analysis of all the literatures related to the adsorption of diatomite in HowNet database. Results: The number of published papers of related research in China is increasing year by year, and the number of published journals is relatively concentrated. There are many authors who have been engaged in related research for a long time, but there are too few research institutions, and the intensity of cooperation among research institutions is not high. Conclusion: This paper deeply explores the development process and research hotspot of diatomite in adsorption, in order to promote the application of diatomite in production and life, and provide reference research ideas for scholars.

1. Introduction
Diatomite is a kind of non-metallic mineral formed by diatom debris growing in the ocean or lake and depositing at the bottom of the water[1]. It has high chemical stability. It is insoluble in any strong acid except hydrofluoric acid, but can be dissolved in strong alkali solution. Special ring and straight chain structure can be observed under scanning electron microscope. These rich and unique pore structure with good temperature resistance constitute a place for adsorption and exchange, forming the special application performance of diatomite. These properties or functions are related to food safety, energy saving, environmental protection, health, biochemical and other fields. Therefore, diatomite and its products have good application prospects[2]. At present, China is the world's second largest diatomite resource reserve and diatomite products production country after the United States[3]. However, the utilization of diatomite in China is far less than that in the United States.

2. Materials and Methods

2.1. Literature sources
First of all, we set "key word" as "diatomite" and "key word" as "adsorption" to search the literatures about diatomite adsorption collected in CNKI database. The search time is limited to 1976-2020 A total of 660 articles were obtained by manually excluding irrelevant articles such as repetitive articles and news reports, all of which were exported in the form of Refworks.
2.2. Data analysis

Citespace is a special bibliometric analysis software developed by Dr. Chen Chaomei. It has unique bibliometric indicators and can show the research hotspots and frontier hotspots in various research fields[4]. Four folders of "input", "output", "date" and "project" are created in the same file of CiteSpace software. The documents downloaded from HowNet are stored in "input". With the help of CiteSpace (version 5.6. R4) software, they are transformed into the recognizable file form of CiteSpace software. And copy the result from "output" to "date". Set "keyword", "burstness", "institution" and "author" to the literature information respectively, the time limit is 1976-2020, and the time slice is one year. Draw the knowledge map, analyze the development process of diatomite in the adsorption field, explore its development hot spots, and predict the development trend.

3. Results & Discussion

3.1. Statistical analysis of the number of papers

Excel is used to make statistics on the number of papers published in all selected literatures year by year, and it is shown in the form of line chart, as shown in Figure 1. According to the chart, the development of diatomite adsorption in China can be divided into three stages. From 1976 to 2002, our country began the preliminary research on diatomite, and the number of papers published each year is less than 10. Then it entered the rapid development stage (from 2003 to 2015), and the number of papers increased rapidly, reaching the peak of 57 papers in 2015. Then it is the relatively stable stage of development so far, the annual number of papers is stable at about 45, which shows that the research on the development and utilization of diatomite resources in China is gradually becoming mature and stable.

![Figure 1 broken line chart of published papers on diatomite adsorption from 1976 to 2020](image)

3.2. Analysis of key words and co-occurrence words

Keyword co-occurrence analysis is the main method to identify current research topics and future directions[5]. Set the node type as "keyword", other settings remain unchanged, and get the co-occurrence graph with keywords, as shown in Figure 2. In order to make the display effect better, the following modifications are made: The similar keywords are manually merged, and because the literature search is set to keyword search, diatomite and adsorption are eliminated. The results showed that the most important key words except diatomite and adsorption were modification. In order to give full play to the function of diatomite, modification is the only way. And how to modify, I believe it will be a major trend of future research.
The emergence keywords in the literature produced in a specific research field can reflect the latest research trends in a research field\cite{6}. Based on the study of emergence keywords in the literature, we can roughly understand the dynamic changes of research topics, thus, the stage division and evolution logic of the research subject in this field are obtained. Using Citespace to create a pop-up vocabulary, a total of 7 pop-up words are produced, as shown in figure. "Year" represents the Year in which the data were collected, and "Strength" is the emergent intensity. Diatomite and adsorbent have the highest emergent rate. "Begin" and "End" are the start and end of the pop-up, respectively. It can be seen that the themes have changed over time and that the themes of adsorption properties and composites have continued since 2015 or 2016 and could be the focus of subsequent research.

**3.3. Analysis of authors**

Most of the authors are the first to carry out scientific research. The exchanges and cooperation between scientific research scholars can greatly promote the progress of scientific research and the development of science and technology. Through the visual analysis of the authors, we can clearly show the cooperation network of diatomite adsorption research. As shown in Figure 3, there are 143 nodes, representing the number of authors. And 247 links, reflecting the number of collaborative projects between authors. As can be seen from Figure 2, the authors of high-frequency articles are Wang Ping (15), Zhu Jian (13), Zhang Yineng (10), Duan Ning (9) and Du Yucheng (8). There is a significant cluster phenomenon among the authors, forming five main research teams.

But unfortunately, the team is only limited to team cooperation, not out of cooperation with other teams. The cooperation between different teams is conducive to broaden the ideas of researchers and promote the further development of diatomite adsorption.
3.4 Analysis of the issuing organization

Based on the evaluation of the academic influence of researchers, countries or institutions, the cooperation map directly shows the social relationship among scholars, countries or institutions in a certain research field\(^7\). Figure 5 shows the co-occurrence chart of the publishing institutions. Through statistical analysis of the research institutions, it is found that the research on the adsorption of diatomite is mainly concentrated between laboratories and universities. Among them, the school of resources and environmental engineering of Wuhan University of science and technology ranked the first, with a total of 9 papers published. In the organization map, it is not difficult to see that the University of Chinese Academy of Sciences has formed a small cooperation team, while the Institute of environmental science and engineering of Central South University of forestry science and technology has chosen to cooperate with Hunan Jiufang science and Technology Co., Ltd. to promote the development of research in the form of integration of industry and education. However, it is a pity that other research institutions are still in the state of fighting alone and have not yet formed cooperative relations with other institutions.

Figure 5 Co-occurrence chart of issuing organization
4. Conclusions
(1) It can be seen from the trend chart of annual published papers that diatomite adsorption development has entered a stable development stage, and the annual published papers are stable at about 45. In order to promote its sustainable development, it is urgent to develop new technologies to form a new driving force, improve the performance of diatomite by means of diatomite modification, and reduce the waste of such non-renewable resources.

(2) From the point of view of key words and emergent words, modification, adsorbent and activated carbon are the research hot spots.

(3) From the author's point of view, in the past 50 years, a series of diatomite adsorption professional research teams, such as Wang Ping, Zhu Jian, Zhang Yinfeng and so on, have evolved, undertaking most of the research work and conducting their own research. On the whole, the research trend is good. However, if we want to achieve sustainable development, we cannot do without the addition of fresh blood. Senior experts can consider driving more new people to join in and contribute to the development and utilization of diatomite resources.

(4) From the perspective of the publishing organization, the school of resources and environmental engineering of Wuhan University of science and technology, as the backbone of research, undertakes the responsibility of the mainstay in the field of diatomite. However, at present, it has not set up a cooperation network like the author, which indicates that the cooperation between the authors is only limited to the cooperation within the team, and has not yet stepped out of the team to seek cooperation with other teams. They are independent research institutions. Similar to the cooperation between the Institute of environmental science and engineering of Central South University of forestry science and technology and Hunan Jiufang science and Technology Co., Ltd., the cooperation between universities and enterprises is a new idea, which can improve the speed of diatomite industrialization and shorten the time of applying theory to practice.

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