Visualization Analysis of Sepiolite Research Progress in Recent Ten Years

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Abstract. The current situation and hot spots of sepiolite research were explored to provide reference for the further work in China. All literature related to sepiolite in CNKI database were searched in the past ten years. CiteSpace 5.6.R3 software was used to analyze the research situation from the perspective of the annual publication volume of key institution authors and other aspects in combination with the literature visualization function of HowNet. A total of 1084 papers were analyzed, and the overall number of publication was risen from 2010 to 2020. The research institute of Environmental Protection, Ministry of Agriculture, Hebei University of Technology, Xiangtan University were in the top list. The high-frequency authors were Xu Yingming, Liang Xuefeng, Qin Xu. Keyword analysis showed the main research hotspots were sepiolite adsorption and modification.

1. Introduction

Sepiolite, known as the ladystone and cork, was first named in 1847 as it is light and similar to the squid's porous bone. It is also known as sepiolite and pailletstone (attapulgite), which is a layer structure and can hold more zeolite than the latrine lattice. Due to the excellent physical and chemical properties, it showed good surface adsorption and cation exchange capacity and gradually become the research focus as potential new adsorbent.

A total of 1084 effective sepiolite related papers were obtained from CNKI database between January 2010 and July 2020 by removing unnecessary articles. Those papers were then analysis by CiteSpace.

2. Consequence

2.1 Time and country distribution

The time span of research papers refers to the time span between the research self and the cut-off year of literature analysis to collect research papers within this time span, which is of great significance for describing the evolution track of research topics, demarcating hot issues involved in research topics, and then proposing the development trend of research topics[2]. From Figure 1 of the number of papers on sepiolite research in the past ten years, it can be found that the number of articles published...
on sepiolite has been increasing, indicating that the industry's attention to sepiolite has gradually increased. The knowledge map of country distribution can also be obtained by running the software. As shown in Figure 2, there are 170 related researches carried out in China (because of the signature, China and PR China are divided into two nodes, but they are actually expressed as China, so they are combined when counting). The United States is closely followed by 112 papers, followed by Spain.

2.2 Analysis of key words
The word frequency analysis is used to extract and express the frequency distribution of key words and subject words in the literature, so as to carry out the research on research hotspots, trends and future development in this field[3]. Figure 3 is the keyword co-occurrence map obtained by visual analysis of data keywords by CiteSpace. There are 457 nodes and 988 connecting lines, and the overall network density is 0.0095. The size of the node represents the frequency of keywords. Mediating centrality is an important factor in discovering and measuring the importance of literature. The point greater than 0.1 calculated by the calculation formula $BC_i = \sum_{s+t+i}^{n} h_{st}$ is called the key node[4]. Combined with the analysis of Figure 3, it is found that the words with high centrality, such as sepiolite, modified sepiolite, adsorption and nanocomposite, occupy an important position in the literature analysis, indicating that the core issues from January 2010 to July 2020 are mainly concentrated in the above aspects.
The emergence word spectrum represents the key turning points and new development trends that occur in different years as time progresses. This article uses the CiteSpace software to draw the spectrum of sepiolite words from January 2010 to July 2020. In Figure 4: a total of 5 emergent words are obtained. "Year" indicates the year of keyword emergence. According to the "strength" of the emergence rate, the mechanical property has the strongest outburst strength from 2013 to 2014, and the outburst strength of composite materials and clay minerals is also higher. "Begin" and "end" respectively represent the earliest and end time of emergence. Combined with Figure 4, it can be seen that the emergence time of composite materials is the earliest, which has appeared in the study in 2010, and is consistent with the emergence time of clay minerals, cuttlebone and photocatalysis, which is 3 years. The emergence of photocatalysis started in 2018 and lasts until 2020. Through the analysis of the emergence words, we can find that the research trend of sepiolite changes constantly, from the earliest composite materials to clay minerals, cuttlebone, and photocatalysis, which has become a research hotspot in recent two years.

**Top 5 Keywords with the Strongest Citation Bursts**

| Keywords            | Year | Strength | Begin | End   | 2010 - 2020 |
|---------------------|------|----------|-------|-------|-------------|
| Composite materials | 2010 | 2.9582   | 2010  | 2012  |             |
| Mechanical property | 2010 | 3.1444   | 2013  | 2014  |             |
| Clay minerals       | 2010 | 2.9302   | 2014  | 2016  |             |
| Cuttlebone          | 2010 | 2.5024   | 2014  | 2016  |             |
| Photocatalysis      | 2010 | 2.5043   | 2018  | 2020  |             |

Figure 4. Highlight word map.

2.3 Author analysis

By adjusting the map node settings, the main author's cooperative network graph with more than 3 articles is obtained. The knowledge map of cooperation can reflect the degree of cooperation in the research field, and network density can measure the degree of cooperation. It can be seen from the figure that the cooperation between authors is mainly in small groups, but the cooperation between small groups is not close. Among the top ten authors, INVALID with 22 articles ranks first, followed by PLILAR ARANDA and EDUARDO RUIZHITZKY with 11 articles.

Figure 5. Co-appearance of authors

2.4 Institutional analysis

Set node types to institution and run the software to get the co-occurrence diagram of the sending organization. Each node in the graph represents a mechanism, and the size of the structure reflects the
frequency of sending documents. The connection between nodes indicates that there is a cooperative relationship between the mechanisms. The color of the lines corresponds to the time axis above. The depth of node contour color represents the intermediate centrality (or centrality) of the node. Centrality can reflect the closeness between the node and other nodes. Centrality $\geq 0.1$ indicates that the node has a close relationship with other nodes[5]. It can be seen from the Figure 6 that many institutions have carried out relevant research on sepiolite, which also reflects that sepiolite has been paid more and more attention by scholars in the industry. Small scale cooperation network has been formed among institutions, but large-scale interdisciplinary and cross regional cooperation network has not yet formed. The future academic research can be considered to expand to the direction of multi-agent cooperation of industry, University, research, government and financial institutions[6]. Among them, Xiangtan University, with its geographical advantage of being close to sepiolite deposits, has carried out a lot of research, and is the institution with the largest number of papers and research contributions in the past decade.

![Figure 6. The co-appearance network of the sending institution.](image)

3. Conclusions
(1) The key words of sepiolite from January 2010 to July 2020 were analyzed. The hot spots of sepiolite research were mainly focused on adsorption, nanocomposite, composite materials, modification and so on. At the same time, with the deepening of the research, scholars focus on sepiolite experimental diversification, focusing on the excellent performance of sepiolite, such as adsorption, catalytic properties. Among them, modified sepiolite and other high-frequency words show that the later stage of the study is more focused on sepiolite modification experiment, by reducing the limitation of its weakness, so as to further improve the excellent performance of sepiolite, and make it have broad application prospect.

(2) The research institutions of sepiolite are still concentrated in colleges and universities, which not only shows that the current research strength is still single and weak, but also limits the research perspective to a certain extent, which is not conducive to the application-oriented transformation of research results.

(3) It is not difficult to see that the cooperation between authors and institutions is symbiotic. Cooperative research can give full play to the advantages of the team and pool ideas to promote the research to be carried out more efficiently. In order to promote the research among scholars, institutions can hold more academic exchange meetings, provide more opportunities for cooperation between scholars, promote interdisciplinary research, and better promote the application and development of sepiolite.
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