Research Status of Oil Water Separation and Oil Absorption Materials -- Visual Analysis of Literature Based on Web of Science Database

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Abstract. To understand the latest research progress, research trends and future research hotspots of oil-water separation and oil absorption materials for oil spill and oily wastewater at home and abroad, through the web of science core collection database, Based on the literature analysis tools of web of Science (WOS) database, vosviewer visual analysis software and origin, the published literatures on oil-water separation materials and oil absorption materials were quantitatively analyzed in terms of the number of papers published at different times, the top 10 countries (regions), research institutions, research directions, journal sources, etc. The results show that: with the growth of time, the number of papers published gradually increases; China, the United States and India rank the top three, among which China accounts for 40% of the total, indicating that China is in the leading position in this field; among them, Chinese institutions are in the absolute leading position; chemistry, materials and engineering are the most concerned research directions.

Keywords: Oil absorption, oil-water separation, web of science, bibliometrics.

1. Introduction
In recent years, with the acceleration of urbanization and industrialization, the water pollution caused by marine and industrial oil spills has become increasingly serious, which seriously endangers human health and ecological environment [1,2]. In order to solve these problems, there are many methods to solve these problems, such as combustion, chemical degradation, physical filtration, adsorption materials and so on, ⁴ In practical application, adsorption method and oil-water separation method are considered to be one of the most effective measures to remove oil pollution. This is because adsorption materials can absorb oil pollution into solid or semi-solid for further removal, or remove oil through oil-water separation. Because adsorption materials and oil-water separation materials have the
characteristics of removing and collecting oil pollution, a large amount of oil is recycled into one the economic benefits are improved step by step. Based on this, a large number of adsorption materials, including inorganic mineral materials and natural materials, have been widely used in oil spill cleaning [5, 6]. Based on the existing research, the synthesis of new oil absorption materials with sufficient buoyancy, high oil absorption capacity and good reusability is of great significance to the development of advanced oil absorption materials [7, 8].

Bibliometric method is a method of quantitative analysis of literature and existing literature work, through the analysis of statistical data, and then find out the law of change, and then predict the future development trend. At present, bibliometrics has been applied in medicine, biology, environment, materials and other aspects [9-11]. This paper aims to study the advanced functional materials for solving oil spill and oil-water separation on the sea from the field of bibliometrics, to find out the leading countries and institutions at present, and to predict the future research direction through the analysis of research hotspots, so as to provide reference for oil-water separation and oil absorption materials in the future We are expected to make guidance work.

2. method

2.1. Data sources
Using the web of science database of Thomson Reuters, the search period is from January 1, 1998 to October 31, 2019, with the keywords of (oil absorption * or oil absorption * or oil water separation *) and (material * or material synthesis *). The paper type is "article".

In the web of science core collection database, there are 2022 research papers published in 1998-2019, including 26 highly cited papers.

2.2. Analysis tools
Different types of literature were analyzed by the analysis method in web of science database, and the relationship between different types was analyzed by origin 9.1 and vosviewer.

3. Result Analysis

3.1. Number of published papers
It can be seen from Figure 1 that from 1998 to 2019, the total number of SCI research papers on oil absorption and oil-water separation materials is basically increasing year by year. Among them, the number of papers published increased sharply in 2010, which may be due to the increasingly serious problems of sponge oil spill and oil-water separation in 2010, so there is a consensus on the use of advanced functional materials to solve such problems at home and abroad. At present, the number of published papers on oil absorption and oil-water separation materials is 339 in 2018, while 305 SCI papers are published in 2019. As the retrieval time of this paper is October 31, 2019, the research on advanced oil-water separation materials in 2019 may exceed that in 2018 and reach the current peak.
3.2. Countries and regions

By analyzing the number of papers published in each country and region, we can understand the research progress and attention of each region in this field. It can be seen from Figure 2 and table 1 that China, the United States and India have the most research in the field of oil-water separation and oil absorption materials, of which China accounts for about 40% of the total research, which shows that Chinese scholars attach the most importance to the development of functional materials to solve the problems of oil spill and oily wastewater. The possible reason is that China's oil resources are relatively scarce, so it depends on foreign oil imports, and shipping has become the most important way of oil transportation because of its more economic mode of transportation. However, with the frequent occurrence of oil spill accidents, how to solve the problem of oil spill on the sea has become an important research hotspot. Therefore, based on the needs of the actual situation, Chinese scholars pay more attention to the synthesis of oil-water separation and oil absorption materials.

In the study of cooperation among all countries, the vosviewer is used for visual analysis. As shown in Figure 2, there are more nodes between China, the United States and India, indicating that these countries cooperate more with other countries. Among them, the connection between China and the United States is the widest, indicating that the cooperation between China and the United States is the closest. In addition, China's cooperation with Singapore and Japan ranked second and third respectively. These data show that, in addition to academic research, China, the United States, New Zealand, Japan and other countries have a consensus on the use of adsorption and oil-water separation methods to solve the problem of offshore oil spill and oil-water separation.
3.3. Research institutions

Different research institutions have different research directions, and the number of papers published is an important standard to judge the research results of an institution in its field. Table 2 lists the top 10 organizations in terms of oil absorption and oil-water separation materials in the world. From the organizations listed in the table, it can be seen that the research organizations of oil-water separation materials are mainly comprehensive and petroleum research organizations, which shows that oil-water separation and oil-water separation materials mainly serve the practical problems of oil spill at sea. It can be seen from the data in the table that among the top five institutions in the world, there are four Chinese institutions. This data also matches the largest number of Chinese institutions in the world.

Table 2 Number of papers published by different research institutions

| Institution                                | Number of papers | % of 2022 |
|--------------------------------------------|------------------|-----------|
| CHINESE ACAD SCI                           | 86               | 4.253     |
| CHINA UNIV PETR                           | 41               | 2.028     |
| BEIJING UNIV CHEM TECHNOL                 | 34               | 1.682     |
| JIANGSU UNIV                              | 31               | 1.533     |
| EGYPTIAN PETR RES INST                     | 30               | 1.484     |
| SOUTHWEST PETR UNIV                       | 26               | 1.286     |
| TIANJIN UNIV                              | 26               | 1.286     |
| CSIC                                       | 20               | 0.989     |
| KING FAHD UNIV PETR MINERALS              | 20               | 0.989     |
| TSINGHUA UNIV                             | 20               | 0.989     |

3.4. Research direction

Oil absorption and oil-water separation materials are widely studied because they involve chemistry, material science, engineering, polymer and other disciplines. Table 3 lists the top 10 research directions in the field of advanced oil-water separation materials. It can be seen from table 3 that chemistry is the most involved research direction. It can be inferred that many chemical reactions are involved in the process of synthesis and oil-water separation, and most materials are synthesized by chemical methods in the process of material synthesis. The second and third research directions are materials science and engineering technology. Materials science is an important research direction in the process of synthesis and production of oil absorption materials. In addition, because most of the materials reported in this paper are in the laboratory stage, the optimization of synthesis process and performance of materials by engineering technology is also an important research direction of oil-water separation materials. In addition, polymer, physics and environmental science are also important research directions of oil-water separation and oil absorption materials.

It can be seen from Table 3 that adsorption is an important means to solve oil-water separation and oil spill at sea. Nanoparticles play an important role in the key word hot spots, which indicates that
loading nanoparticles onto the surface of the substrate is an important strategy for the synthesis of hydrophobic oil-water separation materials. In addition, separation and kinetic equilibrium are also one of the research hotspots, which indicates that it is an important research direction to study the oil-water separation effect of the materials in the application process after synthesis. By studying the actual oil-water separation effect and using the kinetic equation to simulate, the adsorption and separation mechanism and adsorption model of the materials are determined.

Table 3 Number of papers published in different disciplines

| Research direction                      | Number of papers | % of 2022 |
|----------------------------------------|------------------|-----------|
| CHEMISTRY                              | 1040             | 51.434    |
| MATERIALS SCIENCE                      | 550              | 27.201    |
| ENGINEERING                            | 492              | 24.332    |
| SCIENCE TECHNOLOGY OTHER TOPICS        | 256              | 12.661    |
| POLYMER SCIENCE                        | 205              | 10.138    |
| ENERGY FUELS                           | 198              | 9.792     |
| PHYSICS                                | 173              | 8.556     |
| ENVIRONMENTAL SCIENCES ECOLOGY         | 82               | 4.055     |
| BIOCHEMISTRY MOLECULAR BIOLOGY         | 70               | 3.462     |
| FOOD SCIENCE TECHNOLOGY                | 69               | 3.412     |

3.5. Journals
The number of papers in a certain field indicates the importance of the journal in a certain field. There are top 10 journals of publication sources, among which RSc Adv, CEJ and jmca have published the most papers in the field of oil absorption and oil-water separation materials, indicating that these journals pay more attention to the field of oil absorption materials. In addition, these journals are mostly classified into engineering science and technology, chemistry, materials science and comprehensive science. Therefore, these data also show that the direction of oil-water separation materials and oil-water separation materials is mostly in the field of chemistry, materials and engineering.

Figure 3 shows the number of cross citations of papers published in different journals. Among them, Langmuir has the largest number of citations, 2070 times, indicating that the new oil absorbing materials published on Langmuir have the highest quality and are recognized by experts in the same field. JACS is the second most cited journal on oil absorption and oil-water separation materials, and JACS is the most well-known journal in the field of chemistry. This shows that chemical process plays a leading role in the synthesis and application of materials. Therefore, in the study of oil-water separation and oil-water separation materials, chemical direction is still one of the biggest research hotspots. In contrast, although RSc adv, CEJ and jmca have published a large number of papers in the field of oil-water separation materials, the quality and recognition of the papers on them are not as good as Langmuir and JACS, the established journals of ACS.

Figure 3 The citation between Journals
4. Conclusions
Through bibliometric and visual analysis, it is found that chemistry and material science are the hot spots in the research of oil-water separation and oil absorption materials in solving the problems of oily wastewater and oil spill at sea. In addition, in order to solve the practical problems of materials, the direction of Engineering Science and technology is also one of the difficulties in the future research in this field. Because our country is in the absolute leading position in this field, how to carry out scientific research transformation is one of the difficulties in the future. Through the combination of scientific research and engineering, we can further industrialize oil-water separation materials and oil absorption materials.

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