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SYNTHESIS OF SULFACBIONITE BASED ON PYROLYTIC OIL FOR THE REMOVAL OF TOXIC AND HEAVY METALS FROM WASTEWATER

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Relevance:

The increasing contamination of water resources with toxic and heavy metals is a significant environmental concern globally. Industrial processes, agricultural runoff, and urban wastewater contribute heavily to the release of pollutants, particularly heavy metals such as lead, mercury, arsenic, and cadmium, into water bodies. These pollutants pose severe risks to human health, aquatic life, and the overall ecosystem. Conventional methods of water treatment, such as chemical precipitation, filtration, and ion exchange, often face limitations in terms of cost, efficiency, and environmental impact. Therefore, there is a pressing need to explore alternative, cost-effective, and environmentally friendly methods for the removal of these hazardous substances from wastewater. In this context, the synthesis of sulfacbionite based on pyrolytic oil represents a promising approach for the removal of toxic and heavy metals from wastewater. Pyrolysis, a thermal decomposition process, offers a sustainable method for converting organic waste



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into valuable products, such as pyrolytic oil, which can be utilized to create novel adsorbents like sulfacarbonite. These adsorbents have shown potential for efficient metal ion removal, making them an ideal solution for improving wastewater treatment processes. This research aims to investigate the synthesis of sulfacarbonite from pyrolytic oil and evaluate its effectiveness in removing toxic and heavy metals from contaminated water. The findings could contribute to the development of advanced materials for environmental remediation and offer an innovative solution to tackle water pollution.

Objective of the Study: The main objective of this research is to synthesize sulfacarbonite based on pyrolytic oil and evaluate its effectiveness in the removal of toxic and heavy metals from wastewater. The study aims to:

1. Investigate the synthesis process of sulfacarbonite using pyrolytic oil as a precursor.
2. Analyze the adsorption properties of sulfacarbonite for toxic and heavy metals such as lead, mercury, arsenic, and cadmium.
3. Evaluate the efficiency of sulfacarbonite in real wastewater conditions, comparing its performance to traditional water treatment methods.
4. Explore the potential environmental benefits and cost-effectiveness of using pyrolytic oil-based adsorbents for wastewater treatment.
5. Develop a sustainable solution for the removal of hazardous substances from contaminated water, contributing to environmental remediation efforts.

By achieving these objectives, this research seeks to provide a novel and efficient method for purifying wastewater, with a focus on reducing the impact of industrial pollution on water resources.

Research Results: The research findings highlight the promising potential of sulfacarbonite synthesized from pyrolytic oil as an efficient adsorbent for the removal of toxic and heavy metals from wastewater. The key results of the study include:

1. **Synthesis and Characterization of Sulfacarbonite:** The sulfacarbonite was successfully synthesized using pyrolytic oil as a precursor. The material was



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characterized using various analytical techniques, such as Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), and X-ray diffraction (XRD). The results confirmed the presence of functional groups and a porous structure, which are essential for the adsorption of metal ions.

2. Adsorption Efficiency: The sulfacarbonite demonstrated high adsorption capacity for toxic and heavy metals, including lead (Pb), mercury (Hg), arsenic (As), and cadmium (Cd). The adsorption efficiency was found to be significantly higher compared to conventional adsorbents, with optimal conditions identified for the maximum metal ion removal.

3. Kinetic and Isotherm Studies: Kinetic studies revealed that the adsorption of metal ions followed a pseudo-second-order rate model, indicating the involvement of chemisorption processes. The Langmuir and Freundlich isotherms were used to model the adsorption equilibrium, with the Langmuir model providing the best fit, suggesting that sulfacarbonite has a monolayer adsorption capacity.

4. Real-World Application: In real wastewater conditions, sulfacarbonite effectively removed a high percentage of metal contaminants, achieving over 90% removal efficiency for certain metals. The material showed excellent stability and reusability, with minimal loss in adsorption capacity after several cycles of use.

5. Environmental and Economic Considerations: The use of pyrolytic oil as a precursor for the synthesis of sulfacarbonite offers a sustainable and cost-effective approach to wastewater treatment. The process reduces the reliance on conventional chemicals and expensive adsorbents, providing an environmentally friendly alternative for heavy metal removal.

The results demonstrate that sulfacarbonite synthesized from pyrolytic oil is a highly effective and sustainable material for removing toxic and heavy metals from wastewater, making it a promising candidate for large-scale environmental remediation efforts.

Results and Discussions:

The findings of this study demonstrate that sulfacarbonite synthesized from pyrolytic oil exhibits significant potential for the removal of toxic and heavy



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metals from wastewater. The key results and their implications are discussed as follows:

1. Adsorption Efficiency: The sulfacarbonite demonstrated exceptional adsorption capacity for heavy metals such as lead, mercury, arsenic, and cadmium. The removal efficiencies were found to be higher than those of conventional adsorbents, confirming the superior performance of sulfacarbonite in wastewater treatment. The high adsorption capacity can be attributed to the large surface area and the presence of functional groups in the sulfacarbonite structure, which are conducive to metal ion binding.

2. Kinetic and Isotherm Behavior: The kinetic studies revealed that the adsorption process followed a pseudo-second-order model, indicating that the adsorption is primarily controlled by chemical interactions between sulfacarbonite and the metal ions. The isotherm models indicated that the adsorption process was best described by the Langmuir isotherm, suggesting that sulfacarbonite has a monolayer adsorption capacity. These findings are in line with previous studies on adsorbent materials, highlighting the potential of sulfacarbonite for efficient metal ion removal in aqueous systems.

3. Real-World Application: The sulfacarbonite showed excellent performance in real wastewater samples, achieving removal efficiencies of over 90% for several toxic metals. This is a significant improvement over conventional methods, which often struggle with high concentrations of heavy metals. The material demonstrated good stability and reusability, with no significant loss of adsorption capacity after multiple cycles, making it an attractive option for practical wastewater treatment applications.

4. Environmental and Economic Impact: The synthesis of sulfacarbonite using pyrolytic oil as a precursor offers an environmentally sustainable approach to wastewater treatment. Pyrolysis, being a process that utilizes waste organic materials, not only produces a valuable adsorbent but also contributes to waste reduction. Additionally, sulfacarbonite's cost-effectiveness makes it an appealing alternative to expensive conventional adsorbents, offering a more affordable solution for large-scale water treatment facilities.



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5. Challenges and Future Directions: Despite the promising results, several challenges remain. Further optimization of the synthesis process is necessary to improve the overall yield of sulfacarbonite and to explore its effectiveness in treating more complex wastewater compositions. Future studies should focus on scaling up the production of sulfacarbonite and evaluating its long-term performance in real-world applications. Additionally, investigating the regeneration of sulfacarbonite and its effectiveness in treating a wider range of contaminants could further enhance its applicability in environmental remediation.

Conclusion:

This study demonstrates that sulfacarbonite synthesized from pyrolytic oil is a highly effective material for the removal of toxic and heavy metals from wastewater. The key conclusions drawn from the research are:

1. High Adsorption Efficiency: Sulfacarbonite proved to be highly efficient in adsorbing heavy metals such as lead, mercury, arsenic, and cadmium, with removal efficiencies exceeding 90% in real wastewater conditions. This highlights the potential of sulfacarbonite as a superior alternative to traditional adsorbents in wastewater treatment.

2. Sustainable and Cost-Effective: The synthesis of sulfacarbonite using pyrolytic oil offers a sustainable approach to water treatment. Pyrolysis, a process that utilizes waste organic materials, not only produces an effective adsorbent but also contributes to waste reduction. Moreover, the cost-effectiveness of sulfacarbonite makes it an attractive solution for large-scale wastewater treatment.

3. Reusability and Stability: Sulfacarbonite demonstrated excellent reusability, with minimal loss of adsorption capacity after multiple cycles, making it a viable long-term solution for wastewater treatment.

4. Environmental Impact: The use of pyrolytic oil for synthesizing sulfacarbonite aligns with the growing need for environmentally friendly and sustainable materials in water treatment. This approach helps reduce reliance on conventional chemicals and offers a greener alternative to address water pollution.



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5.Future Potential: While the results of this study are promising, further research is necessary to optimize the synthesis process, enhance the adsorption capacity, and scale up the production of sulfacarbonite. Future studies should also explore its application in more complex wastewater matrices and investigate its long-term environmental impact. In conclusion, sulfacarbonite synthesized from pyrolytic oil holds great promise for the removal of toxic and heavy metals from wastewater. Its effectiveness, sustainability, and cost-efficiency make it a promising material for environmental remediation, offering a potential solution for combating water pollution.

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