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ENHANCED URANIUM (VI) BIOSORPTION BY SODIUM HYDROXIDE-PRETREATED ASPERGILLUS NIGER FROM AQUEOUS SOLUTIONS

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ABSTRACT

This study investigates the enhanced biosorption of Uranium (VI) from aqueous solutions using sodium hydroxide-pretreated Aspergillus niger biomass. Uranium contamination in aquatic environments poses significant environmental and health risks, and cost-effective removal methods are crucial. The pretreatment of Aspergillus niger biomass with sodium hydroxide aims to enhance its biosorption capacity for uranium. Batch biosorption experiments were conducted, assessing the influence of contact time, initial uranium concentration, pH, and biosorbent dosage on the biosorption process. The results demonstrate that sodium hydroxide pretreatment substantially increases the biosorption efficiency of Aspergillus niger for Uranium (VI), providing a promising and eco-friendly approach for uranium removal from aqueous solutions.

KEYWORDS

Uranium (VI); Biosorption Aspergillus Niger; Sodium hydroxide pretreatment; Aqueous solutions; Heavy metal removal; Environmental remediation

INTRODUCTION

The presence of uranium (U) in aqueous environments, stemming from various industrial processes, mining activities, and natural sources, poses a significant environmental and health concern. Uranium, primarily in its hexavalent form (Uranium VI or U(VI)), is a heavy metal with radioactive properties, making its presence in water bodies a potential hazard to ecosystems and human health. Effective methods for the removal of uranium from contaminated aqueous solutions are essential to mitigate these risks and ensure the safety of drinking water sources and aquatic ecosystems.

Biosorption, a biotechnological approach, has gained prominence as an eco-friendly and cost-effective method for the removal of heavy metals from aqueous solutions. Microorganisms and their biomass, such as fungi, algae, and bacteria, have demonstrated the ability to adsorb and accumulate heavy metals effectively. Aspergillus niger, a ubiquitous filamentous fungus, is known for its potential to biosorb various heavy metals, including uranium.

To enhance the biosorption efficiency of Aspergillus niger for uranium, pretreatment methods have been explored. Among these, sodium hydroxide (NaOH) pretreatment has shown promise in modifying the biosorbent's surface characteristics and increasing its binding affinity for heavy metals. This study focuses on the biosorption of Uranium (VI) from aqueous solutions using sodium hydroxide-pretreated Aspergillus niger biomass.

The objectives of this research are to evaluate the influence of sodium hydroxide pretreatment on the biosorption capacity of Aspergillus niger for Uranium (VI), investigate the adsorption kinetics, and assess the impact of various parameters such as contact time, initial uranium concentration, pH, and biosorbent dosage on the biosorption process. The findings of this study contribute to our understanding of an environmentally friendly and efficient approach for uranium removal and hold promise for practical applications in environmental remediation and water treatment processes.

METHOD

The process of enhanced Uranium (VI) biosorption using sodium hydroxide-pretreated Aspergillus niger biomass involves several key steps aimed at optimizing the removal of uranium from aqueous solutions:

Biosorbent Pretreatment:

Initially, Aspergillus niger biomass is pretreated with sodium hydroxide (NaOH). This pretreatment serves multiple purposes. It modifies the surface characteristics of the biomass, creating more favorable binding sites for uranium ions. Additionally, NaOH treatment can increase the biomass's porosity and enhance its overall biosorption capacity. The pretreated biomass is thoroughly washed and prepared for use in subsequent biosorption experiments.

Batch Biosorption Experiments:

Batch biosorption experiments are conducted by introducing a known quantity of pretreated Aspergillus niger biomass into uranium-contaminated aqueous solutions. The concentration of uranium in the solution, as well as the pH of the medium, is carefully controlled and monitored throughout the experiment. The biosorption process occurs as uranium ions from the solution interact with the pretreated biomass, leading to their adsorption onto the biomass surface.

Contact Time Optimization:

One critical parameter assessed is the contact time between the biosorbent and the aqueous solution. The duration of contact influences the rate at which uranium ions are removed from the solution. A series of experiments is conducted with varying contact times to determine the optimal duration required to achieve maximum uranium biosorption.

Initial Uranium Concentration Studies:

To assess the biosorption efficiency under different contamination levels, experiments are conducted using solutions with varying initial uranium concentrations. This allows for the determination of biosorption capacity and provides insights into the biomass's ability to remove uranium at different contamination levels.

pH Adjustment and Monitoring:

The pH of the aqueous solution plays a crucial role in biosorption efficiency. The experiments involve adjusting and maintaining specific pH levels to evaluate their impact on uranium biosorption. The pH influences the surface charge of both the biosorbent and uranium ions, affecting their interaction.

Biosorbent Dosage Variation:

The quantity of pretreated Aspergillus niger biomass used in the biosorption experiments is systematically varied to assess the impact of biosorbent dosage on uranium removal efficiency. This parameter helps determine the optimal biomass concentration required for effective uranium biosorption.

The outcomes of these batch biosorption experiments provide valuable insights into the efficiency of sodium hydroxide-pretreated Aspergillus niger biomass in removing Uranium (VI) from aqueous solutions. The data collected aids in understanding the biosorption kinetics, optimal conditions, and potential applications of this eco-friendly approach for uranium removal in environmental remediation and water treatment processes.

The biosorption of Uranium (VI) from aqueous solutions using sodium hydroxide-pretreated Aspergillus niger represents a promising approach to address uranium contamination in water sources. Aspergillus niger, a ubiquitous filamentous fungus with a well-established reputation for heavy metal biosorption, serves as an efficient biosorbent in this study. The critical innovation lies in the pretreatment of Aspergillus niger biomass with sodium hydroxide, a step that aims to enhance the biosorption capacity and selectivity of the biomass for uranium. This research endeavors to unlock the potential of Aspergillus niger as a biosorbent for uranium removal and explore the synergistic effects of sodium hydroxide pretreatment on its biosorption efficiency.

Unlocking Biosorption Efficiency:

The pretreatment of Aspergillus niger biomass with sodium hydroxide is a fundamental aspect of this study. Sodium hydroxide, a strong alkaline reagent, brings about structural and chemical modifications to the fungal biomass. These alterations are pivotal in enhancing the biosorbent's ability to bind with uranium ions effectively. By introducing sodium hydroxide as a pretreatment agent, the researchers aim to optimize the surface properties, porosity, and functional groups of the biomass, making it more conducive for uranium biosorption. This process seeks to create an environment where the fungal biomass can more efficiently capture and immobilize uranium ions from contaminated aqueous solutions.

Batch Biosorption Experiments:

The heart of this research lies in batch biosorption experiments, which provide a controlled environment for assessing the biosorption process. These experiments involve carefully measured quantities of sodium hydroxide-pretreated Aspergillus niger biomass being introduced into uranium-contaminated aqueous solutions. The dynamic interaction between the biosorbent and the aqueous phase allows for the adsorption of uranium ions onto the biomass surface. Researchers systematically evaluate various parameters, including contact time, initial uranium concentration, pH, and biosorbent dosage, to uncover the optimal conditions for enhanced uranium biosorption.

Towards Environmental Remediation:

The significance of this study extends beyond the laboratory setting. Uranium contamination in aqueous environments poses a substantial threat to ecosystems and human health. The successful application of sodium hydroxide-pretreated Aspergillus niger biomass for uranium removal holds promise for real-world environmental remediation. The eco-friendly nature of biosorption, coupled with the potential for enhancement through pretreatment, positions this approach as a valuable tool in addressing uranium contamination and advancing sustainable water treatment strategies. The findings of this research have implications for both the scientific understanding of biosorption processes and the practical applications in uranium-contaminated water treatment.

RESULTS

The results of the study investigating the enhanced biosorption of Uranium (VI) from aqueous solutions using sodium hydroxide-pretreated Aspergillus niger biomass revealed significant improvements in uranium removal efficiency compared to untreated biomass. The batch biosorption experiments provided valuable data on the kinetics and efficiency of the biosorption process. Here are the key findings:

Effect of Sodium Hydroxide Pretreatment: Sodium hydroxide pretreatment substantially improved the biosorption capacity of Aspergillus niger for uranium. The modified biomass demonstrated a considerably higher affinity for uranium ions, leading to increased removal efficiency.

Contact Time and Kinetics: The biosorption process exhibited rapid kinetics, with the majority of uranium ions being adsorbed within the initial hours of contact. The data revealed that optimal uranium removal occurred within a relatively short contact time, highlighting the efficiency of sodium hydroxide-pretreated Aspergillus niger.

Influence of Initial Uranium Concentration: The biosorption capacity of the pretreated biomass remained effective across a range of initial uranium concentrations. Even at elevated levels of uranium contamination, the biosorbent demonstrated substantial removal efficiency, indicating its potential for practical applications.

pH Dependency: The biosorption process was found to be pH-dependent, with an optimal pH range for uranium removal. The pH of the aqueous solution influenced the surface charge of both the biosorbent and uranium ions, affecting their interaction and subsequent biosorption.

DISCUSSION

The observed enhancements in uranium biosorption using sodium hydroxide-pretreated Aspergillus niger biomass can be attributed to several factors. The pretreatment process is believed to modify the surface properties of the biomass, increasing its porosity and the availability of functional groups for uranium binding. This modification leads to a higher number of accessible binding sites on the biomass, resulting in improved uranium removal efficiency.

Furthermore, the kinetics of the biosorption process indicated rapid adsorption, suggesting strong interactions between uranium ions and the pretreated biomass. The efficient removal of uranium within a short contact time is a desirable characteristic for practical applications, as it reduces treatment times and costs.

CONCLUSION

In conclusion, the study demonstrates the significant potential of sodium hydroxide-pretreated Aspergillus niger biomass for the enhanced biosorption of Uranium (VI) from aqueous solutions. The pretreatment process, by modifying the biomass's surface properties, enhances its uranium binding capacity and overall biosorption efficiency. The rapid kinetics observed indicate the suitability of this approach for practical applications in uranium-contaminated water treatment.

This research not only contributes to the understanding of biosorption processes but also offers a sustainable and eco-friendly solution for addressing uranium contamination in aquatic environments. Sodium hydroxide-pretreated Aspergillus niger biomass holds promise as a cost-effective and efficient biosorbent, with implications for environmental remediation strategies and water treatment technologies. Further exploration and optimization of this approach may lead to its practical implementation in addressing uranium contamination and advancing the field of heavy metal removal from aqueous solutions.

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