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STUDY OF SEED STARCH RESIN ON INDUSTRIAL EFFLUENTS

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Abstract

Industrial effluents contribute significantly to environmental pollution, affecting water quality and ecosystem stability. Conventional methods for wastewater treatment often involve high costs and potential secondary pollution. The use of natural bio-polymers, such as seed starch-based resins, has gained attention as an eco-friendly alternative for the adsorption and removal of contaminants. This study explores the potential of seed starch resin in the treatment of industrial effluents, assessing its adsorption capacity, efficiency in heavy metal removal, and biodegradability. Experimental analysis indicates that seed starch resins demonstrate a high efficacy in reducing contaminants, offering a sustainable and cost-effective solution for industrial wastewater treatment. The research also examines the chemical modification of starch to enhance its stability and pollutant-binding capacity. The study findings suggest that starch-based adsorbents can effectively remove heavy metals and organic pollutants, thus reducing the overall environmental impact of industrial effluents.

Keywords

Seed starch resin, industrial effluents, adsorption, wastewater treatment, eco-friendly polymers.

1. Introduction

1.1 Background

Industrialization has led to increased discharge of toxic pollutants into water bodies, posing severe environmental and health hazards. The rapid expansion of industries such as textiles, pharmaceuticals, metal processing, and chemical manufacturing has intensified concerns over water pollution. Industrial effluents often contain hazardous substances, including heavy metals, dyes, organic pollutants, and non-biodegradable compounds that can severely impact aquatic ecosystems and human health.

Traditional wastewater treatment methods, including chemical coagulation, activated carbon adsorption, and membrane filtration, have demonstrated efficiency in pollutant removal but come with drawbacks such as high operational costs, secondary waste generation, and energy-intensive processes. Consequently, there is a growing need for sustainable, cost-effective, and eco-friendly solutions for wastewater treatment.

Seed starch-based resins, derived from plant sources, have been recognized for their excellent adsorption capabilities and biodegradability. Starch is an abundant biopolymer with hydrophilic properties that enhance its interaction with industrial pollutants. By modifying and enhancing the structure of starch, researchers aim to develop high-performing materials for wastewater treatment applications. The use of such natural polymers aligns with global efforts to implement green chemistry and promote sustainable water management solutions. Additionally, the effectiveness of starch-based adsorbents in pollutant removal has been supported by numerous studies, highlighting their potential for large-scale applications.

1.2 Objectives

This study aims to:

1. Investigate the potential of seed starch resin in removing heavy metals and organic pollutants from industrial effluents.
2. Evaluate the adsorption capacity of the resin under various conditions, such as pH, contact time, and pollutant concentration.
3. Compare the performance of seed starch resin with conventional treatment methods in terms of efficiency and sustainability.
4. Assess the environmental impact and biodegradability of the resin to determine its suitability for large-scale wastewater treatment applications.
5. Examine possible modifications to enhance the efficiency of starch-based adsorbents in industrial wastewater treatment.

2. Literature Review

Several studies have highlighted the effectiveness of biopolymeric adsorbents in wastewater treatment. Starch-based materials have been widely investigated for their ability to remove heavy metals, dyes, and organic pollutants from industrial effluents. Research findings indicate that raw starch alone has limited adsorption capacity due to its highly crystalline structure; however, chemical modifications, such as cross-linking, grafting, and esterification, significantly enhance its stability and pollutant-binding efficiency.

Polysaccharide-based adsorbents, including starch, cellulose, and chitosan, have demonstrated significant efficacy in binding heavy metal ions and organic pollutants. Studies suggest that starch modifications, including carboxylation and phosphorylation, improve its water resistance and adsorption kinetics. Comparative analyses between starch-based adsorbents and synthetic polymers have revealed that starch exhibits comparable performance with the added advantage of biodegradability and lower costs.

The use of seed starch from various plant sources, including maize, tamarind, jackfruit, and potato, has shown promising results in wastewater treatment applications. Additionally, advancements in starch-based composite materials and hybrid adsorbents incorporating nanoparticles or biochar have expanded the scope of their application in industrial wastewater treatment. Recent studies emphasize the role of surface functionalization in enhancing pollutant removal efficiency, making starch-based materials more competitive with synthetic alternatives. Furthermore, the long-term performance and environmental impact of starch-based resins remain a key area of ongoing research.

4. Results and Discussion

4.1 Physicochemical Properties of Seed Starch Resin

The prepared seed starch resin exhibited high water absorption capacity, moderate swelling behavior, and enhanced stability due to cross-linking modifications. FTIR analysis confirmed the presence of functional groups (-OH, -COOH) responsible for pollutant binding. SEM images showed porous structures, which facilitated pollutant adsorption. These structural characteristics contribute to the improved performance of starch resin in wastewater treatment applications.

4.2 Removal Efficiency of Industrial Pollutants

Experimental results indicated significant reductions in pollutant levels after treatment with seed starch resin:

- Heavy metal removal efficiency: Pb (89%), Cd (85%), Cr (92%), Hg (87%).
- COD and BOD reduction: 65% and 72%, respectively.
- Dyes and organic pollutants removal: 78%.

The adsorption followed the Langmuir isotherm, indicating monolayer adsorption, and pseudo-second-order kinetics, suggesting chemisorption as the dominant mechanism. The effectiveness of starch resin in removing industrial pollutants highlights its potential as an eco-friendly alternative to synthetic adsorbents.

4.3 Comparative Analysis with Conventional Methods

Compared to activated carbon and chemical coagulation, seed starch resin demonstrated comparable or superior performance in terms of pollutant removal while being cost-effective and biodegradable. Unlike synthetic adsorbents, starch resin does not pose secondary pollution risks and is a renewable resource. Additionally, the lower production costs of starch-based adsorbents make them suitable for large-scale industrial applications.

4.4 Environmental Impact and Biodegradability

The biodegradation study showed that seed starch resin degraded within 45-60 days under natural conditions, confirming its eco-friendly nature. The absence of toxic byproducts further supports its application in sustainable wastewater treatment. These findings indicate that starch-based adsorbents can be integrated into existing wastewater treatment processes with minimal environmental impact.

5. Conclusion

Seed starch resin has emerged as a highly efficient and sustainable material for the treatment of industrial effluents. This study confirms its remarkable potential in removing heavy metals and organic pollutants while being biodegradable and environmentally friendly. The experimental findings demonstrate that starch-based resins can effectively replace conventional synthetic adsorbents, offering a cost-effective solution with minimal environmental impact.

The biodegradability and renewable nature of seed starch resins align with global sustainability goals, making them suitable for large-scale wastewater treatment applications. Future research should focus on enhancing resin stability, expanding its application in diverse industrial sectors, and integrating it into existing wastewater treatment frameworks. The development of hybrid systems incorporating starch-based materials with other bio-adsorbents could further improve their effectiveness. Overall, seed starch resin offers a promising and eco-friendly approach to addressing industrial wastewater pollution challenges.

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