academic publishers

INTERNATIONAL JOURNAL OF CHEMISTRY AND CHEMICAL ENGINEERING (ISSN: 2693-356X)

Volume 04, Issue 01, 2024, pages 01-06
Published Date: - 01-01-2024

PURIFYING WATERS: BISPHENOL-A REMOVAL FROM AQUEOUS SOLUTIONS USING POLYMERIC RESIN IMPREGNATED WITH PHOSPHOROUS-BASED EXTRACTANT

Shivani Batra
Department of Chemical Engineering Malaviya National Institute of Technology (MNIT), Jaipur, Rajasthan, India

Abstract

This study explores an innovative approach for the removal of Bisphenol-A (BPA) from aqueous solutions using a polymeric resin impregnated with a phosphorous-based extractant. Bisphenol-A, a widely used industrial chemical, is known for its endocrine-disrupting properties and environmental persistence. The impregnated polymeric resin offers a promising solution for efficient BPA removal due to the selective binding affinity of the phosphorous-based extractant. The experimental investigations include batch sorption studies, isotherm analysis, and kinetic evaluations to elucidate the efficiency and mechanisms of BPA removal. The findings showcase the potential of the developed polymeric resin as a sustainable and effective tool for purifying water contaminated with Bisphenol-A.

Keywords

Bisphenol-A, Polymeric Resin, Phosphorous-Based Extractant, Water Purification, Sorption Studies, Environmental Remediation, Endocrine Disruptors, Aqueous Solutions, Contaminant Removal, Sustainable Technology.

INTRODUCTION

Bisphenol-A (BPA), a widely employed chemical in the production of plastics and resins, has raised significant concerns due to its adverse effects on human health and the environment. As an endocrine disruptor, BPA can interfere with hormonal balance, leading to potential health risks. The persistence of BPA in aqueous environments further exacerbates these concerns, necessitating effective remediation strategies to ensure water quality and safeguard ecosystems. In response to this imperative, this study explores the utilization of a polymeric resin impregnated with a phosphorous-based extractant for the removal of Bisphenol-A from aqueous solutions.

The impregnated polymeric resin represents an innovative and sustainable approach to address BPA contamination. Phosphorous-based extractants are chosen for their selective binding affinity toward BPA, offering a tailored solution for efficient removal. This method holds promise for large-scale water purification efforts, contributing to the mitigation of BPA-associated risks.

Rationale for the Study:

The motivation behind this research lies in the urgency to mitigate the environmental impact of BPA contamination. Conventional water treatment methods may fall short in effectively removing BPA due to its molecular characteristics. The impregnated polymeric resin, designed with a specific focus on phosphorous-based extractants, aims to overcome these limitations and provide an environmentally friendly solution for BPA removal.

METHOD

The process of purifying waters contaminated with Bisphenol-A (BPA) using a polymeric resin impregnated with a phosphorous-based extractant involves a series of carefully orchestrated steps to ensure effective removal of the endocrine-disrupting compound.

The first stage involves the synthesis of the polymeric resin, employing a matrix known for its high sorption capacity. The phosphorous-based extractant is then impregnated into the resin matrix using a controlled and optimized procedure, ensuring uniform distribution throughout the material. Characterization techniques, including Fourier Transform Infrared (FTIR) spectroscopy and Scanning Electron Microscopy (SEM), validate the successful incorporation of the extractant and confirm the structural integrity of the impregnated resin.

Once the impregnated polymeric resin is prepared, batch sorption studies are conducted to assess its efficiency in removing BPA from aqueous solutions. Controlled experiments expose the resin to varying concentrations of BPA, allowing the interaction to reach sorption equilibrium. The residual BPA concentrations in the aqueous phase are analyzed, providing crucial data for determining the sorption capacity and efficiency of the polymeric resin.

To further understand the equilibrium behavior of BPA sorption, isotherm analysis is performed. Different concentrations of BPA are introduced to the impregnated resin, and the resulting data is fitted to isotherm models such as Langmuir and Freundlich. This analysis elucidates the sorption capacity and affinity of the resin, offering insights into its performance under various BPA concentrations.

The kinetics of BPA sorption onto the polymeric resin are investigated to determine the rate of removal and the underlying mechanisms. Kinetic models, including pseudo-first-order and pseudo-second-order, are applied to the experimental data. This step provides essential information about the practical application of the impregnated polymeric resin for rapid and efficient removal of BPA.

Throughout the process, data analysis and statistical evaluations are applied to ensure the reliability and significance of the findings. The results obtained from the batch sorption studies, isotherm analysis, and kinetic evaluations contribute to a comprehensive understanding of the Bisphenol-A removal process. This well-designed process holds promise for the development of an environmentally friendly and sustainable water purification technique, addressing the urgent need to mitigate the impact of endocrine-disrupting compounds in aquatic environments.

Synthesis of Polymeric Resin:

The first step in the methodology involves the synthesis of the polymeric resin impregnated with the phosphorous-based extractant. The polymeric resin is prepared using a carefully selected matrix known for its high sorption capacity and stability. The phosphorous-based extractant is then impregnated into the resin through a controlled process to ensure uniform distribution and optimal binding efficiency.

Characterization of Polymeric Resin:

Following synthesis, the polymeric resin is subjected to thorough characterization. Techniques such as Fourier Transform Infrared (FTIR) spectroscopy and Scanning Electron Microscopy (SEM) are employed to confirm the successful impregnation of the phosphorous-based extractant and assess the structural integrity of the resin. This step is essential to ensure that the impregnated resin maintains its designed properties for efficient Bisphenol-A (BPA) removal.

Batch Sorption Studies:

The efficiency of the impregnated polymeric resin in removing BPA is evaluated through batch sorption studies. A series of controlled experiments are conducted where varying concentrations of BPA are introduced to the impregnated resin. The sorption equilibrium is reached by allowing the resin and BPA to interact over a specified period. The residual BPA concentrations in the aqueous phase are then analyzed, allowing for the determination of the sorption capacity and efficiency of the polymeric resin.

Isotherm Analysis:

To understand the equilibrium behavior of BPA sorption onto the impregnated polymeric resin, isotherm analysis is conducted. Different concentrations of BPA are introduced, and the sorption equilibrium is established. The data obtained is then fitted to various isotherm models, such as the Langmuir and Freundlich isotherms, to elucidate the sorption capacity and affinity of the impregnated resin for BPA.

Kinetic Evaluations:

The kinetics of BPA sorption onto the polymeric resin are investigated to comprehend the rate of removal and the mechanisms involved in the process. Kinetic models, including pseudo-first-order and pseudo-second-order models, are applied to the experimental data to ascertain the best-fit model that describes the sorption kinetics accurately. This step provides insights into the practical application of the impregnated polymeric resin for rapid and effective BPA removal.

Data Analysis and Statistical Evaluation:

The results obtained from batch sorption studies, isotherm analysis, and kinetic evaluations are subjected to rigorous data analysis. Statistical tools are employed to assess the significance of the findings and determine the reliability of the experimental outcomes. This step ensures the robustness of the data and provides a solid foundation for drawing meaningful conclusions regarding the efficacy of the impregnated polymeric resin for purifying waters contaminated with BPA.

This comprehensive methodology ensures a systematic exploration of the Bisphenol-A removal process using the polymeric resin impregnated with a phosphorous-based extractant. Each step is meticulously designed to contribute valuable insights into the sorption efficiency, equilibrium behavior, and kinetics of BPA removal, laying the groundwork for the development of an environmentally friendly and sustainable water purification technique.

RESULTS

The experimental results demonstrate the efficacy of the polymeric resin impregnated with the phosphorous-based extractant in removing Bisphenol-A (BPA) from aqueous solutions. Batch sorption studies reveal a significant reduction in BPA concentrations as the impregnated resin interacts with varying concentrations of the contaminant. The sorption capacity of the resin is evident, showcasing its ability to efficiently capture and retain BPA from the aqueous phase.

Isotherm analysis further supports the findings, indicating a favorable equilibrium behavior between the impregnated polymeric resin and BPA. The Langmuir and Freundlich isotherm models confirm the sorption capacity and affinity of the resin for BPA, providing valuable insights into the resin's performance under different concentration scenarios.

Kinetic evaluations highlight the rapid removal of BPA by the impregnated polymeric resin. The pseudo-second-order kinetic model fitting reveals a strong correlation with the experimental data, suggesting a chemisorption mechanism. This indicates that the impregnated resin acts as an effective sorbent, forming strong chemical bonds with BPA molecules, leading to rapid and efficient removal.

DISCUSSION

The observed results underscore the potential of the polymeric resin impregnated with the phosphorous-based extractant as a viable solution for BPA removal. The selective binding affinity of the phosphorous-based extractant contributes to the resin's high sorption capacity, allowing it to effectively sequester BPA from aqueous solutions. The equilibrium behavior and rapid kinetics further support the practical application of this novel material in water purification processes.

The success of this method holds significance in addressing environmental concerns associated with BPA contamination. The impregnated polymeric resin offers a sustainable and efficient alternative for water treatment, providing a route to mitigate the adverse effects of endocrine-disrupting compounds on ecosystems and human health.

CONCLUSION

In conclusion, the polymeric resin impregnated with a phosphorous-based extractant demonstrates remarkable effectiveness in purifying waters contaminated with Bisphenol-A. The synthesis process yields a stable and structurally sound material, and the batch sorption studies, isotherm analysis, and kinetic evaluations collectively affirm its potential for practical application. This innovative approach holds promise as a sustainable and environmentally friendly solution for addressing BPA contamination in aqueous environments. Further research and application studies are warranted to explore the scalability and real-world effectiveness of this method in water treatment scenarios, with the ultimate goal of contributing to the development of efficient strategies for mitigating the impact of endocrine-disrupting compounds in water sources.

REFERENCES

1. H. Ashraf and Q. Husain, "Use of DEAE cellulose adsorbed and crosslinked white radish (Raphanus sativus) peroxidase for the removal of α-naphthol in batch and continuous proces," Int. Biodeterior. Biodegrad, vol. 64, pp. 27-31, October 2010.
2. C. Karunakaran, S. Narayanan, and P. Gomathisankar, "Photocatayltic degradation of 1-naphthol by oxide ceramics with added bacterial disinfection," J. Hazard. Mater, vol. 181, pp. 708-715, June 2010.
3. K. Ballschmiter and H. M Kuch, "Determination of compounds and estrogens in surface and drinking water by HRGC- (NCI) -MS in the picogram per liter range, science," Environ. Sci. Technol., vol. 35, pp. 3201-3206, 2001.
4. N. A. Ahmad, M. A. Yuzir, E. L. Yong, N. Abdullah, and M. R. Salim, "Removal of bisphenol a (BPA) in surface water by ozone oxidation process," Appl. Mech. Mater, vol. 735, pp. 210-214, Feb. 2015.
5. C. N. Huy, N. Kim, T. D. phan, I. K. Yoo, and E. W. Shin, "Adsorptive interaction of bisphenol a with mesoporous titan silicate / reduced graphene oxide nanocomposite materials: FT-IR and Raman analyses," Nanoscale Research Letters 2014,, vol. 9, pp. 1-7, 2014.
6. T. Safabakhsh and H. Pourzamani, "Removal of bisphenol a from aqueous solutions using magnetic nanoparticles: Investigation of adsorption isotherms," Int. J. Environ. Health Eng, vol. 5, pp. 25, July 2016.
7. V. Repousi, A. Petala, Z. Frontistis, M. Antonopoulou, I. Konstantinou, D. I. Kondarides, and D. Mantzavinos, "Photocatalytic degradation of bisphenol A over Rh/TiO2 suspensions in different water matrices," Catal. Today, vol. 284, pp. 59-66, Oct 2016.
8. J. Chen, X. Huang, and D. Lee, "Bisphenol A removal by a membrane bioreactor," Process Biochem, vol. 43, pp. 451-456, Jan 2008.
9. Rajan, S. Sreedharan, and V. Babu, "Solvent extraction and adsorption technique for the treatment of pesticide effluent," Civ. Eng. Urban Plan. An Int. J, vol. 3, pp. 155-165, June 2016.

10. J. Bokhove, B. Schuur, and A. B. De Haan, “Solvent design for trace removal of pyridines from aqueous streams using solvent impregnated resins,” Sep. Purif. Technol, vol. 98, pp. 410-418, July 2012.