BATCH ADSORPTION STUDIES ON COCONUT OIL-BASED POLYURETHANE FOAM-ACTIVATED CARBON COMPOSITE FOR LEAD SEQUESTRATION IN AQUEOUS MEDIA DETECTED USING UV-VISIBLE SPECTROSCOPY TECHNIQUE

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ABSTRACT

The extensive occurrence of heavy metals in the environment has led to an ever-increasing concern about such contaminants on human and ecosystem health. Among several types of heavy metals, lead species have profiled widespread interest due to their utility in diverse industrial products. Adsorption is the most widely used method for removing contaminants like heavy metal and cationic dye in wastewater. In this study, a polymer composite adsorbent is prepared by integrating coconut shell-derived activated carbon in the polyurethane foam formulation. Samples were analyzed using UV-Visible Spectroscopy. The presence of activated carbon as a modified filler improved the adsorption of lead to the composite by 20%. This can be attributed to the addition of specific sites, allowing for more metal ions capture. In terms of the initial concentration, the uptake of the ion is increased by as high as 320% with increasing the initial metal concentration. Results also showed that the pseudo-second-order kinetics has a better fit with a correlation of 0.99 to the experimental data. The data prove that the PUAC composite material is an efficient and cost-effective method for lead sequestration in aqueous media.

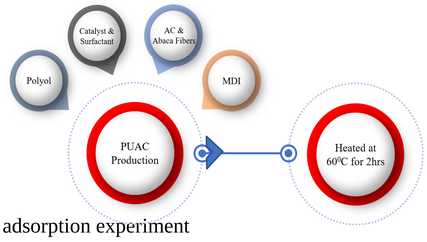
OBJECTIVES

This study aims to rationally design a bio-based polyurethane foam that has an enhanced adsorption performance for lead sequestration in aqueous media with the use of activated carbon as a modified filler. Specifically, the study aims to:

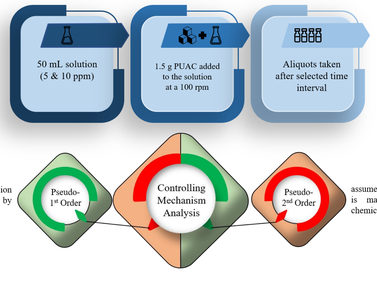
- Develop and characterize a polyurethane foam enhanced with an optimized amount of activated carbon as a modified filler;
- Establish the proof of concept of PUAC composite as a desirable adsorbent for lead sequestration under a batch operating system.

METHODOLOGY

- Polyurethane-Activated Carbon (PUAC) fabrication



- Batch adsorption experiment



CONCLUSIONS

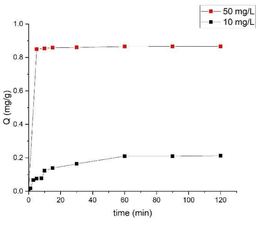
This study reports on the preparation and characterization of PUAC at variable composition. The FTIR results provide complementary support for the adsorbent characterization and the role of non-covalent stabilization effects among the components PUAC was shown to be a sustainable adsorbent material for the controlled removal of Pb(II) ions in wastewater treatment. Experimental results showed that the removal efficiency and adsorption capacity of PUAC was influenced by initial Pb concentration. Kinetics studies on Pb adsorption by PUAC followed the pseudo-second-order model.

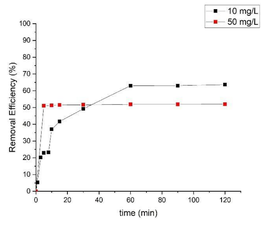
INTRODUCTION

Lead poisoning in humans causes severe harm to the body causing great concern regarding public health. Among the various physical- and chemical-based techniques accessible for contaminant removal, adsorption poses the lowest infrastructure and operational costs for lead sequestration in wastewater. Today, polyurethane (PU) has gained much interest in academic research for its adsorption ability to remove multiple heavy metal ions. Led by the rise of environmental concern, a new trend in PU research has been shifted to the use of bio-polyol resources instead of using petroleum-based products.

In this particular study, coconut has become a subject of interest. We employed PU's applicability in lead removal by incorporating activated carbon as modifying fillers. Most of the current analytical methods for Pb (II) require highly trained operators and expensive equipment. The spectroscopy method without chemical reagents proves useful and is a non-destructive method. In this study, samples were analyzed through the use of UV-Visible Spectrometry.

RESULTS & DISCUSSIONS



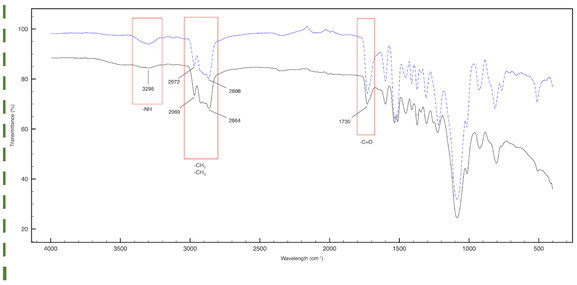


The removal efficiency and adsorption capacity (Q) of PUAC composite increased over time until they reach a maximum, as illustrated in the figures on the left. The removal percentage obtained at both concentrations are similar suggesting that the PUAC can still absorb Pb at higher concentrations. Moreover, the quantity of the pollutant adsorbed per unit of mass of adsorbent increases with the increase of the concentration of the solution.

The pseudo-2nd order model (R^2=0.99) correlated better than the pseudo-first order model, indicating that the pseudo-second order model was the best model to describe the adsorption process.

Kinetic models for the adsorption of Pb

Pollutant	C0 (mg/L)	Qe,exp (mg/g)	Pseudo-First-Order Model k1(min⁻¹)	Qe,calc (mg/g)	R2	Pseudo-Second-Order Model k2(g mg⁻ min⁻¹)	Qe, calc (mg/g)	R2
Pb	10	0.212	0.0573	0.185	0.9428	0.3945	0.234	0.9957
	50	0.866	0.0626	0.053	0.7034	7.6395	0.867	1



FTIR spectrum was used to identify the functional group present in PU composites and in determining if chemical interaction occurs between AC and PU matrix. The presence of the carboxylic group on AC gives interaction between AC and PU matrix. C=O group of hard segments in PU chains may form hydrogen bonding with the carboxylic group of the AC, giving a strong interaction. This shows the possible interaction of hydrogen bonding existing between AC and PU chains.

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