The Effect of Coco-Shell Based Activated Carbon in Hexavalent Chromium Sequestration of Polyurethane Foam: A Batch Adsorption Experiment

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Introduction

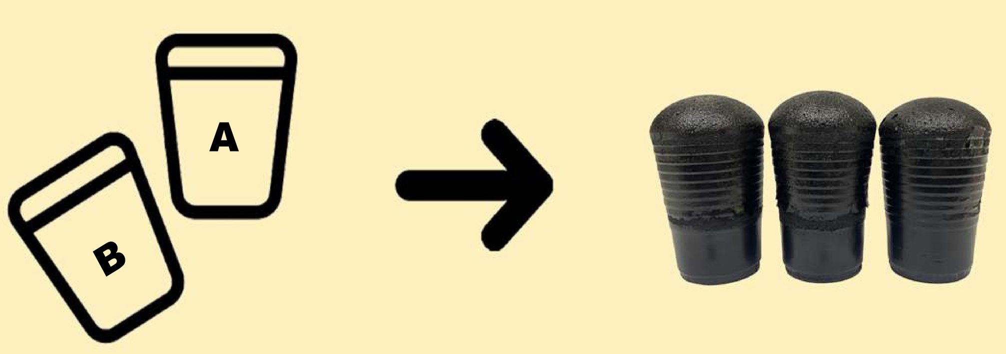
Water is undeniably one of Earth's most essential and abundant resources. However, the supply of clean drinking water is facing a severe threat as it continues to be affected by human anthropogenic activities. The effect affected human civilization from the environmental, social, and economic aspects. Accessibility to clean drinking water has become scarce in most parts of the world and ranked 15th in the causes and risk factors for death and disease in 2017. Global industrialization and the rapid increase in the world population continue to threaten its supply as hazardous materials enter the environmental media at unprecedented speed through untreated wastewater. Heavy metals pose a significant adverse effect on human health and the environment. Through the adsorption process, activated carbon (AC) is considered one of the most promising and commonly applied techniques in treating organic and inorganic pollutants because of the simplicity of its application. However, the usage of commercial AC faces several drawbacks as it utilizes non-renewable materials. Because of this, there is a continuous search for innovative wastewater treatment methods geared toward sustainability. On the other hand, polyurethane (PU) foam is also known for its many application because of its high porosity.

Objective

The general objective of this study is to synthesize a foam that can adsorb pollutants such as hexavalent chromium from an aqueous solution. This study aims to improve wastewater treatment by synthesizing a composite material from sustainable materials to remove hexavalent chromium effectively. Further, synthesizing the composite material also addresses the common drawbacks associated with the traditional way of applying activated carbon, making it renewable by lessening the likelihood of being broken into smaller pieces.

Methods

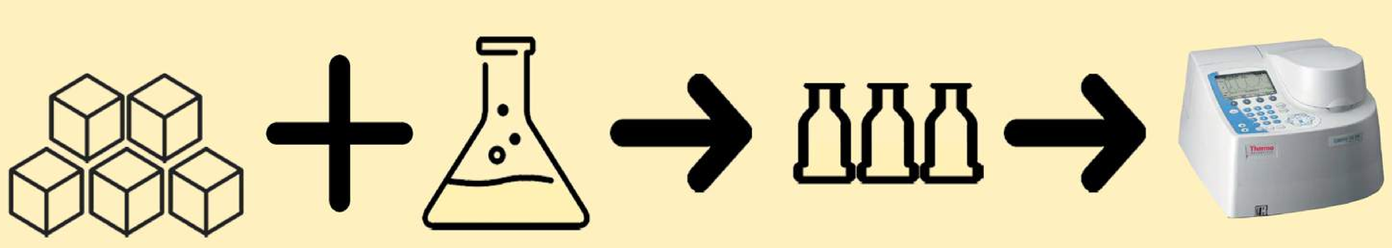
-Composite Material Production



Component A (catalyst, surfactant, polyol, and filler) was mixed with component B (MDI)

PUAC was continuously heated for 2 hours at 60 °C

-Batch Adsorption Experiment



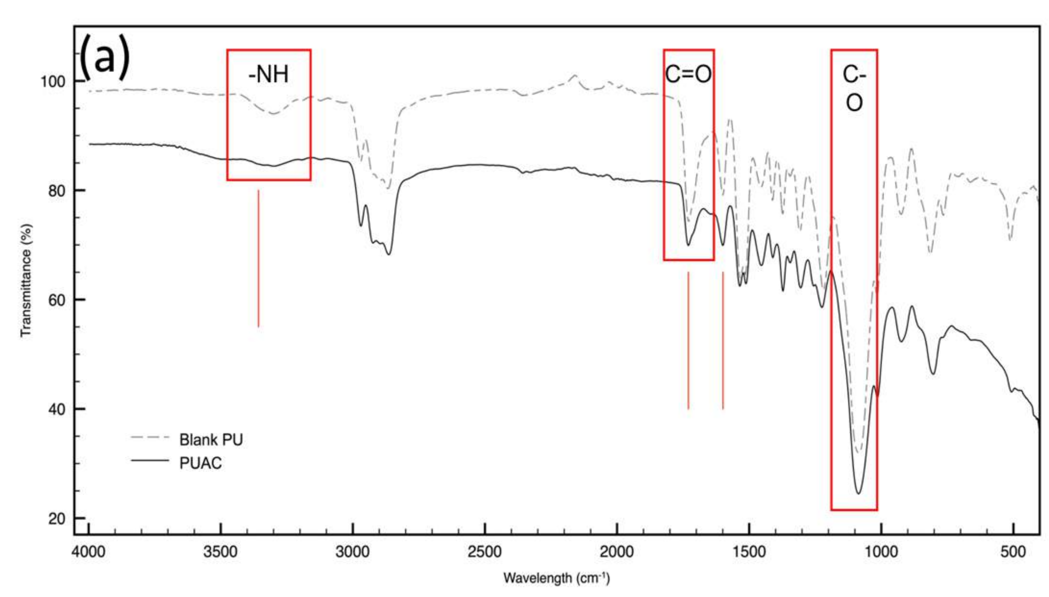
1.5 g of PUAC was added to a 50-mL stock solution (100 & 200 ppm) and shaken at 100 rpm

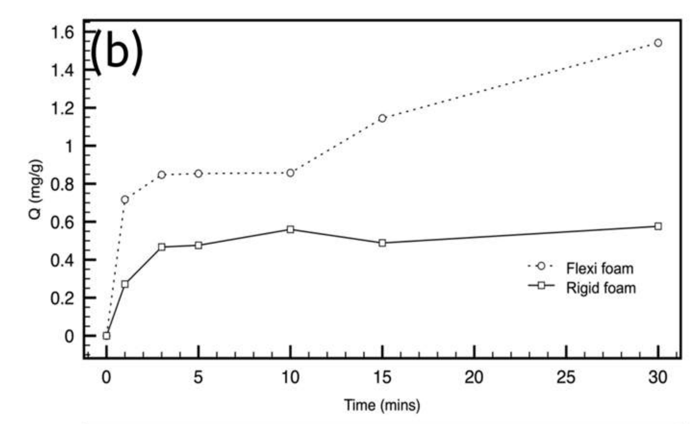
3-5 mL aliquot samples are taken at regular time interval

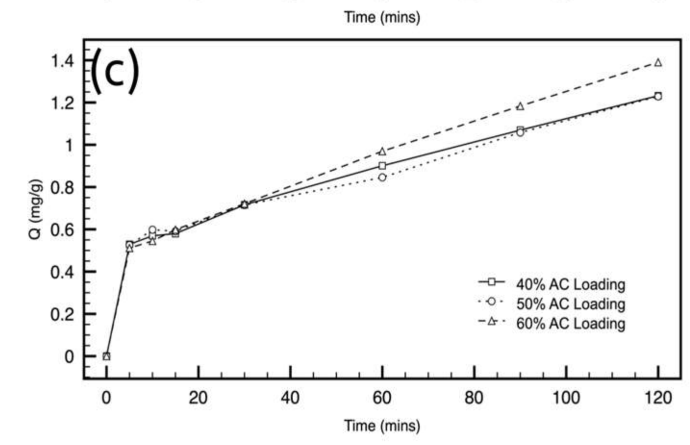
Samples are analyzed using UV-Vis

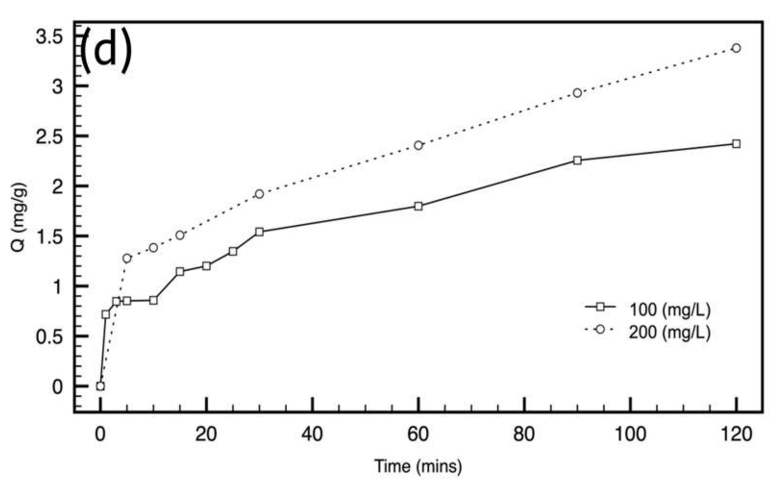
Results & Discussion

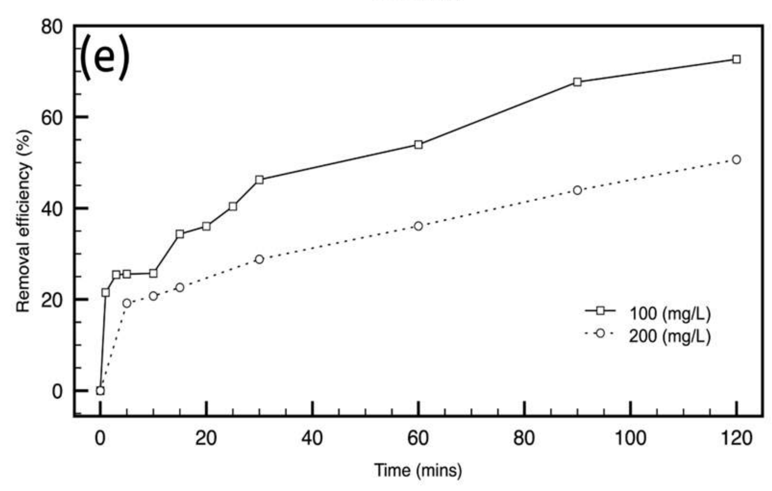
Fourier Transform Infrared Spectroscopy (FTIR) was used to characterize a pristine PU and the PUAC; results (Figure a) revealed that hydrogen bonding took place, confirming the presence of activated carbon in the composite material. The figures on the right represent the data gathered from the type of foam and amount of AC loading. Flexible foam displayed superior adsorption capacity compared to rigid foam after subjecting to batch adsorption (Figure b). In varying the amount of AC loading from 40% to 60%, the adsorption capacity (Q) was increased by 0.158 mg g-1 only (Figure c). However, for economic reasons, 40% AC loading was used.











The adsorption capacity and removal efficiency of the PUAC is illustrated in the left. It can be seen that as the initial concentration and time increases, adsorption capacity (Q) also increases (Figure d). However, the opposite is true with respect to removal efficiency (Figure e). Kinetic models were employed and results show that pseudo-second-order showed better correlation (0.9607 - 0.9659), indicating that adsorption phenomenon of the composite material can be modeled using pseudo second-order kinetics.

Pollutant	C_0 (mg/L)	$Q_{e,exp}$ (mg/g)	Pseudo-First-Order Kinetics			Pseudo-Second-Order Kinetics		
			k_1 (min^{-1})	$Q_{e,calc}$ (mg/g)	R^2	k_2 (g mg^{-1}min^{-1})	$Q_{e,calc}$ (mg/g)	R^2
Cr (VI)	100	2.4217	0.0249	1.9506	0.9480	0.0248	2.5830	0.9607
	200	3.3780	0.0191	2.6569	0.9550	0.0135	3.6800	0.9659

Conclusion

The results of this study suggest that the synthesized PUAC composite material can be an alternative low-cost adsorbent for the effective removal of hexavalent chromium in an aqueous media. Experiments revealed that the initial concentration highly influences adsorption in terms of efficiency and capacity. Further, kinetic models signify that hexavalent chromium follows the pseudo-second-order, indicating that chemical processes govern the overall adsorption.