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Removal of Hexavalent Chromium from Bichromate Effluents using Activated Carbon Derived from Coffee Grounds

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ABSTRACT

The aim of this study is to evaluate the efficacy of a synthesized carbon derived from coffee grounds in the adsorption of chromium VI present in bichromate effluents used during uranium analysis. A comparison with a commercial activated carbon is made under the identical conditions. Chromium is detected in the effluents at a concentration of 582 mg/L. However, following its use in uranium analysis, the measured chromium concentration decreases to 181.87 mg/L. It's worth noting that both activated carbons share similar physical characteristics, including a particle size of approximately 1000 µm and closely matched specific surface areas, around 936 m²/g for the synthesized activated carbon and 1100m²/g for the commercial one. Parametric studies indicate that the adsorption of chromium VI by coffee grounds is favored at acidic pH values. The maximum adsorption capacity of chromiumVI determined for the synthesized activated carbon is 50.65mg/g for the commercial activated carbon; it is 56.86mg/g.

Keywords: Chromium VI, Bichromate, uranium, coffee ground, activated carbon.

1 Introduction

Bichromates, compounds with the dichromate ion, are widely used in industrial applications, including galvanoplasty, photography, pigment manufacturing, and uranium analysis [ISO 7097-2006]. Despite their importance, their release into the environment poses a significant hazard due to the chromium they contain. Our study focuses on adsorbing chromium VI in bichromate effluents used in uranium analysis at the Draria Nuclear Research Center, aiming to develop effective methods to mitigate environmental impact.

2 Experimental

In the effort to optimize Chromium VI adsorption, both synthesized and commercial activated carbons, with similar surface areas and granulometry, are systematically examined under well-defined conditions. Parameters, including contact time, pH (1 to 8), solid-liquid ratio (5 to 10), and bichromate solution concentrations (200 to 500 ppm), are adjusted to assess adsorption efficiency, with residual chromium concentrations determined via meticulous spectrophotometric implementation of the spectrophotometric method using diphenylcarbazide. The assessment extends to real effluent, incorporating chrome-uranium elements. A solution derived from uranium quantification via the bichromate method, containing chrome-uranium (Cr-U), comes into contact with both commercial and synthetic activated carbons. Post-contact, the suspensions undergo filtration, and UV-visible analysis at the chromium-specific wavelength of 554 nm with diphenylcarbazide determines the efficiency of chromium adsorption.

3 Results and Discussion

The pH study highlights the performance of commercial and synthesized activated carbons. It is observed at pH 1, both carbons achieve their maximum efficiency, indicating that this acidic environment promotes effective adsorption between the carbons and chromium [1]. Notably, synthesized carbon generally maintains higher efficiency across the pH range, suggesting better adaptability to slightly alkaline conditions, while commercial carbon is more sensitive to pH variations. Examination of the chrome species diagram at varying pH [2] confirms the prevalence of chrome VI in solution at pH 1, reinforcing the notion that the

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elevated efficiency at this pH is a result of effective adsorption of reactive chromium VI ions by the carbons. The adsorption rates of chromium VI reach maximum percentages of 65.65% for the commercial charcoal (CC) and 68.51% for the synthesized charcoal (CM) at an initial concentration of 100 mg/L at pH 2. A decrease in efficiency is observed with the increasing initial concentration, attributed to the saturation of active sites. The linear Langmuir models prove most credible, showing significant alignment with the experimental results. Optimal adsorption tests showed an efficiency of 97.47% for synthesized activated charcoal (CC) and 94.80% for commercial activated charcoal (CM). In trials with real effluents containing chrome-uranium elements, synthesized activated carbon demonstrated a remarkable efficiency of 92.85%, highlighting its ability to remove chromium VI in the presence of elements such as uranium and iron (figure 1). In contrast, commercial activated charcoal exhibited significantly lower efficiency, reaching only 21.42%, suggesting a potential higher affinity for other coexisting elements like uranium.

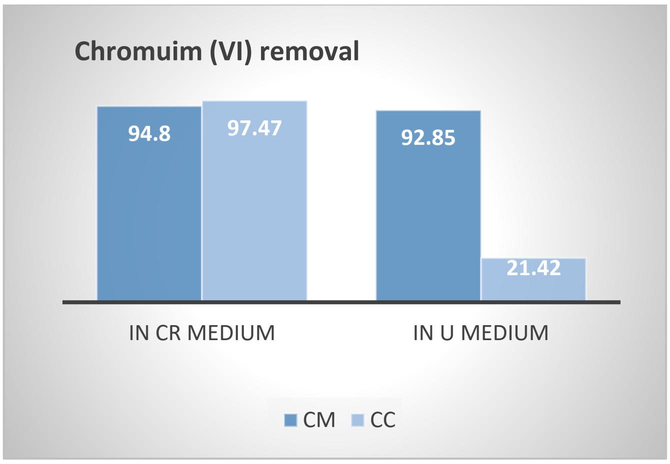

Figure 1: Chromium adsorption efficiency by activated charcoal and commercial activated charcoal

4 Conclusions

The parametric study facilitated the identification of optimal conditions for adsorbing Chromium VI solutions with a concentration of 582 mg/L. These conditions included a 4-hour contact time, a solid/liquid ratio of 10, and an acidic pH of 1. Calculations indicated maximum adsorption capacities of 50.65 mg/g for synthesized activated charcoal (CM) and 56.86 mg/g for commercial activated charcoal (CC). Applying these optimized parameters to a real effluent containing a mixture of chromium and uranium revealed CM's superior efficiency at 92.85% compared to CC. This highlights the efficacy of synthesized activated charcoal in treating effluents with complex compositions, showcasing its potential for environmental remediation applications.

References

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