

THE EFFECT OF ANODE DUST CONCENTRATION ON REMOVAL EFFICIENCY OF Cr (VI) AND Ni (II) IONS FROM AQUEOUS SOLUTION BY ADSORPTION

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ABSTRACT

The examined adsorbent is anode dust known as a solid residue and waste material from aluminium production. The effect of adsorbent concentration on the removal efficiency of Cr (VI) and Ni (II) ions was investigated. The results obtained show that removal efficiency is strongly dependent on adsorbent concentration. The values indicate that the removal efficiency of Cr (VI) and Ni (II) ions from aqueous solutions increases to the optimum concentration of adsorbent and then slowly decreases. The most successful removal of Cr (VI) and Ni (II) ions is achieved with adsorbent concentration of 15 g/l.

Keywords: anode dust, adsorption, Cr (VI) and Ni (II) ions

1. INTRODUCTION

The presence of heavy metals in environment during the last decade aroused considerable public concern since their increasing discharge, toxic nature and other adverse effects on water resources. What is worse, toxic heavy metals cause DNA damage, and their mutagenic ability will probably cause carcinogenic effects in animals and humans [1, 2].

The conventional methods for heavy metal removal from wastewater include precipitation, ion exchange, adsorption, coagulation, evaporation, redox and extraction. But in practice, adsorption has been proved to be an economical, effective and environmentally friendly method for heavy metals removal [3, 4].

The anode dust (CAD) originates from the baking and transport of carbon electrodes - anodes in aluminium production industry and it is not recycled [5]. This is non-toxic metallurgical waste material that has to be disposed of on the specially arranged landfill. This process is rarely applied; it is expensive and requires a lot of area. Therefore, it is necessary to find its use as a secondary raw material.

In this study, the anode dust, a solid residue of aluminium production, was examined as a non-conventional and low-cost adsorbent for the removal of Cr (VI) and Ni (II) ions from aqueous solution.

2. MATERIALS AND METHODS

2.1. Preparation and characterization of anode dust

For analysis, a representative sample of anode dust was obtained using a quartering technique. The sample was dried at 105°C for 4 hours and sieved to particle size 0.125 - 0.2 mm. The chemical composition of the sample was determined by atomic absorption spectroscopy (the AAS method). The mineralogical composition of the carbon anode dust sample was determined by the X-ray diffraction

method (XRD method). It was found that the anode dust was dominated by C (94.49 wt %), followed by Si (1.73 wt %), Al (1.69 wt %), S (1.50 wt %), and Fe (0.34 wt %). The mineralogical composition (XRD analysis) of anode dust is shown in Figure 1.

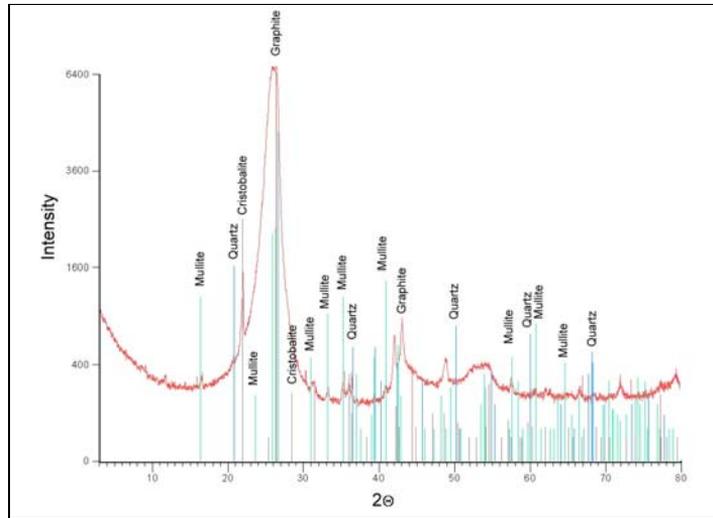


Figure 1. XRD pattern of the anode dust sample

2.2. Experimental procedure

A stock solution of Cr (VI) and Ni (II) ions was prepared by dissolving $K_2Cr_2O_7$ and $NiCl_2 \cdot 6H_2O$ in 1000 ml deionized water. This solution was diluted as required to obtain the standard solutions. The initial concentrations of the solutions contained 200 mg/l of Cr (VI) and Ni (II) ions. The batch experiments were carried out in 100 ml conical flasks by agitating 0.125, 0.250, 0.375, 0.5, 0.625 and 0.750 mg anode dust with 25 ml (mass concentration 5, 10, 15, 20, 25 and 30 g/l) of the aqueous Cr (VI) and Ni (II) ions solution for a period of 30 (for Ni (II)) and 60 (for Cr (VI)) minutes at 20 °C on a mechanical shaker.

The concentration of Cr (VI) and Ni (II) ions before and after the adsorption was determined spectrophotometrically with standard method [6].

Removal efficiency of Cr (VI) and Ni (II) ions, E, (%) was calculated according to equation (1):

$$E = [(c_0 - c_e) / c_0] \cdot 100 \% \quad (1)$$

3. RESULTS AND DISCUSSION

Figure 2. shows the efficiency removal of Cr (VI) and Ni (II) ions as a function of adsorbent concentration. This graph shows that the efficiency removal of Cr (VI) and Ni (II) ions increase to the concentration adsorbent of 15 g/l and then decreases. The efficiency removal of Ni (II) (E = 43.9 %) is better than the efficiency removal of Cr (VI) ions (E = 2.5 %).

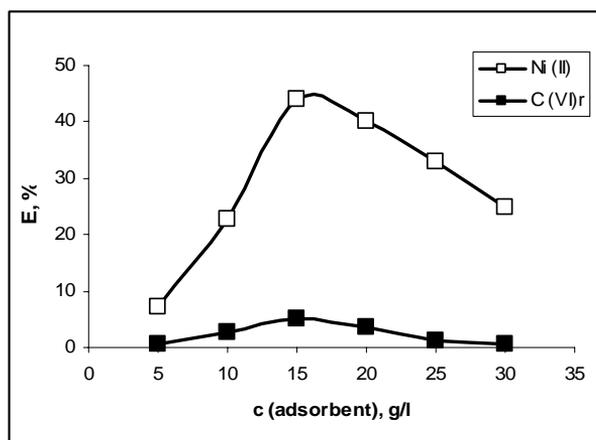


Figure 2. The removal efficiency of Cr (VI) and Ni (II) ions as a function of adsorbent concentration

There are many factors that can contribute to this adsorbent concentration effect. The first and most important factor is that adsorption sites remain unsaturated during the adsorption reaction. This is due to the fact that as the mass of adsorbent is increased, there is a less commensurate increase in adsorption resulting from the lower adsorptive capacity utilization of the adsorbent. The second cause may be the aggregation/agglomeration of adsorbent particles at higher concentrations, which would lead to a decrease in the surface area and an increase in the diffusional path length. The particle interaction at higher adsorbent concentration may also help to desorb some of the loosely bound metal ions from the adsorbent surface [7].

4. CONCLUSION

- The removal efficiency is dependent on adsorbent concentration.
- The removal efficiency of Cr (VI) and Ni (II) ions increase to the concentration adsorbent of 15 g/l and subsequently decreases.
- The efficiency removal of Ni (II) is better than the efficiency removal of Cr (VI) ions.
- The obtained efficiency value is promising in the use of anode dust as an efficient low-cost and non-conventional adsorbent for the removal of Cr (VI) and Ni (II) ions from aqueous solutions.

5. REFERENCES

- [1] Knasmüller S., Gottmann E., Steinkellner H., Fomin A., Pickl C., Paschke A., Göd R., Kundi M., Detection of genotoxic effects of heavy metal contaminated soils with plant bioassays, *Mutation Research*, 420, 1998, 37–48.
- [2] Hartwig A., Current aspects in metal genotoxicity, *BioMetals* 8, 1995, 3–11.
- [3] Tran H. H., Roddick F. A., O'Donnell J. A., Comparison of chromatography and desiccant silica gels for the adsorption of metal ions-I. Adsorption and kinetics, *Water Research*, 33, 1999, 2992-3000.
- [4] Peterlene W. S., Winkler-Hechenleitner A. A., Pineda E. G., Adsorption of Cd(II) and Pb(II) onto functionalized formic lignin from sugar cane bagasse, *Bioresource Technology*, 68, 1999, 95–100.
- [5] Thonstad J., Fellner P., Haarberg G. M., Hiveš, J., Kvande H., Sterten, A., Aluminium Electrolysis, Aluminium-Verlag, Düsseldorf, 2001.
- [6] Fries, J. Getros, H., *Organic Reagents for Trace Analysis*. E. Merck Darmstadt, 1977.
- [7] Erentürk S., Malkoç E., Removal of lead (II) by adsorption onto *Viscum album L.*: Effect of temperature and equilibrium isotherm analyses, *Applied Surface Science* 253, 2007, 4727-4733.

