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## ZnO PARTICLES EMPLOYED IN METAL ADSORPTION FROM WASTEWATER

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### **Introduction**

The increase of water pollution due to rapid growth of industry, agricultural and domestic activities and overpopulation leads to threatening diseases and ecological problems. Even low concentration of metals present in wastewater can cause serious health risks, the effects of these metals are of public health and ecological significance. Metals can become present in waste water due to fertilizers, fungicides, batteries and metal-based paints. While ingested, metals can accumulate in the human body causing a plethora of diseases. The main objectives of this study are to determine if large scale ZnO particles can be used as adsorptive materials, and to determine the effects of different matrices on the adsorption of certain metal ions namely: Cd(II), Ni(II), Cu(II), Cr<sub>(total)</sub>. This element can cause a wide range of diseases (ranging from kidney and liver damage to cancers) due to their toxicity.

### **Materials and methods**

The chemicals used in this study were: Cd(II), Ni(II), Cu(II), Cr<sub>(total)</sub> 1000 µg/L standard solution (CPAchem Ltd.), zinc acetate dihydrate (Honeywell), ethanol, sodium hydroxide pellets and nitric acid. For the quantification of metals an Agilent Technologies ICP-MS 7900 (USA) was used. All the solutions were of analytical purity. The particles size was measured using a Mastersizer 2000 employing a laser diffraction technique. Ultrapure water was used throughout the study.

### **Results and conclusions**

The large ZnO particles (ZnOp) were prepared by a sol-gel method. 20 g of Zn(CH<sub>3</sub>COO)<sub>2</sub>·H<sub>2</sub>O was mixed into 150 mL of ultrapure water to produce a zinc acetate solution. Another solution of 80 g NaOH in 80 mL of ultrapure water was prepared and mixed into the zinc acetate solution. After mixing the solutions, 100 mL of ethanol were titrated into the mix. The resulting gel was dried and calcined. The ZnOp had sizes contained in the 300-700 µm interval, due to the high concentration of zinc acetate used in the synthesis. These dimensions are larger than the traditional ZnO particles used for adsorptive studies.

The adsorptive properties of ZnOp were studied with an initial dose of 0.1 to 0.3 g ZnOp, at 500 rpm. All the solution used in this stage had a volume of 50 mL a concentration of 5 mg/L of each of the four elements.

It was found that the average adsorption of Cr<sub>(total)</sub> and Cu(II) was close to 99% regardless of the initial dose, meaning that the adsorptive material has a higher affinity for them.

The highest adsorptive activity was observed at higher initial dose of ~ 0.3 g (90.73%, 88,63%, 99,19% and 90,73%) than compared its lower counterparts. The results (Represented in % of ions adsorbed by the material) are shown in Table 1.

**Table 1.** Percentages of adsorbed ions at different initial doses at 500 rpm.

<b>Initial dose (g)</b>	<b>Cr (%)</b>	<b>Ni (%)</b>	<b>Cu (%)</b>	<b>Cd (%)</b>
<b>0.1</b>	99.92	43.61	95.92	45.57
<b>0.2</b>	99.96	60.96	98.50	63.51
<b>0.3</b>	99.88	88.64	99.19	90.73

The decision to use different matrices was taken due to the fact that some of the components of an arbitrary sample may decrease or increase the adsorption of metals, some other metals or organic materials may compete with the studied ions for the adsorption onto the surface of the ZnO. In this regard two wastewater samples (P1 from a waste-management company and P2 resulted in a process of osmosis) were spiked to an approximative concentration of 5 mg/L and mixed (for 1h at 500 rpm) with 0.3 g of ZnOp. The two matrices seemed to not prevent the adsorption of ions. With the matrix P1 resulting in an adsorption close to 99% for all four elements (Table 2).

**Table 2.** Percentages of adsorbed ions in two different matrices with an initial dose of ZnOp of 0.3 g at 500 rpm.

<b>Matrix</b>	<b>Cr (%)</b>	<b>Ni (%)</b>	<b>Cu (%)</b>	<b>Cd (%)</b>
<b>P1</b>	99.97	99.98	99.87	99.94
<b>P2</b>	97.53	80.83	82.51	94.67

The P2 sample's matrix resulted in the adsorption of Cr<sub>(total)</sub> and Cd<sub>(II)</sub> ions of 97.5% and 95%, respectively. In the case of Ni<sub>(II)</sub> 80% of the ions were retained on the adsorptive material and 82% for the Cu<sub>(II)</sub> possibly because this particular sample had a higher concentration of zinc ions prior to spiking which can have a higher affinity for the ZnOp material, thus occupying with more ease the surface of the particles. The results are shown in Table 2.

Under optimized conditions it was established that the large ZnO particles had an adsorptive capacity close to 99% for Cr<sub>(total)</sub> and Cu<sub>(II)</sub>, and 90% for Cd<sub>(II)</sub> and Ni<sub>(II)</sub> proving that the ZnOp can be a useful material for the adsorption of certain metal ions. In the near future, more studies will be conducted to see if the ions can be desorbed and to see if the ZnO particles can be used in the manufacturing of water filters for metal capturing.