

Application of faujasite synthesized from illite to the removal of Cr³⁺ and Ni²⁺ from electroplating wastewater

Aplicación de faujasita sintetizada a partir de illita en la eliminación de Cr³⁺ y Ni²⁺ de aguas residuales provenientes del galvanizado

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Abstract

The synthesis of faujasite type zeolite from an illite-rich raw material by an alkaline fusion step prior to hydrothermal treatment was investigated. The synthesis products were characterized by X-ray fluorescence, X-ray diffraction, scanning electron microscopy and Fourier transformed infrared spectroscopy, in order to elucidate their physicochemical and mineralogical characteristics. The transformation of the starting material can be summarized by two processes: (1) destruction of the aluminosilicate structure and (2) crystallization in a zeolite structural framework. The as-synthesized faujasite was tested as an adsorbent material in the removal of Cr³⁺ and Ni²⁺ from aqueous solutions.

Keywords: *faujasite type zeolite, illite, alkaline fusion, aluminosilicate structure, adsorption.*

Resumen

La síntesis de zeolita tipo faujasita a partir de una materia prima rica en illita por el método de fusión alcalina previa al tratamiento hidrotermal fue investigada. Los productos sintéticos fueron caracterizados por fluorescencia de rayos X, difracción de rayos X, microscopía electrónica de barrido y espectroscopía infrarrojo por transformada de Fourier, con el fin de establecer sus características fisicoquímicas y mineralógicas. La transformación del material de partida puede resumirse a partir de dos procesos: (1) destrucción de la estructura del aluminosilicato y (2) cristalización en un arreglo estructural característico de las zeolitas. La faujasita sintetizada fue probada como material adsorbente en la remoción de Cr³⁺ y Ni²⁺ de soluciones acuosas.

Palabras clave: *zeolita tipo faujasita, illita, fusión alcalina, estructura del aluminosilicato, adsorción.*

Introduction

Nearly all industrial effluents are contaminated with heavy metals, which are highly toxic, non-biodegradable and may be cancerogenic. The most common pollutants which are arising from industries such as electroplating, mineral processing, galvanization plants, paints formulation, porcelain enameling, nonferrous metal and vegetable fat producing industries [1]. Due to the discharge of large amounts of metal-

contaminated wastewater, the electroplating industry is one of the most hazardous among the chemical-intensive industries [2]. Inorganic effluent from these industries contains toxic metals such as Cd, Cr, Cu, Hg, Ni, Pb, and Zn, which tend to accumulate in the food chain and they are usually associated with toxicity [3]. Several treatment technologies have been developed for the removal of these metals from wastewater, which include precipitation, ion exchange methods and electrolytic techniques [4,5]. Zeolites are crystalline,

microporous, hydrated aluminosilicates of alkaline or alkaline earth metals. The frameworks are composed of $[\text{SiO}_4]^{4-}$ and $[\text{AlO}_4]^{5-}$ tetrahedra, which corner-share to form different open structures. The tetrahedra are linked together to form cages connected by pore openings of defined size; depending on the structural type, the pore sizes range from approximately 0.3–1.0nm [6]. Due to their exceptional properties, zeolites have been widely used in numerous technical applications as catalysts, adsorbents and ion exchangers [7]. The rapid increase in consumption of zeolites calls for further work seeking cheaper raw materials for their synthesis. Generally, zeolites are synthesized from freshly prepared alkali metal aluminosilicate gels using several silica and alumina sources by hydrothermal treatment. However, the preparation of synthetic zeolites from chemical sources of silica and alumina is expensive. Therefore, in order to reduce costs, zeolite researchers are seeking cheaper raw materials for zeolite synthesis, which include clay minerals such as kaolinite [7-9], halloysite [10], interstratified illite-smectite [11], montmorillonite [12] and bentonite [9,13]. Illite is a non-expanding clay mineral and forms part of phyllosilicate group. Its structure is constituted by the repetition of tetrahedron-octahedron-tetrahedron (TOT) layers. The interlayer space is mainly occupied by poorly hydrated potassium cations responsible for the absence of swelling. This natural clay is another interesting material because is inexpensive and can be incorporated into environmental management projects. However, its potential application in zeolite synthesis and water technology has not been used.

Several studies have been carried out on the use of clay minerals in zeolite synthesis for the removal of heavy metals from aqueous solution by adsorption. However, to the knowledge of the authors, the synthesis of faujasite, type zeolite, from illite and its use as an adsorbent for the removal of Cr^{3+} and Ni^{2+} from aqueous solution has not been reported elsewhere. In this paper, we report for the first time the synthesis of natural illite clay-based faujasite with potential application in Cr^{3+} and Ni^{2+} removal from aqueous solutions.

Experimental procedure and materials

The natural clay used as starting material in this work for zeolite synthesis corresponds to illite-rich clay from the Barroblanco mine, situated in the municipality of Oiba, Santander (Colombia). The raw material was prepared prior to the synthesis

process by drying during 24h, and pulverized with an agate Mortar grinder RETSCH RM 100. Finally, the sample was sieved and particles of 63 μm were selected for zeolite synthesis. On the other hand, illite was thermally activated at 900°C to determine the effect of the dehydroxylation process in the synthesis process. The powder samples were then ground as fine as possible by using mortar and pestle for further characterization. Activating was done using the following chemical reagents: sodium hydroxide, NaOH, as pellets (99wt%, Aldrich) and distilled water. Illite generally is unreactive in the natural form. Subsequently, it was transformed to a more reactive (amorphous) form by subjecting it to heating at 600°C before using it as a reactant. To determine the removal efficiency of Cr^{3+} and Ni^{2+} of the as-synthesized zeolite, a wastewater sample was collected from an electroplating industry located at Bucaramanga, Santander (Colombia). For quantification of the content of chromium (Cr) and nickel (Ni) in water samples contaminated with Chromium and Nickel from Business Nichrome (nickel and chrome) metropolitan area of Bucaramanga, was performed in a brand Atomic Absorption Spectrophotometer PerkinElmer which is located in Instrumental Chemistry Laboratory of the Universidad Industrial de Santander.

Synthesis of faujasite type zeolite

An alkaline fusion step was introduced prior to hydrothermal treatment, because it plays an important role in enhancing the hydrothermal conditions for zeolite synthesis. On the other hand, this approach was adopted in this study because larger amounts of aluminosilicates can be dissolved employing this method. Raw and calcined at 900°C materials were dry mixed with NaOH pellets (starting material/alkaline activator = 1/1.2 in weight) for 30min and the resultant mixture was fused at 600°C for 1h. The alkaline reagent added to the starting material acts as an activator agent during fusion. The product yield from the fusion can be as high as 100%. Some of the inert crystalline phases in the raw materials can be fully reacted. The alkaline fused product was ground in a mortar and then 4.40g of this sample was dissolved in 21.50mL of distilled water (ratio = 1/4.9) under stirring conditions for 30min and then the reaction gel was aged for 24h to form the amorphous precursors. The amount of reagents used for the preparation of the hydrogels was based on previous literature search. Crystallization was carried out by hydrothermal synthesis under

static conditions in PTFE vessels of 65mL at 80°C for different reaction times (6, 24 and 96h). At the end of the process the solid is separated by filtration, washed thoroughly several times with distilled water until the filtrate pH reduced to less than 10. The precipitated solid was dried at 100°C overnight. The dried samples were weighed and kept in plastic bags for characterization.

Characterization

X-ray diffraction (XRD) patterns of illite and as-synthesized products were recorded with a RIGAKU D/MAX IIB diffractometer operating in Bragg–Brentano geometry with Cu- α 1 radiation ($k = 1.5406\text{\AA}$) at 40kV and 20mA and graphite monochromation. The scan parameters were step size 0.02°, dwell time 12s and 2θ range 2–70°. Chemical and thermal treatments were conducted as follows: saturation with K^+ and Mg^{2+} ions, calcinations at 350 and 550°C and solvation with ethylenglycol. Phase identification was performed by the Hanawalt method using the crystallographic database Powder Diffraction File (PDF-2) from International Centre for Diffraction Data (ICDD). Full-pattern Rietveld refinement using RIQAS 3.1 program (MDI Inc.) was performed to quantify the amounts of phases in illite and as-synthesized products. The chemical composition of illite and as-synthesized products was investigated by X-ray fluorescence (XRF) in a Shimadzu EDX 800 HS XRF spectrometer. The quantification of the elements was carried out using the method of fundamental parameters (FP) with the software DXP-700E Version 1.00 Rel. 014. The morphology of the raw and modified clay was examined by environmental scanning electron microscopy (ESEM) (FEI Quanta 200), under the following analytical conditions: magnification = 2500–20000x, WD = 9.4, HV = 7.0kV, spot = 3.0, mode SE, detector LFD. The frameworks of the illite and its derivate products were confirmed by Fourier transformed infrared (FT-IR) spectroscopy by using a Bruker FT-IR Tensor 27 Spectrometer in the 4000–400 cm^{-1} region. Approximately 2mg of the sample plus 200mg of KBr were weighted out, milled and grounded in a mortar. The resulting mixture was then pressed into a pellet.

Determination of Cr^{3+} and Ni^{2+} by atomic absorption spectrometry

A calibration curve is a general method for determining the concentration of a substance in an

unknown sample by comparing the unknown to a set of standard samples of known concentration. Synthetic monoionic solutions with concentrations of 1000mg/L of Cr^{3+} and Ni^{2+} were used as standards in order to prepare calibration curves for these metal ions. One aliquot of 10mL of the standard solutions was initially taken and then it was diluted to 100mL with distilled water in a 250mL Erlenmeyer flask. The final concentration was obtained through the equation:

$$C_1 \cdot V_1 = C_2 \cdot V_2 \quad (1)$$

where C_1 is the initial concentration of each heavy metal, V_1 is the initial volume of the aliquot, C_2 is the final concentration of each heavy metal, and V_2 is the final volume. Therefore, the final concentration of Cr^{3+} and Ni^{2+} was 100mg/L. The preparation of the calibration curves from the standards within these metal ions ranges was carried out using the final concentration of 100mg/L calculated above. Eleven aliquots of 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5 and 5.0mL of the standard solutions were taken to prepare the calibration curves for Cr^{3+} and Ni^{2+} . 0.5mL of nitric acid (HNO_3) these solutions were first spiked to an Erlenmeyer flask, then the calculated amount of volume of the standard solutions were added. Finally, the resultant solutions were diluted to 100mL with distilled water. The final concentration of each solution was determined by the above equation and the results were tabulated. Using the technique of atomic absorption spectrometry absorbance of each pattern (Perkin-Elmer 372 atomic absorption spectrophotometer), where the calibration curve by linear regression method to calculate the concentrations of Cr^{3+} and Ni^{2+} in electroplating wastewater was determined.

Adsorption experiments in batch mode

The sorption of Cr^{3+} and Ni^{2+} onto illite-based faujasite type zeolite was studied in laboratory batch experiments, which were carried out at room temperature to investigate the efficiency of this adsorbents material for removing heavy metals from aqueous solution. A weighed amount of sorbent (0.25 and 0.5g) was introduced in 180g amber glass bottles, and then a volume of 50mL of electroplating industry wastewater was added. Later, the sorbent: aqueous solution mixtures were continuously agitated in a Shaker BIOT-S-04 (GFL) for 24h, and the temporal evolution of the pH of the solution and electrical conductivity (EC) was monitored. At each scheduled reaction time (0, 5,

10, 15, 30, 45, 60, 120, 240, 360, 720 and 1440min) the bottles were removed from the shaker and the adsorbents were separated by filtration, while the filtrates were stored in a refrigerator for chemical analyses. All measurements were done according to the Standard Methods for the Examination of Water and Wastewater. Both pH and EC of the original and treated aqueous solutions were measured using a pH Meter Lab 870 (Schott Instruments) and a 712 conductometer (Metrohm AG), respectively. The efficiency of treatment of the electroplating effluent using faujasite was then determined by the following equation:

$$\text{Metal removal efficiency} = \frac{(C_1 - C_2)}{C_1} \times 100 \quad (2)$$

Where C_1 = initial metal concentration and C_2 = metal concentration after treatment. The sample has a chromium concentration of 117.3mg/L and a nickel concentration of 132.3mg/L.

Results and Discussion

Characterization of the starting material

The chemical composition of illite is 63.02wt% SiO₂, 29.08wt% Al₂O₃, 3.54wt% K₂O, 1.43wt% TiO₂, 1.20wt% Fe₂O₃, 1.11wt% MgO, 0.22wt% CaO, and 0.16wt% Na₂O [7]. As shown in the XRD pattern of the Figure 1, illite is the predominant mineral phase in the starting material and is identified by a series of basal reflections at 10.1Å, 4.98–5.01Å, 3.33Å, and 2.89–2.92Å. However, minor impurities, such as quartz, anatase and aluminum silicate hydroxide also occur. Quartz is identified by its distinctive reflections at 4.26 and 3.35Å. The 3.35Å peak of

quartz was more intense than the other peaks. Illite can be recognized by its sheets or large flaky crystals, which develop clusters (Figure 1).

Characterization of the zeolitic materials

XRD patterns in Figure 2 show the progress of faujasite synthesis by the fusion method, revealing the reduction of intensity of the characteristic peaks of the starting material (illite) and the appearance of new reflection peaks corresponding to zeolitic materials, which show a progressive increase in the intensity with reaction time. After 6h of reaction faujasite peaks appear, with a maximum crystallinity occurring after 96h. Therefore, the reaction time influences the crystallinity of the synthesis products. The synthesis of zeolite via alkaline fusion followed by hydrothermal treatment reveals that the alkaline fusion process promoted the dry reaction between the crystalline mineral phases present in illite and the alkaline activator, and the alkaline fused product corresponds to amorphous sodium aluminosilicate, indicating that fusion was very effective in extracting the silicon and aluminium species from illite.

The presence of aluminosilicate framework in the faujasite structure was confirmed using FT-IR spectroscopic technique. Infrared spectra of the untreated illite and zeolitic products are shown in Figure 3. After 6h, there is appearance of absorbance band situated around at 560cm⁻¹, characteristic of zeolites with double ring and specifying the presence of the zeolites such as faujasite as revealed by Grujć E, *et al.* [14]. Moreover, the observed single strong band at 3450cm⁻¹ ascribed to the presence of hydroxyls in the faujasite supercages and sodalite cages as the building blocks of faujasite structures [15].

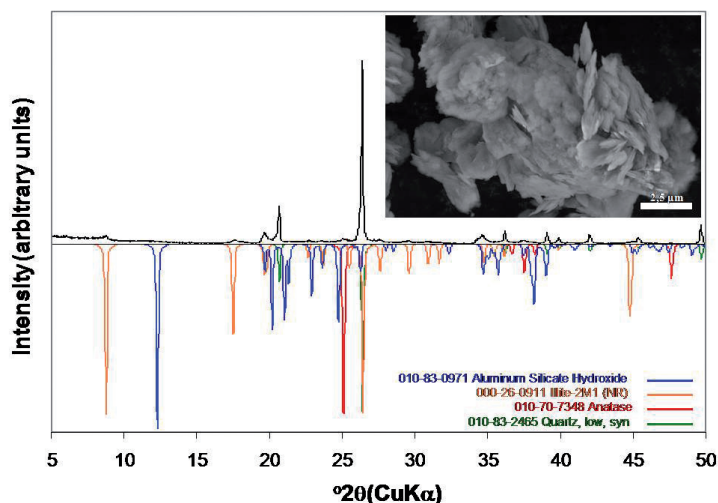


Figure 1. X-ray diffraction pattern and SEM image of the starting material.

New infrared bands located towards 700 and 750 cm^{-1} appears after 24h of reaction, although they may reveal the presence of hydroxysodalite [14], which is a zeolitic phase that can be formed at expenses of faujasite. All these observations confirm the formation of faujasite-type zeolite after alkali fusion followed by hydrothermal treatments of natural clay. We observed also that bands

vibration characteristic of illite do not appear in the final products, whereas quartz present in the end product is characterized by the bands of vibrations appearing at 700, 780 and 800 cm^{-1} are associated with T–O (T = Al, Si) symmetric stretching vibrations. Infrared spectral results are in good agreement with XRD results.

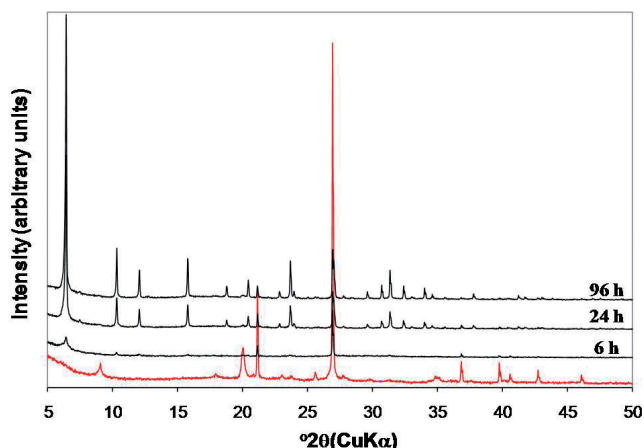


Figure 2. XRD patterns of the unreacted (red) illite and representative as-synthesized faujasite products obtained after its alkaline fusion followed by hydrothermal reaction.

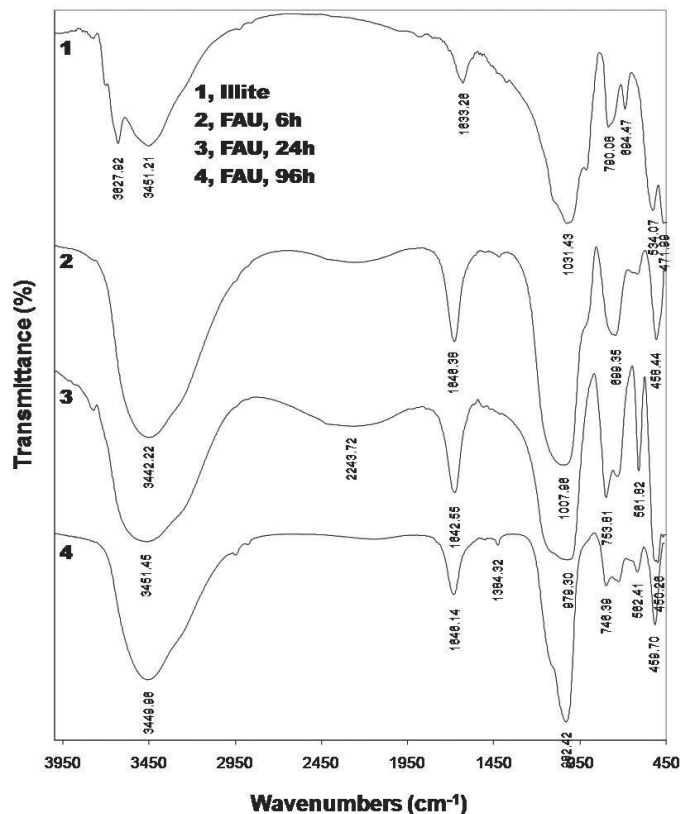


Figure 3. FTIR spectra of the unreacted illite (on the top) and representative as-synthesized products.

Conditions wastewater

The initial concentrations of wastewater contaminated with ions Cr^{3+} and Ni^{2+} in addition to its pH and electrical conductivity were measured. These yielded values of 117.30mg/L Cr^{3+} , with a pH of 3.2 and an electrical conductivity of 43.24mS/cm. Wastewater from Ni^{2+} ion showed a concentration of 132300mg/L, a pH of 6.75 and an electrical conductivity of 142.80S/cm. Taking into account that the industrial water used to carry out the removal of Cr^{3+} , Ni^{2+} ions and not only an effluent contaminated with these elements, also has some other ions such as iron, copper, cadmium, zinc, lead in smaller proportions. These ions may depicting competition of ions at the time of the adsorption capacity of the zeolite, and this results in reducing the efficiency of the removal of ions by said zeolite. They may have an association with the ionic competition for samples of nickel and chromium in which many of the ions in solution, their behavior tend to stay within the zeolite, implying that some of the ions are not eliminated completely and remain in solution.

Adsorption tests

Kinetics of the neutralization reaction. Neutralization is generally the first step in the treatment of the electroplating solution containing Cr^{3+} and Ni^{2+} . Therefore, the kinetics of the neutralization reaction was investigated by monitoring the pH and EC of faujasite/aqueous solution mixtures (0.25g/50mL and 0.50 g/50mL) over a period of 24h. The effect of contact time on pH and EC during the batch experiments for Cr^{3+} and Ni^{2+} is shown in Figure 5. Results indicate that Cr^{3+} and Ni^{2+} adsorption by faujasite was highly pH-dependent and increased with increasing pH conditions. pH increased rapidly within the first 5min of contact between the solution and the sorbent (illite-based faujasite), and then it stabilized (Figures 4a and 4b). According to Genç-Fuhrman *et al.* [16], pH increases mainly due to dissolution of the sorbent in the process of shaking. Final pH values of 7.58-7.69 for Cr^{3+} and 8.42-8.53 for Ni^{2+} were observed in the batches due to hydrolysis of the faujasite as well as cationic exchange. Similar results are reported elsewhere with a remark that the pH increase is almost unavoidable in a zeolite heavy metal system [17]. On the other hand, results reveal that the increase of the adsorbent dosage promoted higher pH conditions. A similar behavior was observed for EC as shown in Figures 4c and 4d.

Removal of Cr^{3+} and Ni^{2+}

The immobilization of heavy metal ions from aqueous solutions is quite a complicated process, consisting

of ion exchange and adsorption and is likely to be accompanied by precipitation of metal hydroxide complexes on active sites of the particle surface [18]. The kinetics of the Cr^{3+} and Ni^{2+} adsorption was also studied over 24h. Metal removal trends as a function of contact time after batch reaction are illustrated in Figure 5. Results indicate that faujasite produced a steep decrease in Cr^{3+} concentration within the first 5min, reaching very low residual concentrations. However, after 45min plateau values were reached for the rest of the time intervals, indicating a complete removal. Cr shows an abrupt decrease in concentration from 0 to 45min and tends to stabilize at values between 0.922 and 1.695mg/L (0.25g of zeolite) and between 0.946 and 1.513mg/L (0.5g of zeolite). Ni showed an inconsistent variation of concentration between 0 and 360min, which is revealed by the fluctuations observed during the batch experiments, and it tends to stabilize at values between 35.6 and 38.7mg/L (0.25g of zeolite) and between 47.9 and 50.1mg/L (0.5g of zeolite).

As shown in Figure 6, the removal efficiency of metal ions by faujasite produced the following ranges: Cr^{3+} (90.53- 99.21% and 88.31 - 99.19%, using 0.25 and 0.5g of zeolite, respectively) and Ni^{2+} (44.74 - 77.73% and 62.07 - 78.30%, using 0.25 and 0.5g of zeolite, respectively). Sorption tests reveal that both metal ions were rapidly removed by faujasite within 45min (Cr^{3+}) and 360min (Ni^{2+}) with 88.31 - 90.53% and 63.24 - 73.54% of the metal removal achieved in the first 5min for Cr^{3+} and Ni^{2+} , respectively. However, sorbent produced lower Ni^{2+} removal (88.31-99.21%) compared with that for Cr^{3+} (44.74 - 78.30%). Therefore, the competition for sorbent adsorption sites in the presence of Cr^{3+} produced a decrease in the uptake of Ni^{2+} . No significant adsorption was observed after 45min (Cr^{3+}) and 360min (Ni^{2+}) of contact time.

According to Peric *et al.* [18], the immobilization of heavy metals from aqueous media is a complex process, which consists of ion exchange and adsorption and is likely to be accompanied by precipitation of metal hydroxide complexes on active sites of the particle surface. On the other hand, the addition of an alkaline material such as faujasite to the electroplating wastewater increased the pH (7.58-7.69 for Cr^{3+} and 8.42-8.53 for Ni^{2+}) and these metal ions could be hydrolyzed and precipitated as suggested by Evangelou and Zhang [19]. However, the efficiency of the tested sorbent with respect to metal retention and/or metal concentration control during its application for the treatment of metal-bearing aqueous media is governed by parameters like contact time, pH, temperature and sorbent

nature as demonstrated in previous studies [20]. On the other hand, mechanisms of interactions, such as

precipitation and adsorption, between Cr^{3+} and Ni^{2+} and faujasite are strongly influenced by pH.

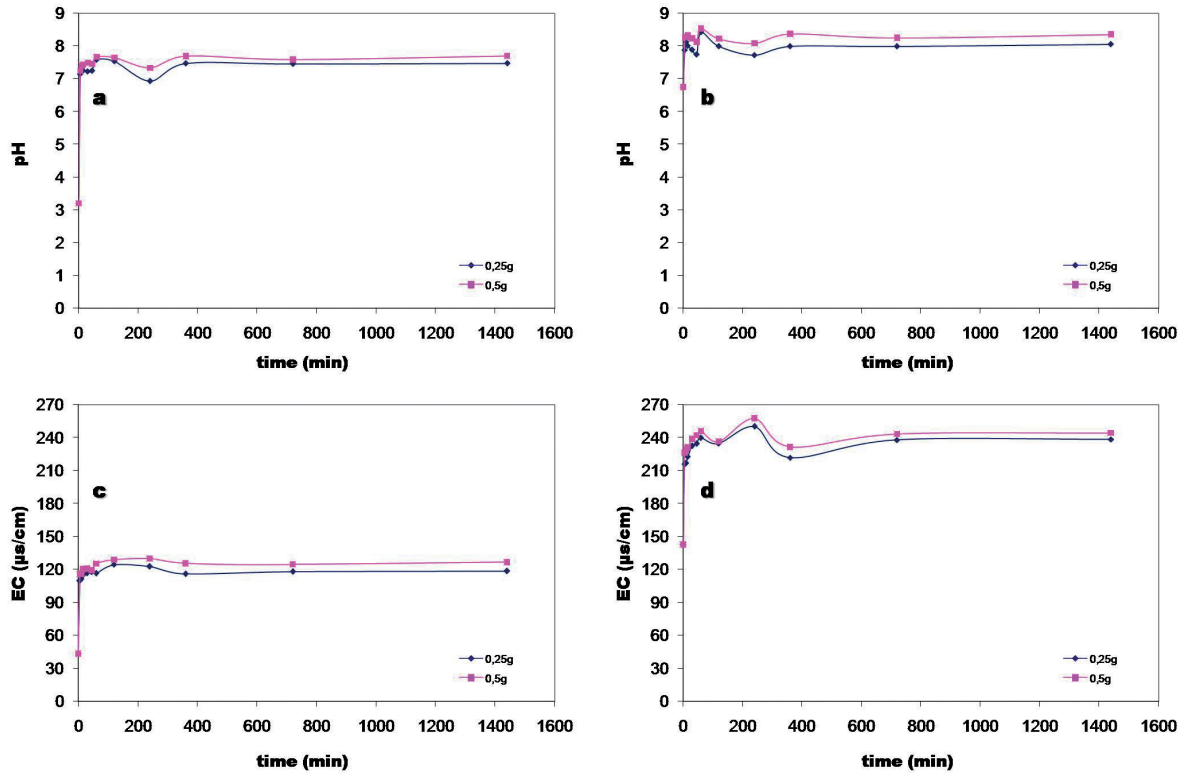


Figure 4. Variation of pH and electrical conductivity as a function of time during the sorption batch experiments for Cr^{3+} (a-c) and Ni^{2+} (b-d). Starting pH and EC of 3.20 and $43.24\mu\text{S}/\text{cm}$ for Cr^{3+} and 6.75 and $142.80\mu\text{S}/\text{cm}$ for Ni^{2+} . Sorbent dosages of 0.25 and 0.5g and volume of solution of 50mL.

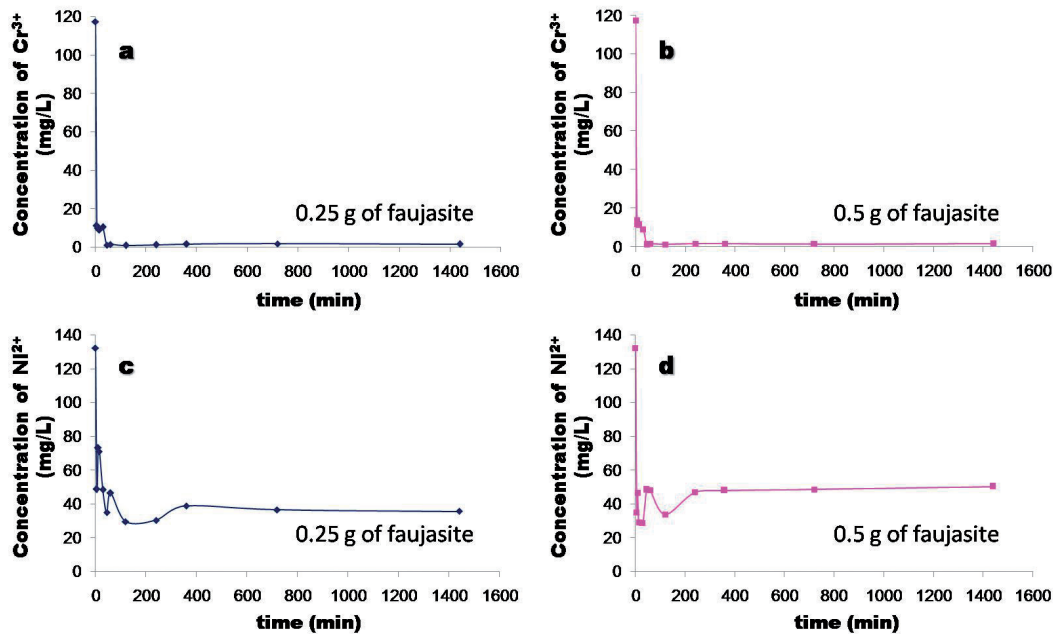


Figure 5. Variation of concentration of Cr^{3+} and Ni^{2+} as a function of time during the sorption batch experiments. Starting concentration $117.300\text{mg}/\text{L}$ for Cr^{3+} and $132.300\text{mg}/\text{L}$ for Ni^{2+} .

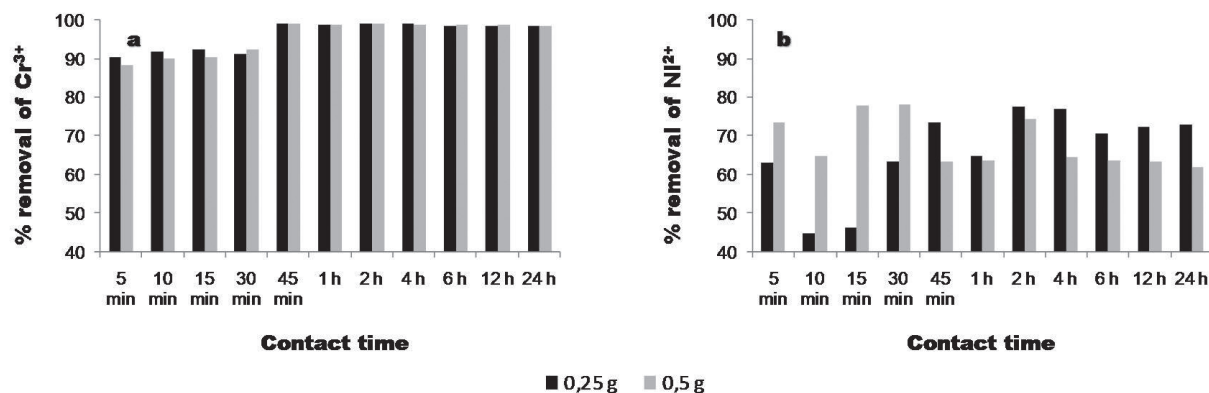


Figure 6. Percentage of Cr³⁺ and Ni²⁺ removal as a function of contact time during the sorption batch experiments.

Effect of sorbent dosage

The adsorption of Cr³⁺ and Ni²⁺ was studied by increasing the adsorbent dosage from 0.25 to 0.5g/50mL. The adsorption efficiency generally improved with increasing adsorbent dosage up to a certain value and then remained constant. The increase in the adsorption percentage with increasing adsorbent dosage is due to the increase in the number of adsorbent sites [21]. However, this does not indicate that the amount removed is directly proportional to the amount of adsorbent used. Sorption test results reveal that residual concentrations of Cr³⁺ obtained using 0.25g of faujasite are a little bit higher compared with those observed with a higher sorbent dose (0.5g). However, higher residual concentrations of Ni²⁺ were obtained when a higher sorbent dose was used.

Effect of contact time

As shown above, both metal ions were very rapidly removed by faujasite in the first 5min. The adsorbed amount of metal ions increased from 5 to 45min for Cr³⁺ and from 5 to 360min for Ni²⁺. Then adsorption rate gradually decreases and removal reaches equilibrium. The time required to reach equilibrium was dependent on metal ion.

Adsorption kinetics

Previous studies [22-28] reveal the effect of ion competition on metal uptake from electroplating wastewater. Given that this effluent is not only contaminated with Cr³⁺ and Ni²⁺ but also with other ions such as iron, copper, cadmium, zinc, lead, in minor proportions, which may represent ion competition at the time of adsorption by the zeolite, this results in lower removal efficiency of Cr³⁺ and Ni²⁺ with many of the ions in solution

showing a behavior that tends to stay within the adsorbent thus implying that some of the ions to be removed are not removed in its entirety and remain in solution. The adsorption of Cr³⁺ and Ni²⁺ by faujasite was strongly affected by pH of the aqueous solution, which is an important controlling parameter in the adsorption process [29-30]. At lower pH value, the H⁺ ions compete with metal cations for the exchange sites in the system thereby partially releasing the latter [25,27]. The maximum adsorption of Cr³⁺ and Ni²⁺ was probably carried out at a pH greater than 6 to avoid competition between ions mentioned above, which can lead to a minimal adsorption at a pH around 2, increasing the mobility of ions into an adsorption of H⁺ [25]. The pH increase is mainly due to dissolution of the inorganic adsorbent (faujasite) during the agitation process. The sorption trends were attributed to the competition between Cr³⁺ and Ni²⁺ and proton for the binding sites on faujasite surface. At low pH, an excess proton can compete with the metal ions, resulting in a low level of metal ion adsorbed. The pH-dependence of adsorption suggests that Cr³⁺ ions are adsorbed according to the ion-exchange mechanism as suggested by Rengaraj *et al.* [31]. However, precipitate could not be excluded at a higher pH [30]. The lower affinity for Ni²⁺ can be explained by its high binding capacity for soluble ligands or its poor competitiveness with other metals in the same solution [22]. Most studies on kinetic process of metal ion adsorption, a distinct two-step behavior was reported [26,32], which can explain the metal ion trends observed for Cr³⁺ and Ni²⁺ after treatment of the electroplating wastewater. Liu and Huang [32] attributed the two-step adsorption characteristic to the heterogeneity of the surface binding sites on sorbents, explaining that different binding sites had different binding

affinities to metal ions and resulted in different binding rates. However, Qin *et al.* [26] asserted that the fast initial sorption owed to the fast transfer of metal ions to the surface of sorbent particles, while the following slow sorption was as a result of the slow diffusion of metal ions into the intra-particle pores of sorbents.

Conclusions

The natural clay, in which illite coexists with quartz was transformed in faujasite type zeolite by fusion with NaOH powder followed by hydrothermal treatment. This synthesis method produced a highly crystalline faujasite type zeolite, obtained after short times of crystallization. This study shows that faujasite can assist in Cr³⁺ and Ni²⁺ pollution control. Findings of our research indicate that Cr³⁺ removal can be much better accomplished by faujasite compared to Ni²⁺ removal during the treatment of electroplating or other industrial effluents. This research can be also used as a reference for future in depth studies considering alternative technologies applied to the mitigation of the environmental impact produced by the electroplating industry.

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