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Chemisorption of toxic effluents from electroplating in residual gypsum from civil construction

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ABSTRACT
Some industrial sectors have an index of pollutants that are more degradable to the environment, for example, the electroplating industries. The treatment of its effluents is essential before it is released into water bodies. The purpose of this work is to test construction waste as possible adsorbents of toxic metal ions. Plaster was used as study material. Specimens were made with plaster moistened with contaminated solutions of Cu2+ and Pb2+. ions. The specimens were submitted to flexural strength tests and the results showed a small decrease in the strength of this type of material when compared to gypsum moistened with drinking water. Adsorption tests were also carried out using gypsum board residues. Kinetic studies showed an adsorption of the Pb2++ ion in a time of approximately 30 minutes. The adsorption isotherm tests showed an adsorptive capacity of approximately 88 mg/g New analyses should be carried out to verify the efficiency of the adsorption of other metal ions such as Cr, Ni and Cd from gypsum as adsorbent and other construction residues.

Keywords: Electroplating, Brass, Plaster.

1 INTRODUCTION

Galvanic activities are considered potentially polluting, especially when it comes to water sources, as this is a sector that promotes the generation of a large amount of waste and for the handling and treatment of these, investment and more and more technical innovations from scientific research and analysis are needed (Franco *et al*., 2011).

The need for the development of durable materials and adaptable manufacturing processes, widely used in automotive and industrial sectors, are increasingly indispensable due to the constant evolutions that human beings have been presenting. But such great evolutions cannot occur in a disorderly way, taking into account that each and every action of man has social and ecological impacts, positive or negative.

In the macro region of Cariri, in the south of the state of Ceará, the city of Juazeiro do Norte stands out for its intense electroplating sector since 1990, with more than 100 factories specialized in

the manufacture of jewelry and semi-jewelry (Costa *et al*., 2008). This process, which involves various electrochemical techniques, ends with the release of wastewater with high concentrations of metals, which are extremely polluting to the environment, and cannot be disposed of immediately. For the treatment of this aqueous waste, a precipitation process is commonly carried out using sodium hydroxide, which reduces the concentration of these metals in the water residue, however, it does not make it clear to the point of consumption or direct return to nature (Moreira, 2010).

As a result of these facts, associated studies are needed to promote an improvement in the treatment of these wastes, so that they do not become harmful effluents for the population.

As in other industrial sectors, Civil Construction also has a considerable share in the production of waste that is intolerable to the environment, with long degradation time and deteriorating effects on the ecosystem.

Especially in large cities, which have a very high population development, there are constant landscape changes, whether in public or private environments, which come from socioeconomic development, improvement in urban mobility, tourism development or greater political notoriety. With these constant changes, many tons of construction waste are produced year after year and often do not have an adequate destination, thus being dumped in landfills or inappropriate places. The reuse of this waste has become a point of concern for developed cities and an object of study, in order to contribute to nature and develop more sustainable production routes (Park and Tucker, 2016).

2 OBJECTIVE

The proposal of this study is based on a qualitative and quantitative analysis of the influence caused in civil construction waste, in this case, gypsum waste, when it is prepared from aqueous solutions that contain minimal and considerable amounts of metals, potentially dangerous to human health, which are present in wastewater from galvanic processes.

Another focus will be the direct use of construction waste as possible adsorbents of metal ions in solution. From pre-limited analyses, it will be possible to identify whether, under such circumstances, the residual material of civil construction can be reused, without compromising its resistance or the safety of those who handle it.

3 METHODOLOGY

3.1 OBTAINING SAMPLES

For the programmed analyses, it was necessary to choose a type of material, commonly used in civil construction. Due to the ease of handling and the many possibilities of applications in the sector, the material initially analyzed was gypsum, Calcium Sulfate hemihydrate extracted from gypsum.

Two different analyses were carried out, one with the virgin material (acquired in construction material deposits) and the other with a sample of residual construction plaster.

3.2 ENDURANCE TEST

With the virgin material, blocks were prepared in triplicate with a solution of Copper II (**Cu^{2+}**) and Lead III (**Pb^{2+}**) in different concentrations. The blocks were standardized so that there were no variations in the results that would induce analytical errors.

The preparation of the gypsum followed the standard used in the industries, with a proportion of 1/2 for water, that is, for a given mass of gypsum, the proportional half of water (50%) was used.

The solutions prepared with the metals initially varied their concentration from 10 to 100 ppm and in a second moment the analyses were redone with concentrations from 150 to 400 ppm. For each analysis, blank samples were used for comparisons.

For the first stage, with lower concentrations, the blocks were standardized in a metal shape, with each block being 2.5 cm wide, 7.6 cm long and 0.5 cm thick. In the second stage, with higher concentrations, the blocks were standardized into wooden molds with a proportion of 6.0 cm in width, 12.0 cm in length and 0.8 cm in thickness. These analyses were qualitative.

The blocks were prepared on a smooth, uniform countertop and dried for 72 hours. After the drying period, the molds were removed and the blocks were subjected to a tension test with a manual press and with the precise measurement of the force. Figure 01 shows the flexure test performed using an IP-90DI (500kgf) dynamometer.

FIGURE 01 – ENDURANCE TEST

Source: the authors (2023).

3.3 REACTION KINETICS ANALYSIS

For the reaction kinetics and isotherm analyses, gypsum residue from civil construction was used. It was crushed and sieved before being submitted to the procedures. The average grain size of the material used ranged from 0.074 to 0.105 mm.

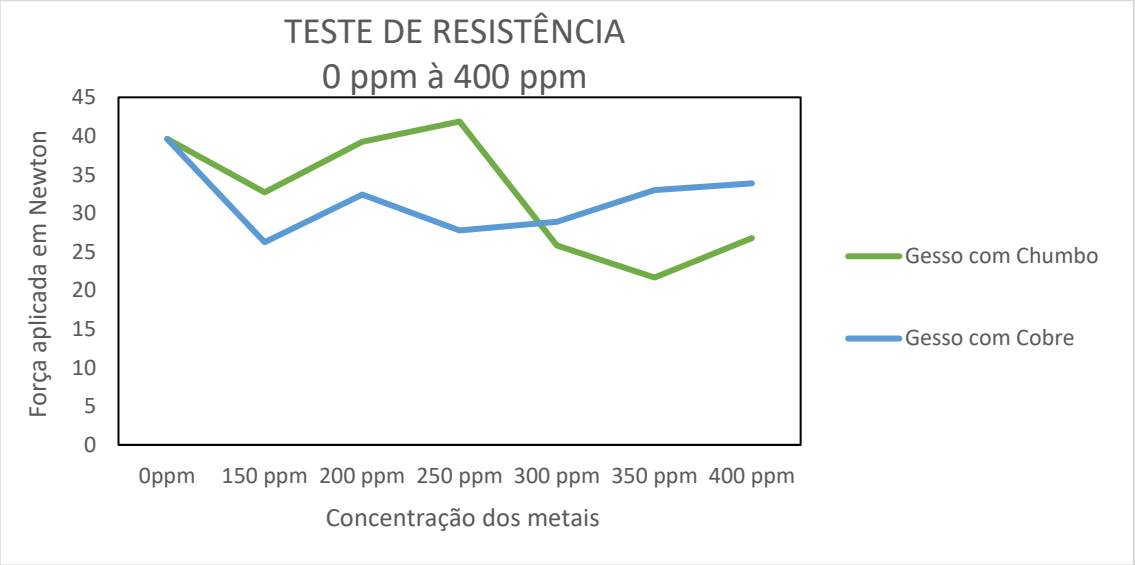
The kinetic analysis is done based on the variation of time, aiming to obtain the speed at which the reaction occurs and the minimum time necessary for it to happen. This analysis is carried out in two stages, being the submission of the study material to a buffered solution at pH 5.5 with a standardized concentration of 100 ppm of the metal ions. For every 10 mL of the solution containing the metal ions, approximately 0.0500 g of gypsum residue were used.

The predetermined times for reaction analysis in minutes were 1, 2, 4, 8, 16, 30, 60, 90, 120 minutes.

4 RESULTS

For the measurement of resistance, the results obtained were satisfactory in what was expected, both for the first stage, with lower concentrations (10 to 100 ppm of both metals), and in the second stage, with very high concentrations (150 to 400 ppm of both metals). The force measured in newton, used to break the block, did not show considerable variation due to the increase of the concentration of the metal in the preparation solution, which can be seen in graph 01. This tells us that the presence of the metal does not promote the loss of its resistance when compared to the value of the white realized.

GRAPH 1 – ENDURANCE TEST RESULTS UP TO 400 PPM

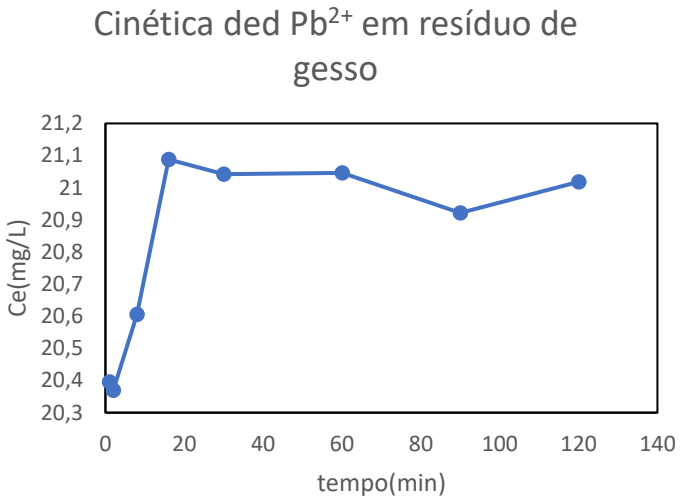


Source: the authors (2023).

For the reaction kinetics test, the results for copper and lead showed significant differences. The equilibrium time was approximately 30 minutes. The experimental data were compared with the pseudo-second-order model and were highly correlated with this model.

Graph 02 shows the experimental results of the kinetic study of adsorption of the Pb^{2+} ion against the gypsum residue.

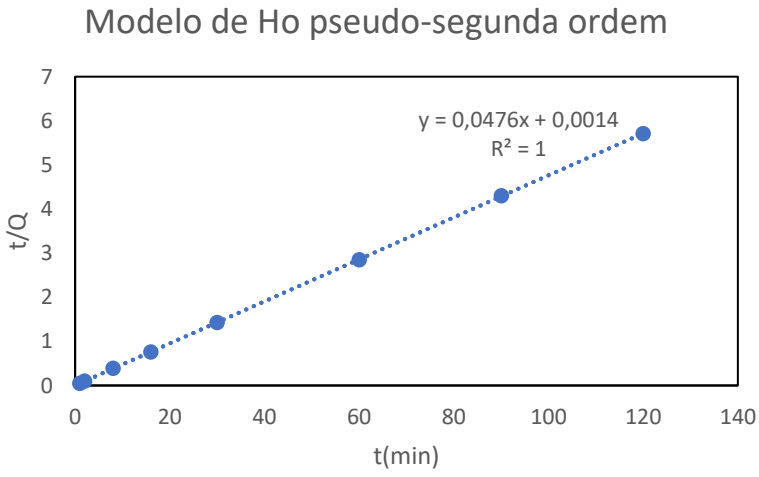
GRAPH 02 – RESULTS OF THE ADSORPTION KINETIC EQUILIBRIUM STUDY. SOLUTION CONCENTRATION OF 100 PPM AT PH 5.5



Source: the authors (2023).

Graph 03 shows the linearity correlation of the experimental data with the pseudo-second-order model

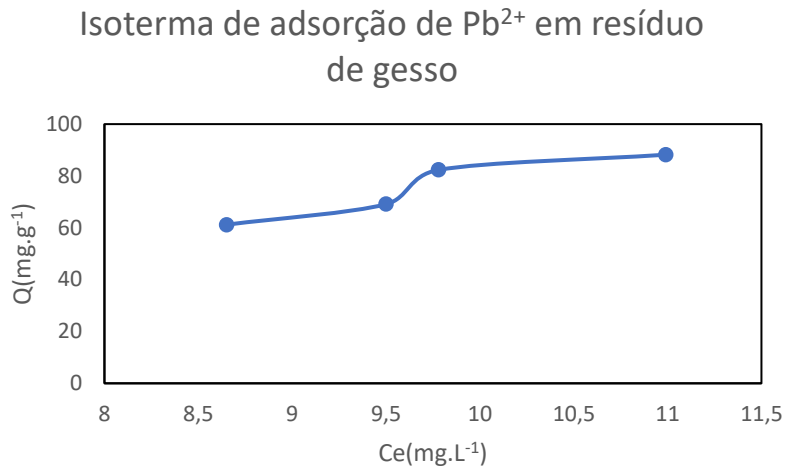
GRAPH 03 – EVALUATION OF THE REACTIONAL ORDER FROM THE PSEUDO-SECOND ORDER MODEL



Source: the authors (2023).

The adsorption isotherm study showed a maximum adsorption capacity of the Pb^{2+} ion of 88 mg/g. This result is shown in graph 04, where the results of Q x CE are also listed.

GRAPH 04 – EVALUATION OF ADSORPTION ISOTHERM (Q X CE)



Source: the authors (2023).

5 CONCLUSION

The preliminary results show that the construction gypsum residue has a good adsorptive capacity against the Pb^{2+} ion. The kinetic study showed a rapid adsorption process. The adsorption isotherm study showed a capacity of around 88 mg/g. The resistance tests of the specimens using waters contaminated with Cu2+ and Pb2+ ions in the manufacture of gypsum pieces showed that the incorporation of these ions, even in high concentrations, did not significantly compromise the resistance of this material.

As a suggestion for further work, it is proposed that other analyses be carried out that will indicate the veracity of the preliminary results that, a priori, are quite satisfactory, and also a new stage of study, which will identify whether other construction waste, such as cement and mortar, also have the ability to absorb metals in solutions.

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