

Chromium Adsorption by Modified Wood

I. Domingos, B. Esteves, A. Figueirinha, Luísa P. Cruz-Lopes, J. Ferreira, H. Pereira

Abstract—Chromium is one of the most common heavy metals which exist in very high concentrations in wastewater. The removal is very expensive due to the high cost of normal adsorbents. Lignocellulosic materials and mainly treated materials have proven to be a good solution for this problem.

Adsorption tests were performed at different pH, different times and with varying concentrations.

Results show that is at pH 3 that treated wood absorbs more chromium ranging from 70% (2h treatment) to almost 100% (12 h treatment) much more than untreated wood with less than 40%. Most of the adsorption is made in the first 2-3 hours for untreated and heat treated wood. Modified wood adsorbs more chromium throughout the time. For all the samples, adsorption fitted relatively well the Langmuir model with correlation coefficient ranging from 0.85 to 0.97.

The results show that heat treated wood is a good adsorbent and that this might be a good utilization for sawdust from treating companies.

Keywords—Adsorption, chromium, heat treatment, wood modification.

I. INTRODUCTION

HEAVY metals are very common pollutants in some industrial wastewaters. One of the most dangerous heavy metal is chromium which exists in very high concentrations in wastewater mainly from the leather, metal cleaning plating and electroplating industries. The removal of chromium from these waters is usually done by precipitation, coagulation, solvent extraction, electrolysis, membrane separation, ion exchange and adsorption [1], [2]. When adsorption is used, activated carbon and ion-exchange resins are preferred. The main problem of these methods is the high cost involved in chromium removal, and therefore several studies were made on low cost adsorption materials, most of them lignocellulosic materials like agro-industrial residues [3]-[7], wood sawing powders [8], [9] or barks [10]. These materials would allow the recovery of the adsorbed metal just by burning the lignocellulosic material. In order to increase the adsorption capacity of some materials, several activation procedures have been tested [11], [12]. Thermal activation was used with good results [2], [13] increasing the removal of several metals.

Thermally modified wood is considered an environmentally benign process to improve wood properties like dimensional stability and durability because it is a process where there is

no use of any harmful chemicals. Treated wood has a large application for outdoor use in cladding, decks, garden furniture and window frames and indoors for kitchen furniture, parquet, decorative panels and saunas. Treating companies generate a high quantity of thermally modified sawdust that is used to produce heat similarly to the untreated wood sawdust. If thermally treated wood is a better adsorbent than untreated wood, this might be important for treating companies which would have a new product based on a common residue. This hypothesis is the base of the present study.

II. MATERIAL AND METHODS

Cubic samples from *Pinus pinaster* wood were treated at atmospheric pressure inside an autoclave for 2 to 12 hours at 210°C. Heating was performed by admission of steam into the autoclave. The samples were milled, sieved and the 40-60 mesh fraction was used for the adsorption tests. To determine the best pH for adsorption 25 mg Cr/L of potassium dichromate solutions were prepared and titrated to pH 1, 2, 3 and 4. Milled samples were dried and 100 mg of each sample were placed in a glass tube with 10 mL solution and agitated in a rotary mixer at 30 rpm for 24 h. Afterwards the samples were filtered and the chromium concentration in the solution was determined by atomic absorption spectroscopy.

In order to plot Langmuir isotherms, adsorption tests were made with varying chromium concentrations from 25 mg/L to 1000 mg/L at pH 2 during 24 h. Langmuir isotherms were plotted for untreated and treated wood.

For the determination of the adsorption along the time, adsorption tests were made with 25 mg/L solutions at pH 2 with time varying from 5 to 1440 min (24 h).

III. RESULTS AND DISCUSSION

Fig. 1 shows the adsorption variation with pH for untreated and heat treated wood. Results show that is at pH 3 that treated wood absorbs more chromium ranging from 70% (2h treatment) to almost 100% (12 h treatment) much more than untreated wood with less than 40%. The maximum adsorption for untreated wood was obtained at pH 2 and was about 56%.

The minimum adsorption was obtained at pH 4 where all the samples presented an adsorption lower than 40%. This shows the high importance of pH on the adsorption process.

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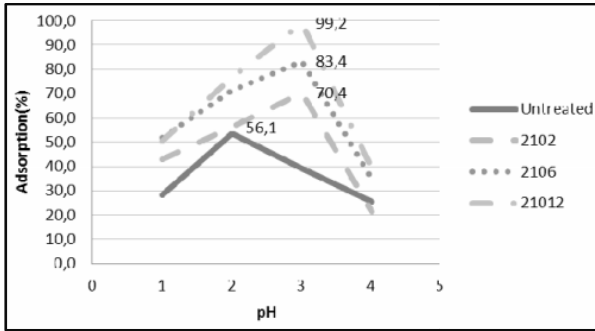


Fig. 1 Adsorption as a function of pH for untreated and for treated wood at 210°C and 2h(2102), 6h(2106) and 12h(21012)

Fig. 2 presents the removal percentage of chromium at pH 2. Most of the adsorption is made in the first 2-3 hours for untreated and heat treated wood (Fig. 2). All the curves are similar to a logarithmic curve with a high increase in the beginning tending to a maximum value. Has expected the final adsorption increases with the treatment.

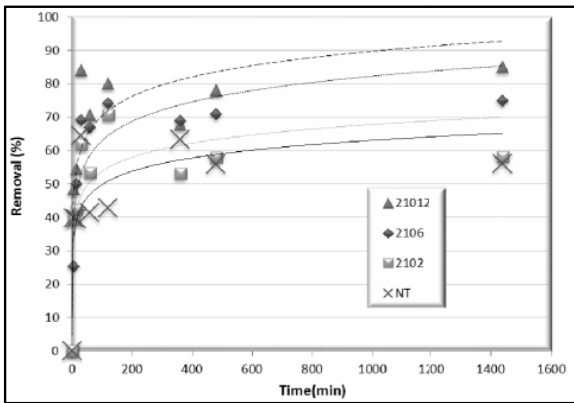


Fig. 2 Concentration as a function of time

Figs. 3 to 6 present the Langmuir curves plotted for untreated and heat treated wood. For all the samples, adsorption fitted relatively well the Langmuir model with correlation coefficient ranging from 0.85 to 0.97. The poorest results were obtained with untreated wood with an R^2 of 0.846 (Fig. 6).

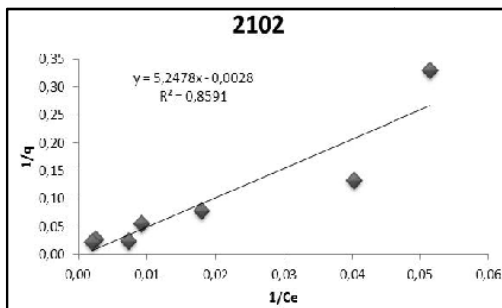


Fig. 3 Langmuir Isotherm for wood treated at 210°C and 2h

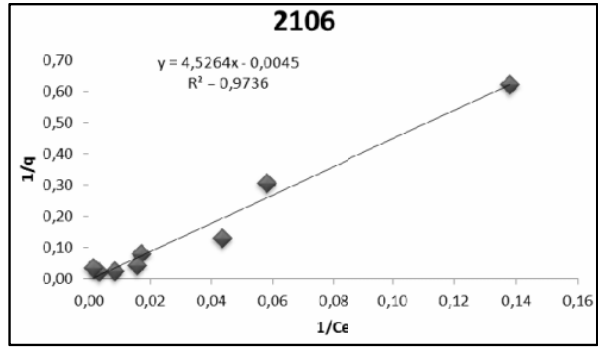


Fig. 4 Langmuir Isotherm for wood treated at 210°C and 6h

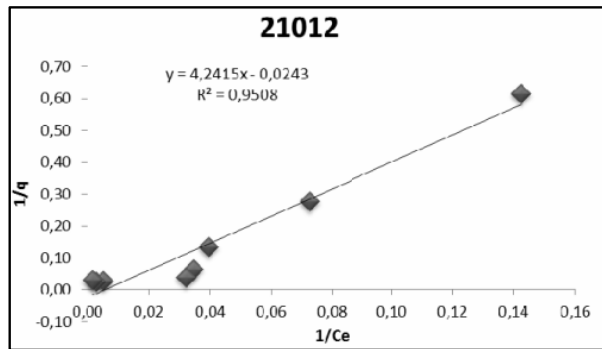


Fig. 5 Langmuir Isotherm for wood treated at 210°C and 12h

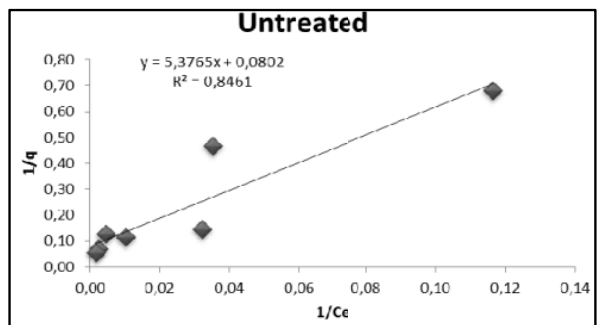


Fig. 6 Langmuir Isotherm for wood untreated

IV. CONCLUSION

Thermally treated wood is more efficient than untreated wood for chromium adsorption, although further tests are needed to determine the optimum treatment to attain the best adsorption results. This can be a good utilization for sawdust from treating companies or for heat treated wood in the end of its life.

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