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Isotherms Modelling for Cu(II) Ions Adsorption using Natural Additives: Effect of pH

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Abstract- The biosorption of copper (II) ions from aqueous solution by an unconventional adsorbent maple wood sawdust was studied as a function of different environmental parameters such as pH, contact time, adsor-bent concentration, initial Cu(II) ions concentration and others. Adsorption was carried out in a batch process and it was observed that an increase in the adsorbent concentration with constant copper ions concentration resulted in greater metal removal from solution. Higher metal loading per unit of weight of sorbent was observed with increasing initial copper ions concentrations for a constant sorbent dose. The Langmuir and the Freundlich adsorptions models were applied to describe isotherms and isotherm constants considering the most important parameter, pH. The variation of adsorption isotherm constants showed pH dependence. The isotherms studies revealed that the maximum copper (II) ions adsorption (q_m) 9.51 mg/g maple wood sawdust was obtained at pH value of 6.0. Therefore, the adsorption studies on maple wood sawdust have been shown to be highly effective in removing of copper (II) ions from aqueous solution. This adsorbent is widely available as a waste material, is mechanically stable, and most importantly it is environmentally appealing. In addition, this adsorbent does not mix with water and it can be separated very easily from water. The maximum copper (II) ions adsorption capacity of maple wood sawdust is very close to other adsorbents. Therefore, it has been suggested that wood sawdust may be used as an alternative adsorbent, replacing costly materials, such as activated carbon, resins, etc.

***Keywords*—** Copper, toxic, adsorption, aqueous media, environmental friendly

1. Introduction

The intensification of industrial activities during the last decades contributed greatly to the level of current environmental pollution. The pollution of water with toxic heavy metals is considered dangerous due to their great toxicity and their non-biodegradability (1, 2). Copper is one of the main toxic heavy metals, which is present in environment. Copper bearing mining wastes and acid mine drainage discharge significant quantities of dissolved copper into wastewater (3). Copper has many industrial applications. For example, it is known as an excellent conductor of electricity, widely used in the electrical industry in all gauges of wires for circuitry. Copper is also utilized in analytical reagents, in paints for ship keels, in pigments, in electroplating, in fertilizer industry, etc. Therefore, a significant amount of copper is continuously coming into environment and thereafter, copper ions might have accumulated through the food chain even at low concentrations, leading to serious problems on aquatic life as well as to animal, plant life and human health. Once copper is absorbed into the gastrointestinal tract, it enters the blood and muscle, liver and brain. Copper acts as an irritant to the skin causing itching and dermatitis and may cause keratinization of the hands and soles of the feet. It also causes serious problems to human such as stomach intestinal distress, kidney damage, anemia and even coma and eventual death (4, 5). Therefore, it is an important field of study for removing copper ions from aqueous medias (6, 7). However, the biosorption of copper (II) ions from aqueous solution by an unconventional adsorbent maple wood sawdust was studied as a function of different environmental parameters such as pH, contact time, adsor-bent concentration, initial Cu(II) ions concentration and others.

2. MATERIALS & METHODS

2.1 Instrumentation

In this study, scanning electron microscope (Hitachi S-4700, Japan) was used to characterize the surface of the maple wood sawdust at very high magnification. The maple wood sawdust was coated with gold and palladium by a sputter coater (Hitachi E-1030, Japan) with conductive materials to improve the quality

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of micro- graph. The thickness of the coating was 30.00 nm, and the density was 19.32 g/cm^3.

Functional groups in maple wood sawdust were determined by the Fourier transform infrared (FTIR) spectroscopy. Spectra were collected with a spectrometer using KBr pellets. In each case, 1.0 mg of dried maple wood sawdust sample and 100 mg of KBr are homogenized using mortar and pestle thereafter pressed into a transparent tablet at 200 kg/cm^2 for 5 min. The pellets are analyzed with a FTIR Spectrometer (VECTOR 22, Bruker Co.) in the transmittance (%) mode with a scan resolution of 4 cm^{-1} in the range 4600–500 cm^{-1}.

Flame atomic absorption spectrophotometer (Spectr*AA* 55B, Varian, Australia) was used for the analysis of copper (Cu^{2+}) in aqueous solution.

2.2. Adsorbent

Maple wood sawdust samples were collected from a local saw mill "Hefler Forest Products Ltd.", 230 Lucasville Road, Halifax, NS, Canada. The maple wood sawdust samples were sieved through 20–50 mesh and it was used directly for adsorption experiments without any physical and chemical treatments.

2.2.1. The Langmuir isotherm model

The Langmuir isotherm model is valid for monolayer adsorption onto surface containing finite number of identical sorption sites which is presented by the following equation:

$$q_e = \frac{q_m K_L C_e}{1 + K_L C_e}$$

where q_e is the amount of metal adsorbed per specific amount of adsorbent (mg/g), C_e is equilibrium concentration of the solution (mg/L), and q_m is the maximum amount of metal ions required to form a monolayer (mg/g). The Langmuir equation can be rearranged to linear form for the convenience of plotting and determining the Langmuir constants (K_L) as below. The values of q_m and K_L can be determined from the linear plot of C_{eq}/q_{eq} versus C_{eq}:

$$\frac{C_e}{q_e} = \frac{1}{K_L q_m} + \frac{1}{q_m} C_e$$

3. RESULTS & DISCUSSION

The Langmuir adsorption isotherm was determined at different pH values ranging from 4.0 to 8.0 for copper (II) ions concentration range of 5–100 mg/L. All solutions contain a fixed specific mass of maple wood sawdust (10 g/L). The isotherm constants were calculated from the isotherm equations for the different pH values. The values of Langmuir adsorption isotherm parameters are shown in Fig. 1.

The variation of the Langmuir isotherm parameters indicate the fact that the affinity of metal ions onto maple wood sawdust is pH dependent and the sorption data can be used for the modeling of both the Langmuir and the Freundlich isotherms. However, a better fit is observed for the Langmuir isotherms.

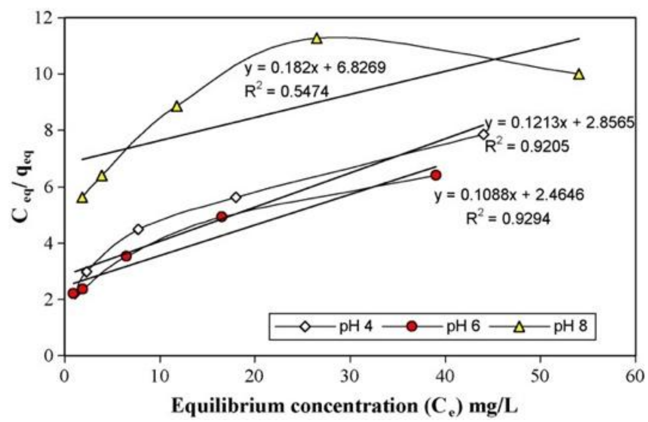

Fig. 1. The Freundlich isotherm plots for the adsorption of copper ions on to maple wood sawdust sample for different pH values.

4. CONCLUSION

Adsorption studies on maple wood sawdust have been shown to be highly effective in removing of copper (II) ions from aqueous solution. This adsorbent is widely available as a waste material, is mechanically stable, and most importantly it is environmentally appealing. In addition, this adsorbent does not mix with water and it can be separated very easily from water. The maximum copper (II) ions adsorption capacity of maple wood sawdust is very close to other adsorbents. Therefore, it may be used as an alternative adsorbent, replacing costly materials, such as activated carbon, resins, etc.

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