

Removal of M-Xylene from Water by Impregnated Activated Carbon.

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Abstract: Volatile organic compounds (VOCs) are the main matters which can pollute water therefore, must be controlled under increasingly stringent environmental regulations. This work analyses the adsorption of impregnated active carbons prepared with oak bark to remove m-xylene from aqueous solutions. When the impregnation step is performed on the raw material then carbonizations of activated carbon was carried out. Not expensive raw material and chemical agent were used as active species where used for preparing the appropriate adsorbent for removal of m-xylene from water. In this work the effect of adsorption temperature, pH and the initial concentration of process were investigated. It is clear that with increasing the initial concentration the removal efficiency of adsorption will be increased. The effect of temperature was studied by increasing the temperature from 20 to 60 oC. with increasing the temperature the removal efficiency will be increased in the range of 20-60 oC.

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1. Introduction

Volatile organic compounds (VOCs) are the main matters which can pollute water therefore, must be controlled under increasingly stringent environmental regulations. Among them, xylene has been widely applied in the industries including the manufacture of herbicides, plastics, and solvents [1]. Uses outside the chemical industry include solvent degreasing in the automotive and aerospace industries, dry cleaning solvents in the garment industries, and solvent cleaning in the electronic industries.

There are commercial methods for removal of m-xylene from water. Among these, adsorption technology has the high efficiency. Activated carbon adsorption is widely used in the VOCs adsorption because of easy operation, low operating cost, and efficient recovery. However, it has been recognized that activated carbon frequently encounters problems such as combustion, pore blocking, and hygroscopicity.

The control of wastewater effluent is therefore an important environmental task. Adsorption seems to be the most promising of the different technologies available, particularly when the concentration of VOC is too low to make the recovery of VOCs. The use of adsorption significantly decreases the working temperature in comparison with traditional incinerators and catalytic oxidation, thereby saving energy [2-3].

In previous works, non activated carbons were used such as zeolites, alumina and molecular

sieves. These adsorbents usually have been prepared by expensive raw materials but activated carbon can be synthesized with low cost material such as agricultural solid wastes. It is clear that activated carbons are prepared by two different methods. Physical methods which can prepare suitable adsorbent by applying carbon dioxide and water vapor as chemical agent but in chemical method, chemical material such as phosphoric acid are used as chemical agent[4-13].

In this paper, the main scope is to prepare appropriate activated carbon for removal of M-Xylene. Based on Wikipedia definition, "M-Xylene (or meta-xylene) is an aromatic hydrocarbon, based on benzene with two methyl substituents. It is an isomer of o-xylene and p-xylene. The m stands for meta, meaning the two methyl substituents are at locants 1 and 3 on the aromatic ring. M-Xylene is commonly produced in BTX processes, and separated as needed from the other aromatic hydrocarbons.

The major chemical use of meta-xylene is in the manufacture of isophthalic acid, which is used as a copolymerizing monomer to alter the properties of polyethylene terephthalate (PET), making PET more suitable for the manufacture of soft drinks bottles. To convert m-xylene on an industrial scale to isophthalic acid, the two methyl groups are both catalytically oxidized to carboxyl groups. It is also used as a raw material in the manufacture of 2,4- and 2,6-xylidine as well as a range of smaller-volume chemicals." In this work, characterizations of adsorbent and effect of

adsorption temperature and initial concentrations of xylene were investigated.

2. Material and Methods:

Oak bark, collected from a local source, was dried and ground. The powdered samples (below mesh No. 150) were impregnated with H₃PO₄ concentrated solution (70%), in a (shell: H₃PO₄) weight ratio of 1:3 (OCH).

The resulting product was then dried in an oven at 140°C for at least 8 h. Impregnated sample was placed on a ceramic boat, inserted in a tubular furnace. The sample was heated to the carbonization temperature under N₂ flow at the rate of 20°C/min. The activated carbon product was then dried in an oven at 100°C.

The adsorbent particle size distribution was obtained and the mean diameter was about 0.105 mm. All the chemical and reagents used were of analytical reagent grade obtained from Merck Company.

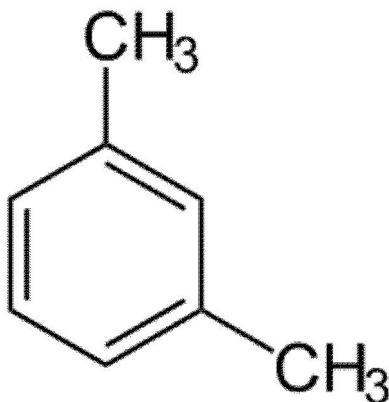


Fig.1 The M-Xylene structure

3. Batch Study:

The adsorption of m-xylene from aqueous solutions by bark of oak activated carbon was studied as follow. Each adsorbate containing solution was prepared by dissolving necessary amount of xylene in the distilled water. Each solution was then diluted to obtain standard solutions containing 50–250 ppm of m-xylene prior to adsorption experiments.

Batch adsorption studies were carried out with 0.08 g sorbent and 50 ml of M-xylene solution with a desired concentration at pH 5.5 in three conical flasks, simultaneously. The flasks containing adsorbent and adsorbate were agitated for predetermined time intervals at 22°C on a mechanical shaker with 750 rpm.

At the end of agitation, the suspensions were filtered by the aid of filter paper. The amount of m-xylene in the final 25 ml volume was determined by atomic absorption spectrophotometer equipped with a Zeeman atomizer. The obtained results for two

similar solutions were averaged and then were reported [4-6].

4. Iodine number:

The surface activity of activated carbons towards iodine was determined by using the DIN 53582 standard method. The iodine No. of the sample is obtained as 950 mg/g.

5. BET Analysis:

Surface area of samples (catalyst and support) was determined by using Brunauer –Emmett –Teller (BET) Theory [5]. The pore volume was found from the amount of N₂ adsorbed at a relative pressure of 0.99. The average pore diameter was calculated from the BET surface area. The surface area for adsorbent is shown in Table 1.

Table 1. BET Results for Activated Carbon derived from oak

Sample	Surface Area (m ² /g)	Average Pore Size (nm)	Average Pore Volume (cm ³ /g)
Activated Carbon	1020	1.5	0.552

5. Results and discussion:

5-1- Effect of Temperature:

Fig. 1 shows the efficiency removal factor (equation 1) versus time at different sorption temperatures of 20, 40 50 and 60°C.

The important constant parameters of solutions were: ion concentration of 50 mg/l, adsorbent dose of 0.1 g and pH = 5.5. The experimental data show that solution concentration of m-xylene reduces with increase in the temperature indicating an endothermic nature of the sorption processes, while the time required reaching equilibrium remains practically unaffected.

Increase in the adsorption capacity with temperature suggests that active centers on the surface available for adsorption increase with temperature. This could also be attributed to the change in pore size and enhanced rate of intraparticle diffusion of the solute as diffusion is an endothermic process. In these results, it can be found that the diffusion step is determining reaction.

$$R = \frac{(C_0 - C)}{C} \times 100 \quad (1)$$

Where R is the removal efficiency of adsorbent, C₀ and C are the initial and equilibrium concentrations of metal ion (ppm) in the aqueous solution.

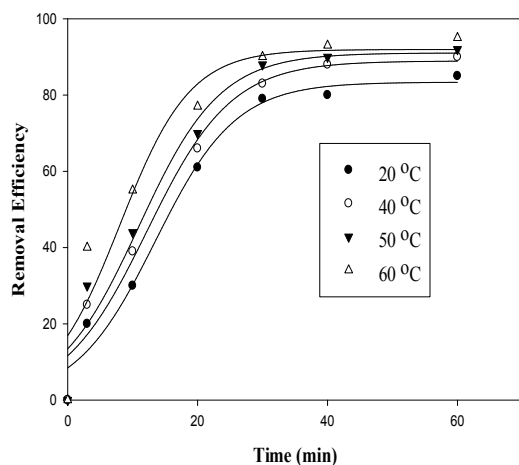


Fig 2. Temperature effect on m-xylene adsorption.

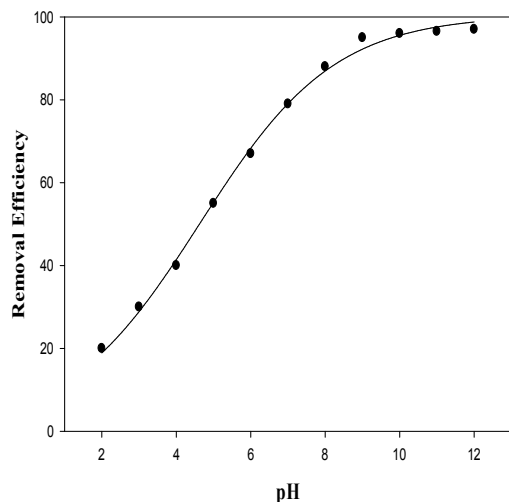


Fig 3. pH effect on adsorption of m-xylene.

5-2- Effect of Acidity:

The effect of pH on the ad removal of m-xylene by OCH over a pH range 2.0–11 is shown in Fig. 2. From the figure it is clear that OCH is effective for the adsorption of VOC over the pH range 4.5. With increasing the pH of solution the removal efficiency of m-xylene has been increased in the experiment.

As the pH increases from 2.0 to 6.0, there is a sharp increase in the amount of adsorption and at pH 6.0, carbon shows maximum adsorption of m-xylene.

5-3- Effect of initial concentration:

The initial concentration of the m-xylene solution plays an important role on the adsorption capacity. The variation initial concentration has been

investigated versus removal efficiency of m-xylene by oak activated carbon. All of results are shown in Fig. 3. By results, it is clear by increasing the initial concentration the removal efficiency has been increased.

But it is shown that with increasing the contact time the stationary state has been reached. These results have been proved in many studies, previously [10-13]. Also, Based on the studies conducted on the effect of contact time for the removal m-xylene with different initial concentrations and adsorbent doses, it was concluded that a contact time of 120 min was sufficient to reach equilibrium. Initial concentration has been changed from 50 to 250 ppm. pH=5.5, Temperature=20°C Dose of adsorbent= 0.1g were constant.

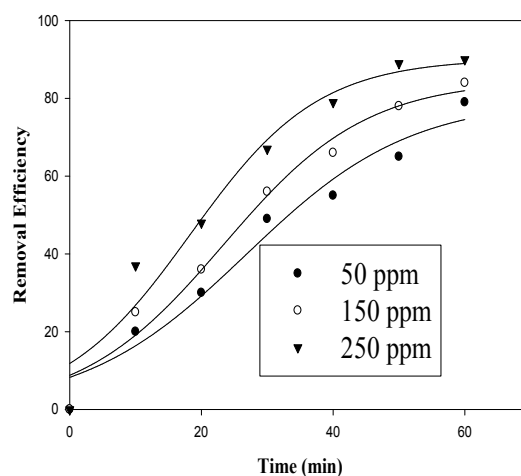


Fig 4. Effect of initial concentration on m-xylene from water.

6. Conclusion:

It has been indicated that designed activated carbon from oak bark can be effectively used for the removal of m-xylene from aqueous solutions. The investigated adsorbent was cost effective as well as eco-friendly. The adsorption process was highly pH and initial concentration dependent and was more effective within the pH over 4.5. The increase in percentage adsorption with increase in temperature demonstrated the endothermic nature of adsorption. With increasing the initial concentration, removal efficiency has been increased. It is clear bark of oak is known as trifling matter, but in this research we have shown that this solid waste can be used as the best adsorbent to remove m-xylene from water as dangerous contaminant.

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