

## Carbon Obtained from the Pyrolysis of Scrap Tires as a Cheap Adsorbent for Lead Ion Removal from Water

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**Abstract.** The disposal of scrap tires represents a serious concern in environmental management. Scrap tires are rich in carbon content and it is feasible to convert them to carbon by pyrolysis. This study was focused on the use of base treated pyrolytic carbon, obtained from scrap tires, as an adsorbent for lead ion removal from water. The characteristics of carbon were investigated by scanning electron microscopy and energy disperse analysis of x-rays. The adsorption capacity was 87.72 mg/g. The equilibrium data were better fitted to the Langmuir model and the kinetic data were shown well correlation with the pseudo-second-order reaction.

**Keywords:** Scrap tire, pyrolytic carbon, lead adsorption.

### 1. Introduction

Industrialization, annually generated vast amount of scrap tires that need disposal management. There are four ways for disposal as landfill, stockpile, burn and illegal dump of the scrap tires. All of the mentioned ways pollute the environment. Nowadays disposal is considered in form of material recovery. Scrap tires are rich in carbon content and can be applied as precursors in the production of carbon, by pyrolysis [1]. This carbon can be use as an adsorbent [2]-[10].

On the other hand industrial processes generate large quantity of lead waste products, which are discharge into the water. Lead is poisonous to animals, damages the nervous system and causes brain disorders. Adsorption on activated carbon is one of the most effective ways to remove lead ion from water. The high cost of activated carbon has prompted a search for cheaper and recycles substitutes [11].

This study aims to use carbon obtained by pyrolysis of scrap tires for lead ion removal from water. The effects of adsorption conditions on the adsorption efficiency were investigated. Adsorption isotherm models and kinetic of the adsorption were also evaluated.

### 2. Experimental

#### 2.1. Materials

All chemicals were purchased from Merck.

#### 2.2. Instruments

Atomic absorption spectrometer Varian AA-240 was used for adsorption studies. Scanning electron microscopy images were obtained by VEGA-TESCAN.

#### 2.3. Preparation of carbon

The carbon was obtained by pyrolysis of scrap tires at a temperature 550<sup>0</sup>C. The powder was washed with 50% v/v solution of acetone and water and again with water to remove the impurities. The washed

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sample was ground and dried at 120<sup>0</sup>C for 24 h. Briefly 100 ml of NaOH 0.1 M was added to 5 g of prepared carbon and was stirred for 3 h to obtain base treated carbon.

## 2.4. Adsorption studies

A stock 1000 ppm solution was prepared by using Pb(NO<sub>3</sub>)<sub>2</sub> salt. This solution was diluted with distilled water to obtain desirable concentrations. The batch adsorption experiments were carried out in a 250 mL erlenmeyer flask by shaking a pre-weight amount of carbon powder with 50 mL of the aqueous Pb (II) solution for a predetermined. The lead content in the samples were measured by atomic absorption spectroscopy for 3 samples of each case.

## 3. Results and Discussion

### 3.1. Characterization of carbon

The scanning electron microscope (SEM) images of the samples (Fig. 1) taken before (1a) and after (1b) the treatment processes were revealed significant differences in the sample's morphology. It was clearly shown that the treatment was improved the porous structure of the treated product. These pores were occupied by metal ions after adsorption (1c).

Energy disperse analysis of x-rays (EDAX) for pyrolytic and base treated pyrolytic carbon (Table 1) was well established that by base treatment of carbon, various minerals were dissolved. It was evident that sodium hydroxide treatment is capable of reducing the inorganic components of carbon, regard to the major inorganic species, zinc. This capability was formed a porous structure for carbon after treatment.

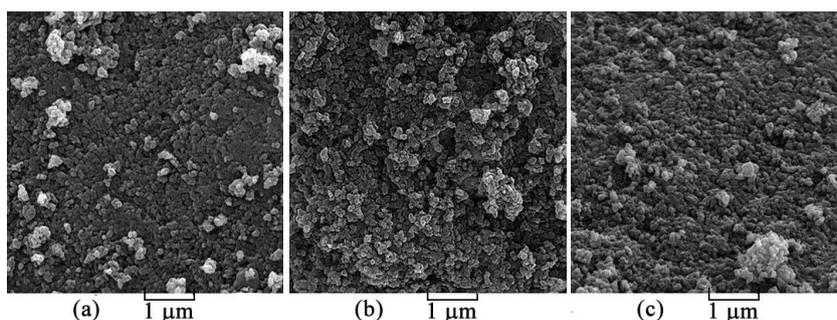


Fig. 1: SEM images (a) pyrolytic carbon; (b) base treated pyrolytic carbon; (c) base treated pyrolytic carbon after lead adsorption

Table 1: Results of EDAX analysis

Component	Pyrolytic carbon (%)	Base treated pyrolytic carbon (%)
C	89.15	88.24
O	6.13	8.42
Mg	0.24	-
Si	0.22	-
S	2.01	1.58
Ca	0.20	0.18
Zn	2.05	1.56

### 3.2. Adsorption studies

The capability for removal of Pb (II) ions were compared by using carbon and base treated carbon. Results were shown about 18% improvement in the lead ion adsorption efficiency. It was confirmed the development of porous structure after basic treatment. Other adsorption studies have done by using treated carbon.

The effect of adsorption conditions are shown in Fig. 2. The equilibrium concentration of Pb (II) ions in solution phase was decreased by increasing the adsorbent amount (2a). Increasing the amount of the adsorbent was provided greater surface area and adsorption sites. The maximum of adsorption was seen by using 0.05 g of the adsorbent.

In order to establish equilibrium time for maximum uptake and to know the kinetic of the process, the adsorption was studied as a function of contact time (2b). It was seen that the rate of uptake was rapid at the beginning. The initial faster rate might be due to availability of the uncovered surface area of the adsorbent. As these sites were progressively filled, the adsorption became more difficult. The maximum of adsorption was seen after 90 min.

The effect of initial concentration of Pb (II) ions on removal of metal ions was also investigated (2c). It was seen that the adsorption of Pb (II) ions decreases by increasing the initial concentration. It could be explained by the fact that the adsorbent had a limited number of active sites that was saturated above a certain concentration.

The adsorption was increased with increasing pH of the solution (2d). The maximum adsorption was obtained at pH 6. Above pH 6, Pb (II) ions were started precipitating.

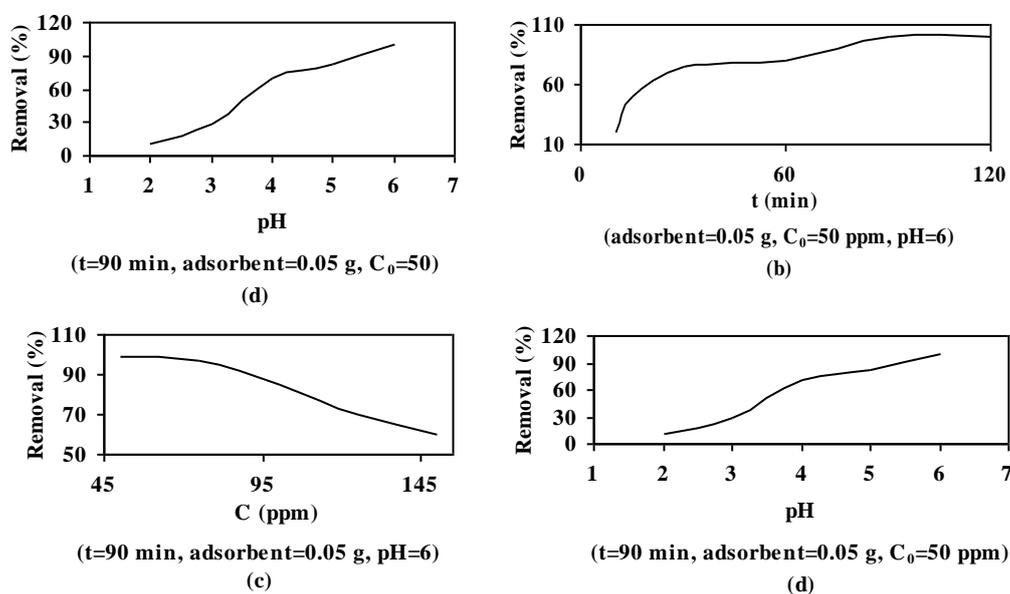


Fig. 2: Investigation on the variation of adsorption conditions (a) adsorbent amount; (b) adsorption time; (c) initial concentration; (d) pH

### 3.3. Investigation on adsorption isotherm models and the kinetic of adsorption

The analysis of the equilibrium adsorption isotherms data is important to study the adsorption capacity and equilibrium coefficients for adsorption. Two Langmuir (equation 1) and Freundlich (equation 2) isotherm models were considered for adsorption of Pb (II) ion into the treated carbon.

$$1/q_e = 1/q_m + 1/bq_m C_e \quad (1)$$

$$\log q_e = 1/n (\log C_e) + \log K_f \quad (2)$$

where  $C_e$  is the equilibrium concentration of the adsorbed (mg/L),  $q_e$  the amount of adsorbed per unit mass of adsorbent (mg/g),  $q_m$  (mg/g) and  $b$  (L/mg) are Langmuir constants related to the adsorption capacity and rate of adsorption,  $K_f$  and  $n$  are Freundlich constants that gives the adsorption capacity of adsorbent and indicates the adsorption favorability. Table 1 is shown that results were better fitted with Langmuir model.

The kinetic of Pb (II) ions adsorption onto the treated carbon was analyzed using pseudo-first-order (equation 3) and pseudo-second-order (equation 4) kinetic models.

$$\log (q_e - q_t) = \log q_e - K_1 t / 2.303 \quad (3)$$

$$t/q_t = 1/K_2 q_e^2 + t/q_e \quad (4)$$

where  $q_e$  and  $q_t$  are the adsorption capacity at equilibrium and time  $t$ , respectively (mg/g),  $K_1$  and  $K_2$  are the rate constant of pseudo-first-order (1/min) and pseudo-second-order (g/mg.min) adsorption reaction respectively. Table 1 is shown the results were better fitted with pseudo-second-order reaction kinetic.

Table 1: Investigation on adsorption isotherms and kinetic models

Langmuir isotherm			Freundlich isotherm			Pseudo-first-order			Pseudo-second-order		
$q_m$	$b$	$R^2$	$K_f$	$1/n$	$R^2$	$K_1$	$q_e$	$R^2$	$K_2$	$q_e$	$R^2$
87.72	2.533	0.9950	58.88	0.1162	0.8845	0.0179	23.01	0.8447	0.0009	57.80	0.9557

## 4. Conclusion

It has been demonstrated on the basis of this study that the base treated carbon prepared from pyrolysis of scrap tires is a suitable adsorbent for lead ions in water. The maximum adsorption was taken place at pH 6, that is close to the natural pH of water. The equilibrium time for the adsorption was found to be 90 min and the rate of adsorption is faster in the initial periods of the time. Removal of Pb (II) ions was increased by increasing the amount of adsorbent and the adsorption was more efficient in lower initial concentration of Pb (II) ion. The adsorption isotherm was better fitted with Langmuir model and the reaction kinetic was confirmed with pseudo-second-order reaction.

## 5. References

- [1] P. Williams. Pyrolysis of waste tyres: a review. *Waste Manage.* 2013, 33:1714-28.
- [2] C. Troca-Torrado, M. Alexandre-Franco and C. Fernandez-Gonzalez. Development of adsorbents from used tire rubber: their use in the adsorption of organic and inorganic solutes in aqueous solution. *Fuel Process. Technol.* 2011, 92: 206-12.
- [3] Y. Lin and H. Teng. Mesoporous carbons from waste tire char and their application in wastewater discoloration. *Micropor. Mesopor. Mat.* 2002, 54: 167-74.
- [4] N. Hamadi, S. Swaminathan and X. Chen. Adsorption of papaquat dichloride from aqueous solution by activated carbon derived from used tires. *J. Hazard. Mater.* 2004, 112: 133-41.
- [5] W. Tanthapanichakoon, P. Ariyajwanich, P. Japthong, K. Nakagawa, S. Mukai and H. Tamon. Adsorption-desorption characteristics of phenol and reactive dyes from aqueous solution on mesoporous activated carbon prepared from waste tires. *Water Res.* 2005, 39: 1347-53.
- [6] L. Li, S. Liu and T. Zhu. Application of activated carbon derived from scrap tires for adsorption of rhodamine B. *J. Environ. Manage.* 2010, 22: 1273-80.
- [7] E. L. K. Mui, W. H. Cheung, M. Valix and G. McKay. Dye adsorption onto activated carbons from tyre rubber waste using surface coverage analysis. *J. Colloid Interf. Sci.* 2010, 347: 290-300.
- [8] E. L. K. Mui, W.H. Cheung, M. Valix and G. McKay. Mesoporous activated carbon from waste tyre rubber for dye removal from effluents. *Micropor. Mesopor. Mat.* 2010, 130: 287-94.
- [9] M. Hofman and R. Pietrzak. Adsorbents obtained from waste tires for NO<sub>2</sub> removal under dry conditions at room temperature. *Chem. Eng. J.* 2011, 170: 202-8.
- [10] G. Skodras, I. Diamantopoulou and A. Zabaniotou. Enhanced mercury adsorption in activated carbons from biomass materials and waste tires. *Fuel Process. Technol.* 2007, 88: 749-58.
- [11] P. C. Mishra and R. K. Patel. Removal of lead and zinc ions from water by low cost adsorbents. *J. Hazard. Mater.* 2009, 168: 319-25.