

Preparation of Activated Carbon From Waste Cooked Tea for Using as Chemical Dyes – Filter

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Abstract: Eco-friendly adsorption material was prepared from waste cooked tea and characterized by spectroscopic techniques. The target of this work was using this activated carbon as multi-use filtration disc that may be applied in life and science. The action of newly multi-adsorption filter disc was evaluated through the UV-Vis measurements of methylene blue adsorption. This multi-adsorption filter disc contained activated carbon prepared from waste cooked tea with / or without silica gel presence. The removal percentage (R%) and adsorption capacities (Q) values were more than 99% and 496 mg/g respectively for all repeated times. Presence of silica gel in filter disc accompanied by our prepared activated carbon was unchangeable in dye removing quantities so silica gel can be dispensed and the filter disc was satisfied with our prepared activated carbon. Also, this multi-adsorption filter can be introduced as a promising investment in adsorption technology or equipments. The obtained data showed the privilege of this filter in both cases especially in the absence of silica gel. Also, the removal percentage and adsorption capacity demonstrated the superiority of the prepared filter.

Keywords: Activated carbon, Methylene blue, Adsorption, Filter disc, Pollution

Introduction

Porosity, penetration, surface area, adsorption capacity, and regeneration processing are important properties of eco-friendly adsorption materials such as activated carbon prepared from different waste sources. These low cost-environmental materials can be produced through various methods. One of these is chemical activation that its base is human, agricultural, or food wastes accompanied by thermal decomposition and chemical reagent [Zhong et al., 2012; AlSlaibi et al., 2013a; Al-Slaibi et al., 2013b; Klijanienko et al., 2008; Urabe et al., 2008; Hameed and El-Khaiary, 2008; Singh et al., 2008; Ugurlu et al., 2008; Petrov et al., 2008; Cabal et al., 2008; Román et al., 2008; Tan et al., 2008; Rauof et al., 2015; Hameed et al., 2008].

Our team work previously prepared and characterized activated carbon from consumed black tea by following different steps beside adsorption steps of different chemicals [Rauof et al., 2015, Hammud et al., 2016a; Hammud et al., 2016b].

It is important in research work that any field has a continuous step forward and with this progress may be achieved. With this point of view, our research team took the obtained activated carbons and used them in another application (s) such as polluted pigment removal.

Chemicals: all chemical were from obtained from famous companies and used as they received.

Instrumental Characterization: all available needed instruments for characterization were same as in our published articles [Hammud et al., 2016a; Hammud et al., 2016b].

Preparation steps: all steps for preparation of activated carbon from waste cooked tea (Figure 1) were the same as previously published [Hammud et al., 2016a; Hammud et al., 2016b].

Adsorption study steps:

Filter disc: an accurate weight of our material was compressed using (15 tons) commercial mechanical press with template as used with FTIR instrument. The disc was with the same diameter as in micropore membrane syringe filter for HPLC filter. Also, the micropore membrane was replaced with our pressed disc (Figure 2).

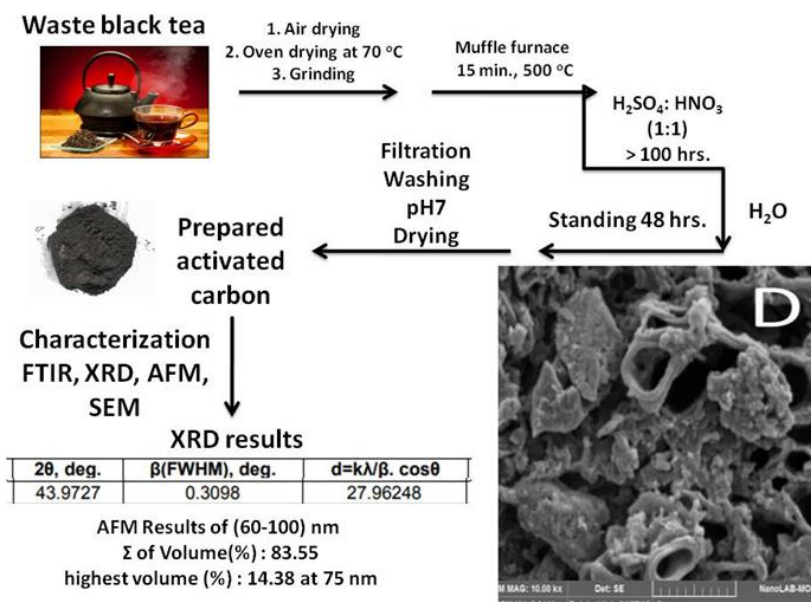


Figure 1. Activated carbon preparation steps



Figure 2. Activated carbon Filter Disc prepared in this study

Measuring of adsorption [Rauof et al., 2015; Gundogdu, et al., 2013]:

At lab temperature, Accurate volume (500 mL) of (500) ppm of aqueous dye solution was preattached through the septum and plunger was pressed. Calculation of adsorption efficiency were done through removal percentage (R%) and adsorption capacity (Q)) from the UV-Vis absorbance measurement of the filtrated solution.

Important note: the determination of our material capacity in adsorption of methylene blue was repeated for several times and in each one the eluent was separately collected from its previously one then its UV-VIS absorbance measurement.

Results and Discussion

Pollution is a critical issue in science and life because of its influences on health on earth planet. Many research studies involved in removal of carcinogenic or expected carcinogenic chemicals like metallic ions or organic compounds beside radioactive substances. There are many techniques were applied to remove these chemicals from environment such as filtration, adsorption, ...etc. Adsorption technique is widely used in this research area because of its flexibility, low cost, excellent removal data, regeneration ability, availability of raw materials, beside other reasons.

To test any adsorbent against any water soluble pigments or dyes, UV-VIS instrumentation is used under specific requirements to qualify its removal percentage and capacity and quantify them through the applying their known equations as below:

$$\text{Removal \%} = [(C_o - C_t) / C_o] \times 100 \dots\dots\dots (a)$$

Where C_o : initial concentration (ppm) and C_t : concentration after adsorption (after a specific time) (ppm).

$$Q \text{ (Adsorption capacity)} = [(C_o - C_t) / m] \times v \dots\dots\dots (b)$$

Where C_o : initial concentration (ppm) of adsorbate, C_t : concentration of adsorbate after adsorption (after a specific time) (ppm or mg/L), m : weight of adsorbent (g); v : volume of solution (L), Q : Adsorption capacity of adsorbent after a specific time (mg/g).

Figure 3. shows the standard curve data at specific λ_{max} with its correlation coefficient (R^2). Also, Table 1. shows the detailed experimental data in this study.

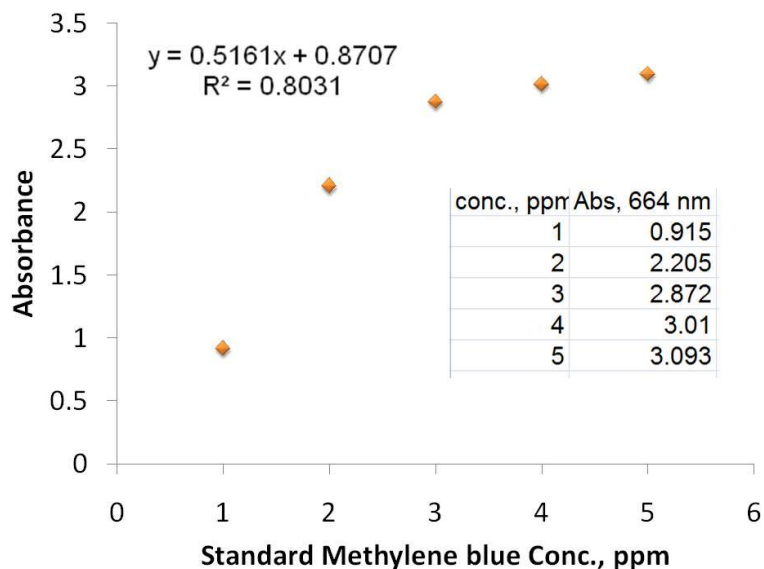


Figure 3. Standard methylene blue curve with (1-5) ppm range

Table 1. Experimental data of adsorption with Filter Disc technique

Experimental condition	Try number	Absorbance at 664 nm	Calculated concentration, ppm	Removal percentage, %	Adsorption capacity(Q), mg/g (0.5g, 0.5 L)
0.5 g prepared activated carbon (Filter Disc)	1	2.872	3.877737	99.22445	496.1223
	2	2.799	3.736291	99.25274	496.2637
	3	2.783	3.70529	99.25894	496.2947
	4	2.696	3.536718	99.29266	496.4633
	5	2.737	3.61616	99.27677	496.3838
Total			18.4722		2481.5278
0.25 g prepared activated carbon and 0.25 gm silica gel (Filter Disc)	1	2.872	3.877737	99.22453	496.1223
	2	2.834	3.804108	99.23918	496.1959
	3	2.783	3.70529	99.25894	496.2947
	4	2.696	3.536718	99.29256	496.4633
Total			14.92385		1985.076

The adsorption of any material especially dye is affected by the presented micropores and the functional chemical groups in the activated carbon surface. The particle size of our prepared material was in nano-andmicroscale and this was an excellent indication of its quality particularly in adsorption process.

MB adsorption can be affected by surface functional groups and micropore presence. The applied materials adsorbed 500 ppm MB with excellent efficiency (both R% and Q values) where commercial activated carbon was more influence in MB adsorption than our prepared material as shown in Table 1.

Table 2. demonstrated the previous published results of adsorption of methylene blue with different tea-activated carbon materials. The adsorption capacity (mg/g) were ranged (24 to 43) and these variations were resulted from activation – carbonization steps, weight and the properties of the produced activated carbon, beside concentration and volume of the adsorbate (methylene blue).

Comparison in results between the published capacity (Table 2) and our present study (Table 1) evaluated the importance of the previous mentioned factors and declared the privilege of the present preparation steps and the obtained measurements.

For example, our (Q, mg/g) data (Table 1) were approximately 496 mg/g while our published data [Rauof et al., 2015] (Table 2) was 24 mg/g. This output might be resulted from the variation in particle size (XRD measurements) and consequence the pore size and the quantity of the captured dye molecules.

This comparison might be more accurate if the 496 mg/g corrected to the same calculated conditions (volume and weight in equation –b-) which will be (49 mg/g with 500 mL not 50 mL) and even with this calculated correction, the present study excelled on the former study (24 mg/g) [Rauof et al., 2015].

Table 2. Tea-activated carbon adsorption capacity of methylene blue in published papers

Material description	Adsorption capacity (Q), mg/g	Ref.
Waste activated carbon, sodium carbonate activation, microwave carbonization	24.00977	Rauof et al., 2015
Tea industry waste carbon (only carbonized material)	27.8	Gundogdu et al., 2013
Activated carbon with ½:1 activating agent/ tea industry waste	31.9	
Tea-industry waste	39.1	Duran et al., 2011
Spent tea waste	39.30	
Thermally activated carbon from spent waste tea	43.0	Fadhil et al., 2012

From Table 1, several important points can be concluded as below:

- Presence of silica gel in filter disc accompanied by our prepared activated carbon gave the same effect of adsorption after four repeated adsorption steps. This indicated that silica gel can be dispensed and satisfied with our prepared activated carbon.
- Multi-adsorption by repeating using the same filter disc presented excellent numerical adsorption capacity and removal percentage. Also, this multi- adsorption filter can be introduced as a promising investment in adsorption technology or equipments.
- By simple mathematical calculations and using the Table 1. data, we can found the superiority of our multi-adsorption filter disc through the following:

Adsorption quantity by filter disc (ppm) = (no. repeating * initial conc. (ppm)) - \sum calculated conc. (ppm)

For 0.5 g prepared activated carbon (Filter Disc)

$$\text{Adsorption quantity} = 5 * 500 - 18.4722 = 2481.5278 \text{ ppm}$$

$$\text{Adsorption quantity} = 4 * 500 - 14.856 = 1985.144 \text{ ppm}$$

For 0.25 g prepared activated carbon and 0.25 gm silica gel (Filter Disc):

$$\text{Adsorption quantity} = 4 * 500 - 14.924 = 1985.076 \text{ ppm}$$

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