

# Methylene Blue Colour Removal Using Physically And Chemically Activated Cashew Nut Shell Activated Carbon

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**Abstract:** Activated Carbon is one of the foremost adsorbents. It is much sought after in almost all fields of pollution control and mitigation, owing to its highly efficient nature in adsorbing a wide range of solid, liquid and gaseous pollutants. Most commercially activated carbon is prepared from coconut shells. Since coconut shells have a variety of other uses, the perceived economic value of this raw material has seen a steady increase in the past few years. This naturally adds up to the cost of the carbon prepared from the shells, even though coconut shell activated carbon is still considered among the superior carbons. Therefore a lot of research has gone into making activated carbon out of food and agricultural wastes that as yet don't have much perceived economic value. This paper takes a brief look at the physical and chemical activation methods used for preparing activated carbon from Cashew Nut Shells, and its efficiency in the removal of Methylene Blue (MB) dye from aqueous solutions.

**Keywords:** activated carbon, adsorption, cashew nut shells, methylene blue, MB

## Introduction

Activated carbon (AC) is the undisputed choice in tertiary treatment of polluted liquid effluents or gases. The main reason for this is the ability of activated carbon to adsorb a huge variety of pollutants from the media. AC is a highly porous carbonaceous substance that contributes very high surface area up to 3000 m<sup>2</sup>/g of the adsorbent. The activation treatment results in the creation of pores and tuning of functional groups which facilitate adsorption of pollutants from their streams. Its common use as an adsorbent is because of fast adsorption rates, and ease of regeneration [2]. The technology of producing and utilizing activated carbon is not a novel idea, as the use of charcoal for cleaning water predates the industrial age. Activated carbon commercially is produced from a variety of organic and inorganic materials depending on the purpose, type of pollutant to be adsorbed, volume, raw material availability and economy. Most carbon is area-specific depending on ease of raw material procurement, but the treatment mainly proceeds on the basis of final cost. Adsorption process is a fundamental process in the physicochemical treatment of municipal wastewater, a treatment which can be economically meet today's higher effluent standard and water reuse requirements. Activated carbon is the most effective adsorbent for this application [1] AC is prepared by two methods. One method is physical activation and the other is chemical activation. Physical activation is a two-step process. Carbonization, in the absence of oxygen, is done in the first step whereas activation at higher temperature in the presence of an activating gas like carbon dioxide, etc is done in the second step. The tar formed during carbonization may block the pores resulting in low surface area. Chemical activation, on the other hand, is a single step process. Both carbonization and activation takes place in single step at lower temperature. Further, comparison among both the methods reveals that chemical activation results in lesser tar formation and results in the high yield since char burn-off is avoided [2]. The raw material used for in this study is Cashew Nut Shell Cake. Cashew (*anacardium occidentale*) is a tropical fruit grown in

South East Asia and India. The Dakshina Kannada District of Karnataka State in South India has large amount of cashew cultivation and hence a large number of industries catering to the supply of cashew nuts. After the cashew nut is removed from the shell, the shell is crushed to extract a liquid known as Cashew Nut Shell Liquid. What remains after the crushing is known as Cashew Nut Shell Cake (CNSC).

## 1. Carbon from Cashew Nut Shell Cake

The Cashew Nut Shell Cake used in this study was obtained from Mahalasa Shell Oil, Hiriyaadka (Dakshina Kannada District) and Prakash Cashew Industries, Karkala (Karkala Taluk). The proximate and ultimate analysis of the Cashew Nut Shells is as shown in Table 1.

**Table 1: Properties of Cashew Nut Shells [4]**

Proximate analysis (wt%)		Ultimate analysis (wt%)		Ash chemical composition (wt%)	
Volatile matter	65.21	Carbon	45.21	Silica	64.53
Moisture	9.83	Hydrogen	4.25	Iron oxide	3.27
Ash	2.75	Oxygen	37.75	Aluminium oxide	2.19
Fixed carbon	22.21	Nitrogen	0.21	Calcium oxide	26.89
		Sulphur	NIL	Magnesium oxide	2.49
		Moisture	9.83	Sodium oxide	0.63
		Ash	2.75		

### 1.1 Preparation of AC

The carbon was prepared by two methods, viz physical activation method and chemical activation method. In the physical activation method, The CNSC was weighed, washed to remove dust etc. and sun-dried for some time. It was then placed into a metal pot with a loose fit lid and heated up to around 400°C. The shells take about 1.5 – 2 hours to carbonize completely, depending on the weight of shells taken. This is checked once in a while by slightly moving the lid. The finished carbon was placed in a normal pressure cooker and steamed for around 5 whistles. This ensures enlargement of the pores and accomplishes physical activation by steam (steam activation). This carbon was then roughly crushed and powdered using a porcelain mortar and pestle, and then sieved. 4 particle sizes of 600µm, 300µm, 150µm and 90µm were obtained, and these particles were used as needed. In the chemical activation method, the CNSC was weighed, washed and dried. Concentrated Sulphuric Acid (1.5 times by weight, charring agent) and 30% Hydrogen Peroxide (0.4 times by weight, activating agent) were used to char the shells and activate the carbon respectively. Both the chemicals were used simultaneously. The carbon was kept in an air oven at 150±5°C for 24 hours. The carbon was washed with distilled water to remove all traces of acid. The carbon was then soaked in Sodium Bicarbonate (2 N) solution until effervescence stopped and then left to soak in it overnight. Then the carbon was again washed to remove traces of the alkali and dried in the oven at 100°C for about 2 hours. This carbon was then roughly crushed and powdered using a porcelain mortar and pestle, and then sieved. 4 particle sizes of 600µm, 300µm, 150µm and 90µm were obtained, and these particles were used as needed.

### 2.Methylene Blue (MB) Preparation

A synthetic coloured dye solution was prepared using Methylene Blue as the dye. Methylene Blue (basic blue 9, C.I. 52015; chemical formula, C<sub>16</sub>H<sub>18</sub>N<sub>3</sub>ClS, and molecular weight 319.85 g/mol) was obtained from a local supplier (Sai Chemicals, Udipi) and was not purified before use. A stock solution of MB dye of 100 gm/L was prepared by dissolving the required amount of dye powder in double distilled water. All working solutions of the desired concentrations were prepared by diluting the stock solution with distilled water. Elico SL-191 Double Beam UV Spectrophotometer was used to estimate the degree of colour removal using the activated carbon. The

concentrations that were used in the calibration curve were 5ppm, 10ppm, 20ppm, 30ppm and 40ppm. The trials were carried out at a wavelength of 652nm.

### 3.Colour Removal Trials

The colour removal trials were carried out varying the parameters like Concentration of MB Solution, Weight of carbon used and Particle sizes of carbon. 200ml of MB solutions of different concentrations were taken in 1 litre glass jars. The carbon in powder form was placed into the jars, and the solutions were stirred until equilibrium was reached. Then the solutions were filtered using Whatman 42 filter paper to remove the carbon particles, and the initial and final concentrations of MB in the solutions were measured using Elico SI-191 Double Beam UV Spectrophotometer.

## 4.Results

### 4.1 Results for physically activated carbon

**Table 2: Same concentration of MB, different weights of carbon**

Conc (ppm)	Vol of soln (ml)	Weight of carbon in gms (150microns)	Conc obtained (ppm)	%age recovery
50	200	0.5	26.5	47
50	200	1	16	68
50	200	1.5	9.5	81
50	200	2	7.25	85.5

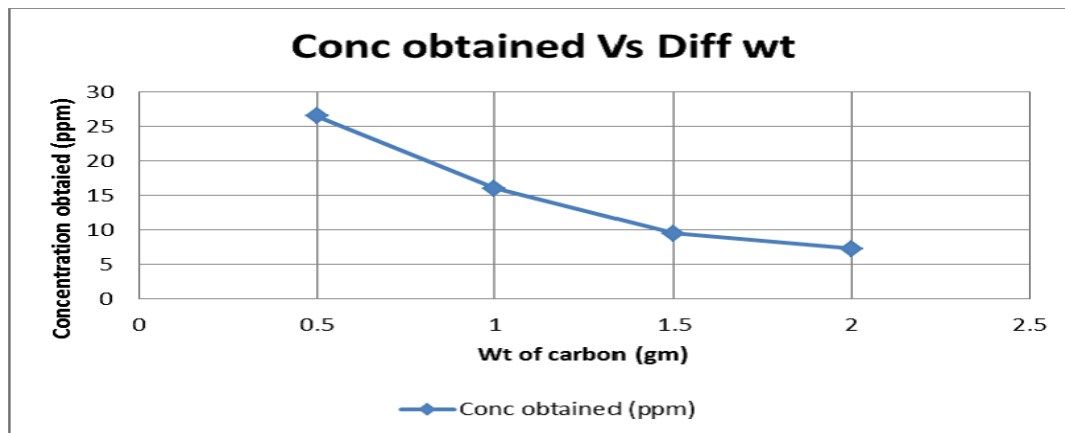
Agitation time: 60 minutes

**Table 3: Same concentration of MB, different particle sizes of carbon**

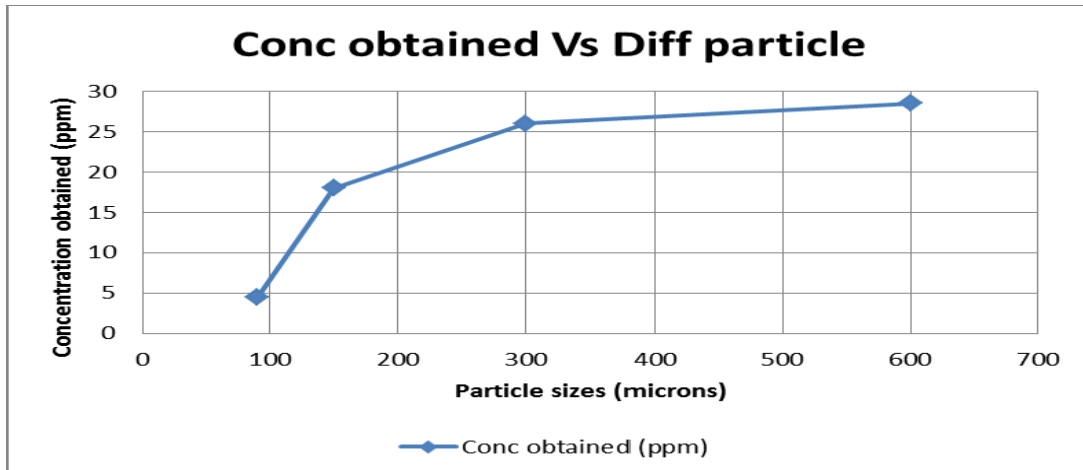
Conc (ppm)	Vol of soln (ml)	Weight of carbon in gms	Conc obtained (ppm)	Particle sizes (microns)	%age recovery
40	200	1	4.5	90	88.75
40	200	1	18	150	55
40	200	1	26	300	35
40	200	1	28.5	600	28.75

Agitation time: 60 minutes

**Figure 2: Same concentration of MB, different weights of carbon**



**Figure 3: Same concentration of MB, different particle sizes of carbon**



**4.2 Results for chemically activated carbon**

**Table 4: Same concentration of MB, different weights of carbon**

Conc (ppm)	Vol of soln (ml)	Weight of carbon in gms (150microns)	Conc obtained	%age recovery
46	200	0.5	6.25	86.43
46	200	1	4.5	90.22
46	200	1.5	4.5	90.22
46	200	2	4.5	90.22

**Table 5: Same concentration of MB, different particle sizes of carbon**

Conc (ppm)	Vol of soln (ml)	Weight of carbon in gms	Conc obtained (ppm)	Particle sizes (microns)	%age recovery
50	200	1	46.4	600	7.2
50	200	1	39	300	22
50	200	1	27.5	150	45
50	200	1	4.5	90	91

Figure 4: Same concentration of MB, different weights of carbon

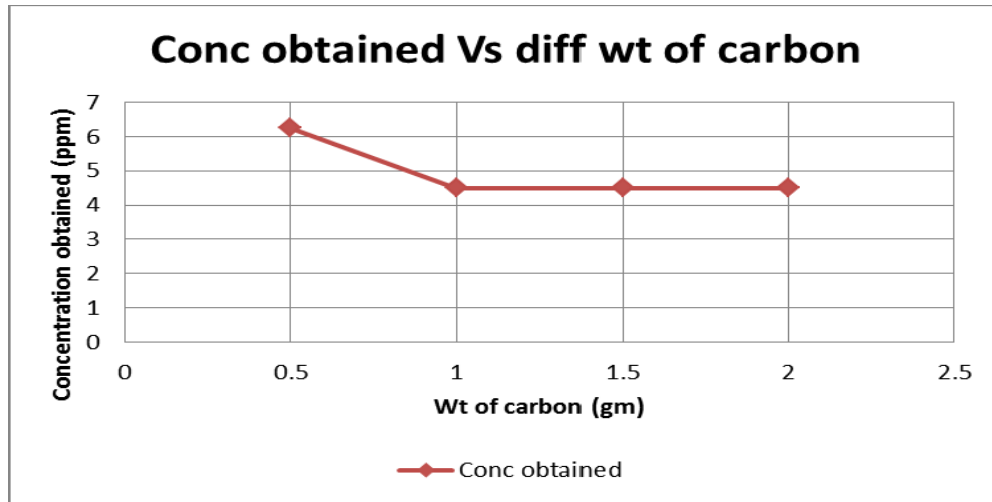
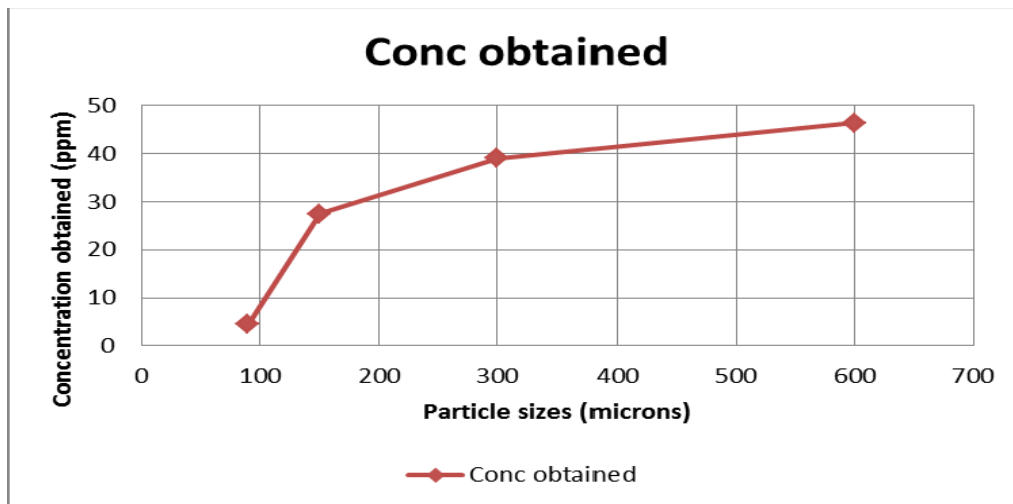


Figure 5: Same concentration of MB, different particle sizes of carbon



## 5. Conclusions

From the study, it can be concluded that cashew nut shell can show considerable promise as a raw material for activated carbon. The quality of the carbon obtained will depend on the quality of the raw material in general, and its residual oil content in particular. The chemical carbon showed remarkable MB colour removal efficiency in comparison with the physical carbon. In the trials with varying parameters, the physical carbon showed 88.75% (at 40ppm initial concentration) of maximum colour recovery, whereas the chemical carbon showed 91% (at 50ppm initial concentration).

## References

- [1]. NordianaSuhadaMohmadTahiruddin&SitiZubaidah Ab Rahman (2013), "Adsorption of lead in aqueous solution by a mixture of activated charcoal and peanut shell", World Journal of Science and Technology Research Vol. 1, No. 5, July 2013, PP:102-109, ISSN: 2329 – 3837
- [2]. Sunanda, Tiwari D. P., Sharma D. N. and Raunija Thakur Sudesh Kumar (2013), "Sapindus Based Activated Carbon by Chemical Activation", Research Journal of Material Sciences, ISSN 2320–6055, Vol. 1(7),9-15, August (2013)
- [3]. WankhadeAmey A. and Ganvir V.N. (2013), "Preparation of Low Cost Activated Carbon from Tea Waste using Sulphuric Acid as Activating Agent", International Research Journal of Environment Science, ISSN 2319–1414, Vol. 2(4), 53-55, April (2013)
- [4]. Nor AdillaRashidi et al, "Activated carbon from renewable agriculturalresidues using single step physical activation: a preliminary analysis", APCBEEProcedia3 ( 2012 ) 84 – 92
- [5]. Sachin M. Kanawadeand R. W. Gaikwad, "Removal of Methylene Blue fromEffluent by Using Activated Carbon and Water Hyacinth as Adsorbent", International Journal of Chemical Engineering and Applications, Vol. 2 , No. 5 , (2011)

- [6]. P. Senthil Kumar, S. Ramalingam, S. Dinesh Kirupha, A. Murugesan, T. Vidhyadevi, S. Sivanesan, "Adsorption behavior of nickel(II) onto cashew nut shell: Equilibrium, thermodynamics, kinetics, mechanism and process design", *Chemical Engineering Journal* 167, 122–131 (2011)
- [7]. P. SenthilKumar, S. Ramalingam, V. Sathyaselvabala, S. Dinesh Kirupha, S. Sivanesan, "Removal of copper(II) ions from aqueous solution by adsorption using cashewnut shell", *Desalination* 266, 63–71 (2011)
- [8]. G. Alagumuthu, M. Rajan, "Equilibrium and kinetics of adsorption of fluoride onto zirconium impregnated cashew nut shell carbon", *Chemical Engineering Journal* 158, 451–457 (2010)
- [9]. SandroAltenor et al, "Adsorption studies of methylene blue and phenol onto vetiver roots activated carbon prepared by chemical activation", *Journal of Hazardous Materials* 165, 1029–1039 (2009)
- [10]. B.H. Hameed, "Evaluation of papaya seeds as a novel non-conventional low cost adsorbent for removal of methylene blue", *Journal of Hazardous Materials* 162(2009) 939–944
- [11]. Akinhanmi, T. F. et al, "Chemical Composition and Physicochemical Properties Of Cashew nut (*Anacardium occidentale*) Oil and Cashew nut Shell Liquid", *Journal of agricultural, food and environmental sciences*, ISSN 1934-7235, Volume 2, Issue1, 2008