Preparation of Activated Carbon from Coconut Shell

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ABSTRACT: Activated carbon is a non-graphite form of carbon which could be produced from anycarbonaceous material. Activated carbons are increasingly used as the economic and stable mass separation agent for the removal of surfactants to raise the final product quality many industrial processes. Activated carbons also play an important role in many areas of modern science and technology such as purification of liquids and gases, separation of mixtures and catalysis. The main objective of the study is to produce activated carbon from dry coconut shell and to treat the domestic waste water and to recycle the treated water for home gardens. The higher purity, negative cost, high rate of production and strong carbonaceous structure of coconut shell proves to be a precursor for carbon production. This research will pave way for the recycle and reuse of waste water that could further reduce the level of water pollution.

KEYWORDS: Activated carbon, Coconut shell, Waste water, Adsorption.

I. INTRODUCTION

Increase in population has boosted the growth of different industries leading to discharge of pollutants into the water bodies. Among those industries textile, food, cosmetic and paper industries lead to discharge of dye that needs immediate attention. Color in the water results from various organic chemicals that prevent the sunlight to penetrate affecting the aquatic system. Aquatic organisms and plants are affected due to the release of toxic organic chemicals. Various methods to address this issue has been published by many researchers such as sedimentation with clarification, coagulation and flocculation, chemical oxidation, filtration using membranes, adsorption, biodegradation etc . Among these adsorption is a well-established technology to deal with dye removal. Methylene blue dye has been used in most of the industries and its removal is a matter of great concern. Low cost adsorbents such as coir pith, sawdust, fruit shell, banana pith, pea nut hull, wheat barn etc has been employed [Vadiyelan et al, 2005; Chandran et al, 2002; Bhattacharya et al, 2005; Kumar et al, 2005; Garg et al, 2003; Hamdaoui et al, 2007]. However due to its less adsorption capacity use of activated carbon as an adsorbent is greatly sorted. Activated carbon is a special type of carbonaceous substance. It has highly crystalline form and extensively developed internal pore structure. Due to activation, internal pore network is created which imparts certain surface chemistries (functional groups) inside each particle. Thus carbon gets its unique characteristics leading to high surface area, porosity and greater strength.Theabsorptivity of the adsorbent depends on both the size of the molecule being adsorbed and the pore size of the adsorbent.The organic material which has high carbon content is used as the raw material for the synthesis of activated carbon. There are many cheap, easily available materials such as wheat husk, straw, palm fiber, rubber wood saw dust, bamboo dust, date pits, palm fiber, coconut shell, groundnut shell, oil cake etc which have been used as the source for the synthesis of activated carbon. They are used in the abatement of hazardous contaminants, treatment of municipal and industrial waste water, as catalyst or catalyst support in medicine and the recovery of valuable metalsThus the aim of this research is to look for a good adsorbent based on their surface characteristics. It also explores the adsorption capacity of the adsorbent for methylene blue dye removal.

II.   LITERATURE SURVEY

Many experiments and studies have been carried out regarding the characterization of the activated carbon which was synthesized from source such as fluted pumpkin seed, groundnut shell, palm oil waste, karanja oil seed, rubber wood saw dust etc.

K Mallick, 2004, used Mahogany sawdust to develop an effective carbon adsorbent. This adsorbent was employed for the removal of dyes from spent textile dyeing wastewater. The experimental data were fitted to Langmuir and Freundlich models of adsorption. There are many cheap, easily available materials such as wheat husk, straw, palm fiber, rubber wood saw dust, bamboo dust, date pits, palm fiber, coconut shell, groundnut shell, oil cake etc which have been used as the source for the synthesis of activated carbon. They are used in the abatement of hazardous contaminants, treatment of municipal and industrial waste water, as catalyst or catalyst support in medicine and the recovery of valuable metalsThus the aim of this research is to look for a good adsorbent based on their surface characteristics. It also explores the adsorption capacity of the adsorbent for methylene blue dye removal.

M.M.Nourouzi and T.G.Chuah in 2009, studied the adsorption behavior on Reactive Black 5 and Reactive Red 3 using Palm Kernel Shell Activated carbon. Applications of batch kinetic data to pore and film surface diffusion models were explored.

Jun –jieGao et al., 2013, produced activated carbon from tea seed shells. They obtained activated carbon of BET surface area 1530 m^2/g. The precursor was chemically activated using zinc chloride and pyrolysed in a tubular furnace at 500^oC for one hour duration at a heating rate 5^oC/min.Methylene blue dye has been used in most of the industries and its removal is a matter of great concern. Low cost adsorbents such as coir pith, sawdust, fruit shell, banana pith, pea nut hull, wheat barn etc has been employed [Vadiyelan et al, 2005; Chandran et al, 2002; Bhattacharya et al, 2005; Kumar et al, 2005; Garg et al, 2003; Hamdaoui et al, 2007]. However due to its less adsorption capacity use of activated carbon as an adsorbent is greatly sorted. Activated carbon is a special type of carbonaceous substance. It has highly crystalline form and extensively developed internal pore structure. Due to activation, internal pore network is created which imparts certain surface chemistries (functional groups) inside each particle. Thus carbon gets its unique characteristics leading to high surface area, porosity and greater strength. The absorptivity of the adsorbent depends on both the size of the molecule being adsorbed and the pore size of the adsorbent. The organic material which has high carbon content is used as the raw material for the synthesis of activated carbon.

Halandemiral et al., 2008, prepared activated carbon from Hazelnut bagasse through chemical activation technique. The surface area developed was significant 1489 m^2/g. It was employed to remove Sandolan blue from the water bodies.
Increase in population has boosted the growth of different industries leading to discharge of pollutants into the water bodies. Among those industries textile, food, cosmetic and paper industries lead to discharge of dye that needs immediate attention. Color in the water results from various organic chemicals that prevent the sunlight to penetrate affecting the aquatic system. Aquatic organisms and plants are affected due to the release of toxic organic chemicals. Various methods to address this issue has been published by many researchers such as sedimentation with clarification, coagulation and flocculation, chemical oxidation, filtration using membranes, adsorption, biodegradation etc . Among these adsorption is a well-established technology to deal with dye removal.

III.   MATERIALS AND METHODS
1.   Raw material
For this project the raw materials such as coconut shell activated carbon, activated carbon from rice husk and activated carbon from karanja oil cake was obtained.

2.   Chemicals
The various chemicals used during this project were hydrochloric acid, sodiumthiosulphate, iodine solution, starch, 1N sulfuric acid, 1N sodium hydroxide etc.

3. Instrumentation

Muffle furnace, oven, weighing machine,Brunaner Emmett Teller surface area analyzer, pH meter, mercury porosimetry, scanning electronic microscope, hand shaker, UV spectro-photometer.

4. Proximate analysis

According to ASTM D 121, proximate analysis is the determination of moisture, volatile matter, fixed carbon, and ash content by prescribed methods. The proximate analysis of the different type of activated carbon was done using the following procedure.

4.1 Moisture content

Small amount of activated carbon sample (coconut shell) weight was measured and then taken in a petri dish. It was spread nicely on the dish. It was then heated in an oven at a temperature of $(105\text{-}110)^{\circ}$c for 1.5hr. The petri dish was left open or not covered during heating process. After heating petri dish was removed and cooled in a desicator. After cooling the weight of dried sample was measured.

Moisture content $M=100(B\text{-}F)/(B\text{-}G)$
B=Weight of petri dish +original sample
F=Weight of petri dish+ dried sample
G= Weight of petri dish
Same procedure was also followed for determination of moisture content for activated carbon of rice husk and karanja oil cake.

4.2Ash content

1 gm of sample was taken in a silica crucible. It was heated in a muffle furnace to 750℃ for 1.5hr. During this heating process the crucible was left open. After the required heating, the crucible was cooled in a desicator and then weight of the ash was measured.

Ash content $A=100(F\text{-}G)/(B\text{-}G)$
G=Mass of empty crucible
B=Mass of crucible + sample
F=Mass of crucible+ ash sample

Same procedure was also followed for determination of moisture content for activated carbon of rice husk and karanja oil cake.

4.3 Volatile matter content

A known quantity of sample was taken in cylindrical crucible closed with a lid. It was thenHeated to 925℃ for exactly seven minutes in a muffle furnace. Then the crucible was cooled in adesicator and weighted.
Volatile matter on dry basis
$VM=100[100(B\text{-}F)\text{-}M\,(B\text{-}G)]/[(B\text{-}G)(100\text{-}M)]$

IV.   PREPARATION OF ACTIVATED CARBON

Most carbonaceous substances can be converted into activated carbon; the final properties of the carbon will depend significantly on the nature of the starting material. A large number of processes for making activated carbons have been developed over the past century. However, most processes consist of the pyrolysis of the starting material, followed by a stage of controlled oxidation or vice versa. The purpose of the oxidation stage is to activate the carbon.

Pyrolysis step (or also called as Carbonization) involves heating the source materials to temperatures ranging between 600 to 900ºC in the absence of air (Cooney 1999). Low molecular weight volatiles are first released, followed by light aromatics and finally the hydrogen gas, the resultant product being a fixed carbonaceous char. The residual carbon

atoms are grouped into condensed sheets of aromatic ring with a cross-linked structure in a random manner. The mutual arrangement of these aromatic sheets is irregular and leaves free interstices between the sheets, which may be filled with the tarry materials. To remove these tarry materials, activation process is carried out. It also enlarges the diameters of the pores, which were created during the carbonization process and creating new porosity (Smisek&Cerny 1970).

The basic characteristics of a carbon are established during the pyrolysis, and the ensuing oxidation step must be designed to complement the pyrolysis step. During this step, the oxidising agent increasingly erodes the internal surfaces of the carbon, develops an extensive and fine network of pores in the carbon, and changes the atoms lying on the surface to specific chemical forms which may have selective adsorption capabilities. This activation step is done by two methods physical activation or chemical activation.

1. Physical activation

Physical activation or partial gasification is generally carried out at elevated temperatures between 750 and 1100_oC using oxidants such as steam, carbon dioxide, air or mixture of these gases. Chlorine, sulphurvapours, sulphur dioxide, ammonia and a number of other substances having activation effects are rarely used. Gasification of the carbonized material with steam and carbon dioxide occurs by the following endothermic reactions:

$$C + H_2O \longrightarrow H_2 + CO \tag{2.1}$$

$$C + CO_2 \longrightarrow 2CO \tag{2.2}$$

The reaction of steam with carbon is accompanied by the water gas formation reaction, which is catalyzed by the carbon surface as,

$$CO + H_2O \longrightarrow CO_2 + H_2 \tag{2.3}$$

Since the reaction of carbon with steam and with carbon dioxide is both endothermic, external heating is required to drive the reactions and to maintain the reaction temperature. The activation process can be manipulated to produce products of desired characteristics. Activation temperature, steam and CO2 flow rates control the pore development, which in turn affect pore size distributions and the level of activity of the activated carbon.

2. Chemical activation

Chemical activation is usually carried out by impregnating the raw or pre-carbonized material with an activating agent and pyrolyzed between 400 and 800℃ in the absence of oxygen. The most commonly used activating agents are phosphoric acid, hydrochloric acid, sulphuric acid, alkalis namely KOH and NaOH, zinc chloride and alkaline metal compounds. Phosphoric acid and zinc chloride are used for the activation of lignocellulosic materials. Phosphoric acid is the most preferred activating agent because of its low environmental impact when compared to zinc chloride. The resultant activated carbon is washed, dried till constant weight is obtained and ground to required size. Activated carbons produced by chemical activation generally exhibit a very open structure and bottle shaped, ideal for the adsorption of large molecules.

3. Combination of physical and chemical activation

A combination of physical and chemical activation can be used to prepare granular activated carbons with a very high surface area and porosity adequate for certain specific applications such as gasoline vapour control, gas storage, etc. Activated carbons of these types have been reported using lignocellulosic precursors chemically activated with phosphoric acid and zinc chloride and later activated under a flow of carbon dioxide. Uniform, medium-size microporosity and surface areas above 3600 m^2/g are obtained with this mixed procedure (Bansal 1988).

4. APPLICATION OF ACTIVATED CARBON

In the water treatment sector, activated carbon is used either in powdered (suspension process) or granular (fixed bed process) form, depending upon the specific application and process. The objectives pursued with the use of activated carbon in water treatment have changed significantly in recent decades. Years ago, activated carbon was employed primarily for the removal of excess chlorine and the elimination of substances affecting odour and taste from relatively good-quality raw water. Increasingly exacting quality requirements for drinking water, coupled with increasing pollution levels in untreated water (groundwater and surface water), have led to the optimization of activated carbon as a means of guaranteeing acceptable drinking water quality. In parallel, changes in treatment processes, such as the reduction of high-strength chorine treatment, have resulted in the elimination of traditional applications. In recent years, the use of activated carbon processes has become widely established in drinking water treatment, groundwater rehabilitation and the treatment of service water. Likewise, activated carbon is being used to an increasing extent in waste water treatment, whether it be in the systematic treatment of individual effluent streams (e.g. in the chemicals industry), in the removal of substances toxic to bacteria in biological waste water treatment or in tertiary waste water treatment, where effluent restrictions are particularly severe. Among the wide range of physical, chemical and biological processes used in waste water treatment, activated carbon adsorption is gaining steadily in importance. The use of activated carbon is especially advisable in cases requiring the removal of toxic substances or pollutants that are not easily biodegradable. Activated carbon is almost always employed in the treatment of waste water in the paper, textile and petrochemical industries. The textile finishing industry generates a large amount of wastewater. Wastewaters from dyeing and subsequent rinsing steps form one of the largest contributions to wastewater generation in the textile industry. Because dyes are almost invariably toxic, their removal from effluent stream is ecologically necessary (Santhy&Selvapathy 2006).

V. TREATMENT OF TEXTILE EFFLUENTS

Environment is the broad concept encompassing the whole range of diverse surroundings, which we perceive, experience and react to events and changes that are taking place on it. It includes land, water and air. One of the main problems prevailing in this environment is pollution. It is the unhealthy and undesirable change in the environment that is caused directly or indirectly by the human beings, either in the process by living or through any industrial processes. Considering the volume discharge and effluent composition, the wastewater generated by the textile industry is rated as one of the most polluting among the industrial sectors. The dye is the major polluting agent of water among the various processes. The principal route by which the dye enters the environment is through wastewater from the manufacturing activity in both the dye manufacturing and the dye consuming industries.

VI. CONCLUSION

Activated carbon is prepared by different methods both physical and chemical activation as well as combination of both physical and chemical activation. The drawback of physical activation is that the yields are relatively poor while also required higher temperature for the activation process. A number of literaturesare available for the chemical activation process using the different chemical activating agent. Chemical activation gives higher yields of carbon as well as larger pore size in the carbon is created. Mesopores development is normally desired in treatment of effluents. As the activated carbon produced is highly dependent on the raw materials used as well as the activation procedure. In order to optimize parameters for the activation process information from literature though in plenty cannot be directly applicable to a particular biomass chosen leading to extensive experimental work for its optimization as carried in the further studies.The study required to conduct many characterization techniques like proximate analysis, bulk density, BET surface area, pH, pore volume, iodine number test, blue methylene number test. This is followed by an adsorption experiment to find the better adsorbent for adsorption process. Then SEM test of better adsorbent was performed on the adsorbent and show the pore structure of that adsorbent.Proximate analysis of activated carbon provides a good idea about the physical properties of sample. From this analysis it is found out that, the fixed carbon content of coconut shell activated carbon is higher than other two. It shows that the moisture content of activated carbon prepared from coconut shell is high while the volatile and ash content are the least. This is due to its high fixed carbon, which is a preferred adsorbent in comparison to other two.

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