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PURIFICATION OF AIR USING IMPREGNATED ACTIVATED CARBON PRODUCED FROM COCONUT SHELL

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Abstract - *As the industrial areas are the most prone areas that contributes to the air pollutants now a days, it is necessary to reduce the outcomes of air pollutions from thess areas by using some methods. Inspite of this scenario, I have selected one of the most polluted industrial area of Kerala that is Edayar, Eloor belt in Ernakulam district for carrying out the study. As several industries are situated in this area and almost all industries here contribute towards air pollution which are more acidic in nature. So, in this study the impregnated activated carbon produced from coconut shell is adopted as a medium to absorb all kinds of air pollutants present in the air particularly carbon dioxide, Sulphur dioxide, oxides of nitrogen etc which are the most serious polluting gases that would harm both the environment and the human being as well. And also in this study we present the adsorption capacity of impregnated activated carbon (ac) prepared from coconut shells at various optimum temperatures of 25°C ,35°C ,45°C and/or high concentration of impregnation (~20 mol%) which were examined by me and there corresponding characteristics have been plotted by carrying out the the test in the company Activated Carbon Production Limited(ACPL)also known as Indo German chemicals ltd in Edayar, Eloor belt, with the use of a fixed-bed column adsorption system designed and developed in the industry and also the kinetic and thermodynamic parameters of the coconut shell impregnated activated carbon was analyzed in detail for acidic gases like carbon dioxide, Sulphur dioxide, oxides of nitrogen and the results were interrupted. Research on the adsorption of impregnated activated carbon (ac) produced from coconut shell adsorbents has gained significant interest due to their low cost, low regeneration energy, and ecofriendly characteristics. This would help us in future to meet out the pollution problem at economical way and also there by preparing a filter medium of appropriate quality to absorb the air pollutants and thereby saving the universe and also the future generation from this serious problem.*

Key Words: *Air pollution, coconut shell, Impregnated activated carbon, carbon dioxide, Sulphur dioxide, oxides of nitrogen.*

1. INTRODUCTION

As days proceed pollution is increasing day by day in the case of air and water. Air pollution has become more serious than water pollution as the control on air is very less compared to water and we inhale air continuously throughout our life. Air gets contaminated due to several reasons, two of the most prominent ones being chemical factories and vehicles. At present the air has started been polluted by microorganisms like virus and bacteria as well. There are several ways by which the air gets polluted. Chemicals and related industries are the main source of air-pollution. The other sources are motor vehicles running on fossil fuels and natural gas. The increased population also pollutes the air by several means by generating different kinds of pollutants. Except the trees having chlorophyl which produce oxygen during day time by photosynthesis all other living entities pollute the air by carbon dioxide and consume oxygen. If we have to survive on earth for long, we should have to have strict control on the emission of pollutants to the air

The aim of the present project is to provide solution to the polluting industries by providing them suitable filters so that the outgoing air is purified from pollutants. For the purpose of this study the most polluted area of Kerala, namely Edayar-Eloor area of Kochi is selected where in several pollutants are let out by several industries freely into the atmosphere. If this trend continues oxygen parlours will be required for getting pure air in this area. Otherwise, we have to fix suitable carbon filters at the exhaust from which pollutants are coming out as emissions from the industry.

As far as pollution from the vehicles is concerned, vehicles give out carbon dioxide, carbon monoxide and unburnt hydrocarbons into the air. The out-let of the exhaust of the engine should be attached to a filter which can remove these pollutants so that the air coming out will be pure. Now several thousands of vehicles are polluting the atmosphere and in some of the Indian cities it has become a serious issue. So even in the absence of polluting industries the air can get polluted due to large number of vehicles. Such a situation will become imminent in cities like Kochi.

Of the gases emitted by vehicles CO is very poisonous. It is as poisonous as cyanide. CO will get attached to hemoglobin of blood and stop the oxygen supply to the cells. CO forms a permanent bond with the iron of the hemoglobin and will stop acting as the oxygen carrier from lungs to heart. Thus the affected person will die immediately due to the lack of oxygen in the cells. The other pollutant given out by the vehicles is CO2. Even though CO2 as such is not a poison, being heavier than air it accumulates on the surface of earth. It gets filled in drainages and unused wells and cuts off oxygen supply. This leads to the death of persons entering to such pits. Its concentration in the air increases the atmospheric temperature as it is a polar molecule and absorbs infrared radiations entering the air. Unburnt hydrocarbons will go directly to the lungs and gets settled there and thus reduces oxygen absorption capacity of the lungs. By constant inhalation of this, the total oxygen availability in the blood decreases to a great extent and will lead to several diseases.

Pollutants from vehicles include oxides of carbon, sulphur and unburned hydrocarbons. Pollutants from factories include a wide spectrum of chemicals depending on the factory itself. These can include oxides of nitrogen, sulphur etc. Almost all of these oxides are acidic in nature. Yet another type of pollutants is ammonia Hydrogen sulphide and mercaptans (thiols) etc... Almost all of these pollutants are harmful to living beings. Satisfactory solution to purify the air from pollution is the very need of the hour. Some cities like New Delhi have already come under the clutches of pollution making the life unbearable for the inhabitants. This can happen for our city also in the near future. Even though some attempts were made to curtail the problem of pollution by different agencies none of them have really succeeded and a permanent solution was not yet arrived at. The aim of the project is to approach the problem of pollution and solve it. Activated carbon has been identified as the material to fight against air pollution. The reason for selecting this material was due to the fact that carbon can be activated and impregnated with a wide variety of materials to curtail the pollution wherein the pollutants never attack the carbon (the base) whereas many base materials like zeolites react with the pollutants and thus gets degraded by itself.Carbon has three allotropes and out of this amorphous carbon is selected for the purpose due to its easy availability and low cost. The 3 forms of amorphous carbons that are easily available are (i) wood carbon (ii) coal carbon and (iii) coconut carbon. Of the three, coconut carbon is the best suited for air purification. Being a natural material, its disposal is not a series problem. The project was carried out in ACPL Binanipuram, which is one of the earliest activated coconut carbon manufacturing company in the country.

1.1 OBJECTIVES OF THE PRESENT STUDY

1. To provide a solution for industrial air pollution by letting the polluted exhaust from the industries through a suitable filters so that the outgoing air is purified from pollutants.
2. To investigate the adsorption efficiency of chemically treated activated carbon produced from coconut shell for various polluting gases like carbon dioxide, Sulphur dioxide, oxides of nitrogen etc.
3. To understand the suitability of various temperature for the adsorption of various pollutant gases on to the chemically treated activated carbon produced from coconut shell.
4. As far as pollution from the vehicles is concerned, vehicles give out carbon dioxide, carbon monoxide and unburnt hydrocarbons into the air. The out-let of the exhaust of the engine should be attached to a filter which can remove these pollutants like CO2 and unburnt hydrocarbons so that the air coming out will be pure.
5. The present study aims to investigate the adsorption of carbon dioxide, Sulphur dioxide, oxides of nitrogen using chemically treated activated carbon utilizing specifically acidic

1.2 SCOPE OF THE PROJECT

1.The study should focus on the selection of reusable chemical compound for the chemical activation of activated carbon. That the process may involve a complex recovery and recycle of the activating agent that generates problems in the recovery and disposal of adsorbed materials.

2.Using impregnated activated carbon completely elimination of pollution from industrial areas and vehicles is to be achieved or suitable recommendations is to be made.

2. LITERATURE REVIEW

Olivares-Marin M* et al *(2011) The adsorption process of carbon dioxide, Sulphur dioxide, oxides of nitrogen, carbon monoxide on a solid adsorbent, can be easily exploited for several applications aimed to these approaches. Several effective methods of carbon capture and storage (CCS), such as adsorption, membrane separation and cryogenic separation, have been proposed to reduce the amount of emitted CO2 in the atmosphere.

S. Sumathi, et al (2009) and A. Arami-Niya, et al (2019) Activated carbon has been known as the most effective and useful adsorbents for the removal of pollutants from polluted gas and liquid streams. This is due to the properties of activated carbons which have a large active surface area which can provide high adsorption capacity, well developed porous structures and good mechanical properties. In addition, activated carbon is most widely used since most of its chemical (e.g. surface groups) and physical properties (e.g. surface area and pore size distribution) can be designed and adjusted according to the required application. Besides, the adsorption on activated carbon appears to be most common techniques because of its simplicity of operation since the sorbents material can be made highly efficient, easy to handle and in some cases they can be regenerated.

El-Shafey et al, (2016) Physical adsorption on activated carbons has been widely used for the applications of separation and purification of gases and adsorption based gas storage systems. To design and develop these systems, it is important to determine the adsorption isotherms and isosteric heat of adsorption of the adsorbate adsorbent pairs. In recent years, considerable attention has been focused on removal of pollutants by using adsorbents derived from low-cost agro-wastes. Adsorption processes are generally performed using activated carbon and polymeric adsorbents. He also revealed that activated carbon can capture CO_2 and SO_2 because it consists of a large surface area per unit volume and submicroscopic pores, in which contaminant adsorption occurs. Moreover, activated carbon is stable under acidic and basic conditions. It is also cost effective because it can be regenerated and thus suitable for organic compound removal. Considering cost effectiveness in activated carbon production, researchers developed different precursors from abundant waste materials, such as palm shells, sea mango, cocoa pod shells, and rice husks. For instance, successfully produced activated carbon from rice husks and utilized it to remove CO_2 and SO_2 generated from industrial activities as well.

3.METHODOLOGY

3.1 COCONUT SHELL

Coconut shell (CS) is selected for activated carbon preparation. CS was collected from the local community in Kerala. The materials were cleaned with distilled water several times to remove dust and impurities. CS samples were later dried in the oven at 110oC for 24h to remove any surface moisture and were then ground to a desired size. The proximate and ultimate analysis were carried out to evaluate the volatiles and fixed carbon contents as well as to quantify the elemental composition, respectively. Coconut shell (CS) is selected for activated carbon preparation. CS was collected from the local community in Kerala. The materials were cleaned with distilled water several times to remove dust and impurities. CS samples were later dried in the oven at 110oC for 24h to remove any surface moisture and were then ground to a desired size. The proximate and ultimate analysis were carried out to evaluate the volatiles and fixed carbon contents as well as to quantify the elemental composition, respectively.

3.2 PREPARATION OF ACTIVATED CARBON

3.2.1 Activated carbon preparation

Carbon can be activated in two ways one of the main is

Physical activation:

Coconut shell (CS) were loaded into a stainless steel reactor, which was heated up by an electrical tube furnace. In the initial stage, the reactor was heated up to 300oC and was kept at this temperature for 30 minutes. The temperature was later ramped up to about 800oC. At this rate, CS was completely pyrolyzed. Water was then injected at the flow rate of 120 ml/hr to the reactor to activate the samples. The reaction between steam and carbon was taken place and pore was generated. After completing the activation process, the reactor was cool down, the samples was taken out and washed using distilled water.

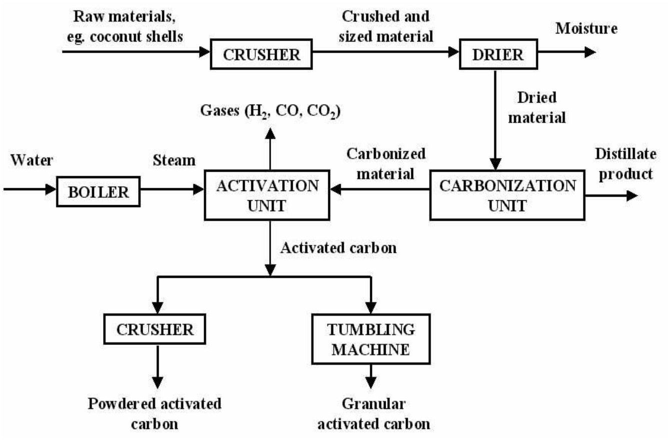


Fig-1: Flow diagram of preparation of steam activated activated carbon.

The use of steam for activation can be applied to virtually all raw materials. A variety of methods have been developed but all of these share the same basic principle of initial carbonization at 500-600 degrees C followed by activation with steam at 800-975 degrees C. Since the overall reaction (converting carbon to carbon dioxide) is exothermic it is possible to utilize this energy and have a self-sustaining process.

$$C + H_2O\ (steam) \longrightarrow CO + H_2\ (-31\ Kcal)$$

$$CO + \tfrac{1}{2} O_2 \longrightarrow CO_2\ (+67\ Kcal)$$

$$H_2 + \tfrac{1}{2} O_2 \longrightarrow H_2O\ (steam)\ (+58\ Kcal)$$

$$C + O_2 \longrightarrow CO_2\ (+94\ Kcal)$$

Raw material is introduced through a hopper on top of the retort and falls under gravity through a central duct towards the activation zone. As the raw material moves slowly down the retort the temperature increases to 800-9750C and full carbonization takes place. The activation zone, at the bottom of the retort, covers only a small part of the total area available and it is here that steam activation takes place. Air is bled into the furnace to convert the product gases, CO and H_2 into CO_2 and steam which, because of the exothermic nature of this reaction, reheats the firebricks on the downside of the retort, enabling the process to be self-supporting. Every 15 minutes or so, the steam injection point is alternated to utilize the “in situ” heating provided by the product gas combustion. The degree of activation (or quality) of the product is determined by the residence time in the activation zone. The resulting product is in the form of

1" to 3" pieces and requires further processing before being suitable for its various end uses. This entails a series of crushing and screening operations to produce specific mesh ranges. Certain products may undergo further processing such as drying, acid washing or chemical impregnation to satisfy particular requirements.

3.2.2 IMPREGNATION PROCESS :

The best activated carbon from physical and chemical activation were loaded with 5wt%,10wt% ,15wt% and 20wt% of selected different materials (NaOH, KOH and K2CO3) to enhance the selective adsorption capacity of the adsorbent. The selection of 5wt% concentration for all materials was based on the preliminary study. Initially, the solutions of materials were prepared in a beaker and a required amount of activated carbon was added into the solution. The mixture was left for 24 h at room temperature, then the excess solution was filtered out and the solid mass was dried at 70-80 °C in oven for overnight. The dried sample was then placed in the same stainless steel reactor and was heated up to 750oC and was left the reactor at this temperature for 1 h under the flow of nitrogen gas at the rate of 200 ml/min. After 1h, the reactor temperature was cool down to room temperature, and the product was taken out and stored in a desiccator.

3.2.3. EXPERIMENTAL SET UP FOR ADSORPTION

The scheme of the experimental setup is shown in Fig below. A fixed-bed reactor set-up for gaseous adsorption experiments was designed and built at the Active char Products Pvt Ltd, Edayar, Ernakulam. For this the Activated Coconut Carbon was used to eliminate contaminants present in air in a polluted industrial area. Column was packed with Activated Carbon and contaminated air was passed through it under normal conditions. As a typical contaminant SO2, CO2, NO and CO was chosen. Concentration of the inlet and outlet were measured using gas detectors. A 1000ppm SO2, CO2, and NO in Nitrogen was used for the purpose. Experiment was conducted by passing this gas mixture through the carbon packed in gas column of height 4 cm and diameter 2 cm. It was found that the gas mixture coming out from the column was free from SO2. The passing of gas mixture through the column was continued until the outlet showed a concentration of 50 ppm of SO2, CO2, NO.

TABLE -1: The details of experimental setup are shown in the table below:

height of the carbon column	Diameter of the carbon column	Concentration of inlet gas mixture	Concentration of outlet gas mixture	Retension Time
4 cm	2 cm	1% SO2 ,(CO2) and 99% Nitrogen	50 ppm	28 min

The flow rate of CO2 and N2 mixture are controlled by a mass flow controllers, max flow 600 ml/min and a metering valve coupled with a mass flow meter. The fixed-bed adsorption of CO2 from CO2/N2 mixtures on activated carbon was studied. The single component adsorption equilibrium of CO2 and N2 were measured at feed concentration of 15mol%, temperature of 25°C, 35°C and 45°C and feed flow rate of 50ml/min. The inlet and outlet gases concentrations are analysed with Gas Chromatograph. The adsorption process was continued up to the saturation point where the outlet concentration of CO2 reached the inlet concentration of CO2.

Fig – 2: Picture of the testing apparatus

3.2.4 ISOTHERMAL GASEOUS ADSORPTION

The commercial activated carbon of size 8x30 are compared with AC impregnated with NaOH, K2CO3, KOH, FeCl2 etc at different concentration of 10mol%, 15mol% and 20mol% are used. The experiment is conducted at different temperature of 25°C, 35°C and 45°C with a constant flow of 50ml/min mixture of 15mol% CO2, SO2 etc and 85mol% N2. Prior to the adsorption process, the sample materials were weighed using a thermal gravimetric analyser (EXSTAR TG/DTA 6300) under a vacuum condition, to ensure that excess moisture had been entirely removed. In a similar way gas adsorbed AC is also weighed. The amount of gas adsorbed on adsorbents (S mol/gram) at a certain time (t sec) at a constant temperature and inlet concentration can be determined by

CO2 Adsorption Capacity = [wt (mg)-w0(mg)] /w0(g)

Where, wt and wo represents mass of adsorbent at time t and original mass of adsorbent.

The adsorption capacity is reported as the number of mol of CO2 adsorbed per kg of adsorbent (mol/kg) and it can be converted to mg/g by multiplying by 44(CO2 molecular weight).

4. RESULT AND DISCUSSION

The aim of the present project is to provide solution to the polluting industries by providing them suitable filters so that the outgoing air is purified from pollutants. Activated Coconut Carbon was found to be a very good material for adsorbing common pollutants present in industrial area. The fixed-bed adsorption of gaseous from CO2 or SO2 or NO and N2 mixtures on activated carbon was studied. The single-component adsorption equilibrium of CO2 (SO2, NO, CO) and N2 were measured at 25°C, 35°C and 45°C.

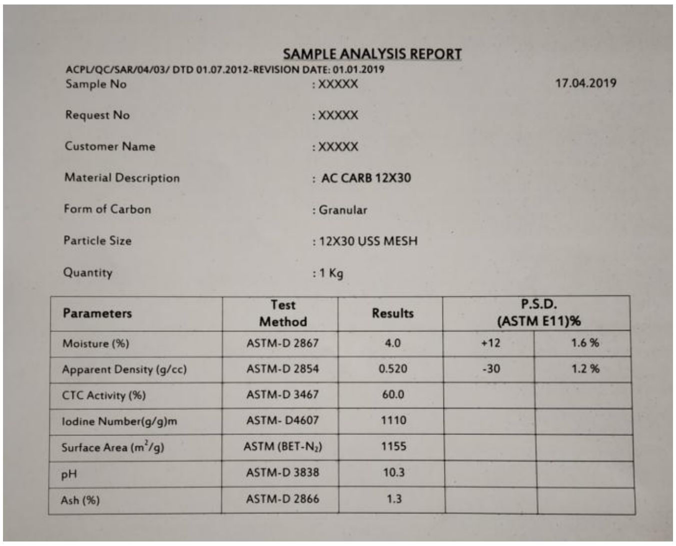
Fig -2 4x 30 size, impregnated coconut shell activated carbon.

Table-2: Consolidated lab report of CSAC samples

Parameters of Adsorbent							
	Test Method		ASTM D 2867	ACPLTM	ASTM 2854	ASTM D 6556	ASTMD 4607
Sl No	Sample	Particle size	Moisture %	% of impregnation	Apparent Density g/cc	BET Surface area m2/g	Iodine value mg/g
1	CSAC	4x30	7		0.480	1128	1125
2	5%K2CO3ImCSAC	4 x 30	10	5.02	0.560	1085	1070
3	10% K2CO3 Im CSAC	4x30	11	10.02	0.580	960	964
4	15%K2CO3 Im CSAC	4x30	11.5	15.03	0.610	850	862
5	20% K2CO3Im CSAC	4x30	12.01	20.02	0.624	780	785
6	5%KOH Im CSAC	4x30	12.2	4.98	0.528	1035	1051
7	10%KOH Im CSAC	4x30	11.6	10.04	0.580	975	980
8	15%KOH Im CSAC	4x30	12.4	15.01	0.610	861	870
9	20%KOH Im CSAC	4x30	11.8	20.06	0.630	790	800
10	10.01 %Cu Im CSAC	4x30	12.3	12.01	0.595	960	948
11	10%NaOH Im CSAC	4x30	12.6	10.04	0.560	970	950
12	15%NaOH Im CSAC	4x30	11.2	15.01	0.590	850	870
13	20%NaOH Im CSAC	4x30	12.6	20.04	0.630	800	790
14	10%H2SO4 Im CSAC	4x30	11.2	10.03	0.575	979	965
15	20%H2SO4 Im CSAC	4x30	11.2	10.03	0.574	978	965
16	10.02 %HCL Im CSAC	4x30	11.4	12	0.560	1040	1048
17	10%KMnO4 Im CSAC	4x30	12.03	11.6	0.590	980	950

4.1 FINAL INTERRUPTION

Coconut Shell can be used as the perfect raw material to prepare activated carbon with high surface area for CO2 (SO2, NO etc) adsorption rate. Among the prepared activated carbons, CS produces the activated carbon with high surface area (1128 m2/g) using physical activation techniques. The best of physical and chemical activated carbon were loaded with different alkali to further improve their adsorption.



SAMPLE ANALYSIS REPORT

ACPL/QC/SAR/04/03/ DTD 01.07.2012-REVISION DATE: 01.01.2019

Sample No : XXXXX 17.04.2019

Request No : XXXXX

Customer Name : XXXXX

Material Description : AC CARB 12X30

Form of Carbon : Granular

Particle Size : 12X30 USS MESH

Quantity : 1 Kg

Parameters	Test Method	Results	P.S.D. (ASTM E11)%	
Moisture (%)	ASTM-D 2867	4.0	+12	1.6 %
Apparent Density (g/cc)	ASTM-D 2854	0.520	-30	1.2 %
CTC Activity (%)	ASTM-D 3467	60.0		
Iodine Number(g/g)m	ASTM- D4607	1110		
Surface Area (m²/g)	ASTM (BET-N₂)	1155		
pH	ASTM-D 3838	10.3		
Ash (%)	ASTM-D 2866	1.3		

Fig – 3 Certificate of Analysis of Carbon used is being attached herewith.

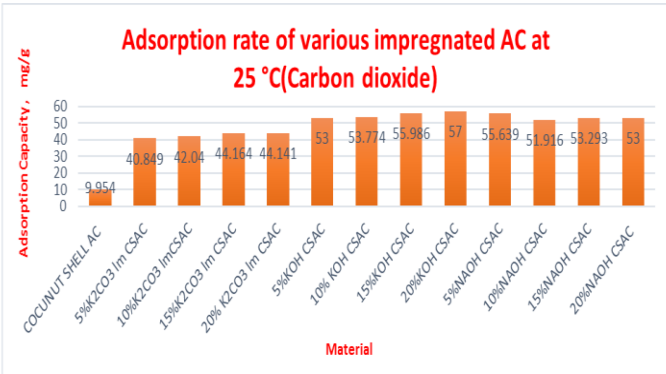
4.2 Comparison of Adsorption capacity of samples at 25°C, 35°C and 45°C

Adsorption capacity of CSAC impregnated with different materials at different concentrations of 5%,10%,15% and 20% at temperatures25°C,35°Cand 45°C are tabulated in tables below:

Table- 3 Adsorption capacity of samples at 25°C(Carbon dioxide)

Comparison of adsorbtion capacity of impregnated activated carbon at 25° C and flow rate of 50ml/min

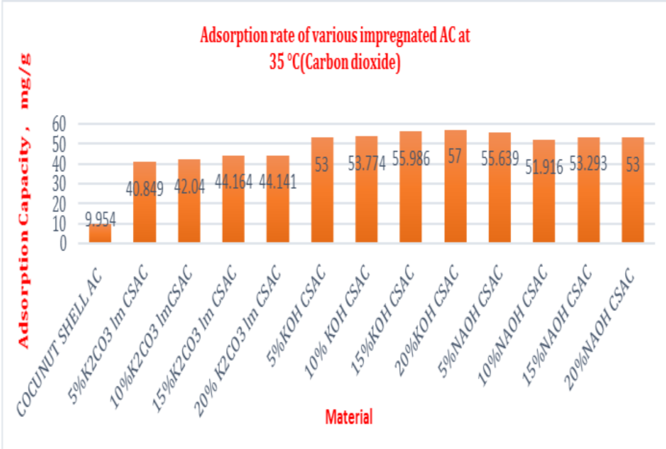
Materia ls	part icle size	Mass of AC in bed	Mass of AC afterad sorpt ion	Mass of adsorb ate,C O2	Mass/ gram	Adsorp ti on Capacit y , mg/g
COCUN UT SHELL AC	4x3 0	10.9 8	22.457	11.477	1.045	10.453
5%K2C O3 lm CSAC	4x3 0	10.3 4	67.11	56.77	5.490	54.903
10%K2 CO3 lmCSAC	4x3 0	10.5 47	68.23	57.683	5.469	54.691
15%K2 CO3 lm CSAC	4x3 0	10.6 9	69.11	58.42	5.465	54.649
20% K2CO3 lm CSAC	4x3 0	10.8 1	73.12	62.31	5.764	57.641
5%KO H CSAC	4x3 0	11.0 4	96.023	84.983	7.698	76.977
10% KOH CSAC	4x3 0	11.2 1	97.68	86.47	7.714	77.136
15%KO H CSAC	4x3 0	11.4 6	100.97	89.51	7.811	78.106
20%KO H CSAC	4x3 0	11.7 3	104.64	92.91	7.921	79.207
5%NA OH CSAC	4x3 0	11.0 0 4	88.012	77.008	6.998	69.982
10%NA OH CSAC	4x3 0	11.0 8 7	89.21	78.123	7.046	70.464
15% NAOH CSAC	4x3 0	11.2 3 3	91.56	80.327	7.151	71.510
20%NA OH CSAC	4x3 0	11.3 2	93.16	81.84	7.230	72.297



At 25°C maximum adsorption capacity of CSAC & impregnated CSAC with K2CO3, NaOH and KOH are found to be 10.453,57.641, 72.297 & 79.207 mg/g for a concentration of 20mol% impregnation.

Table – 4: Adsorption capacity of samples at 35°C (Carbon dioxide).

Comparison of adsorbtion capacity of impregnated activated carbon at 35 °C and flow rate of 50ml/min						
Materials	particle size	Mass of AC in bed	Mass of AC after adsorption	Mass of adsorbate, CO2	Mass/gram	Adsorption Capacity , mg/g
COCUNUT SHELL AC	4x30	10.9	22.01	11.11	1.019	10.193
5%K2CO3 lm CSAC	4x30	10.21	58.231	48.021	4.703	47.033
10%K2CO3 lmCSAC	4x30	10.52	61.89	51.37	4.469	48.831
15%K2CO3 lm CSAC	4x30	10.69	63.65	52.97	4.960	49.597
20% K2CO3 lm CSAC	4x30	10.86	66.213	55.353	5.097	50.970
5%KOH CSAC	4x30	11.45	79.21	67.76	5.918	59.179
10% KOHCSAC	4x30	11.21	81.12	69.91	6.236	62.364
15%KOH CSAC	4x30	11.51	83.21	71.7	6.229	62.294
20%KOH CSAC	4x30	11.72	85.1	73.39	6.262	62.619
5%NAOH CSAC	4x30	11.25	72.12	60.87	5.411	54.107
10%NAOH CSAC	4x30	11.07	72.53	61.46	5.552	55.519
15% NAOH CSAC	4x30	11.31	74.98	63.67	5.630	56.295
20%NAOH CSAC	4x30	11.33	76.89	65.56	5.786	57.864

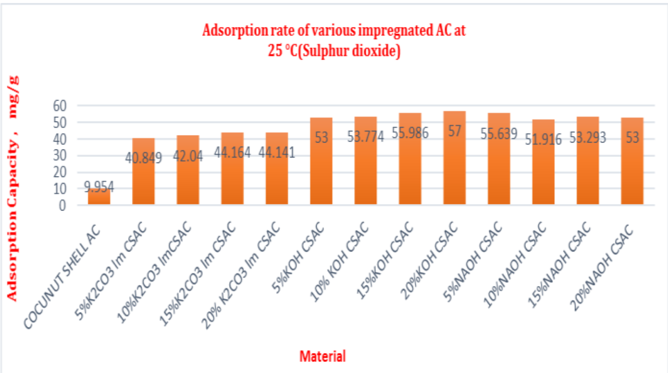


At 35°C maximum adsorption capacity of CSAC & impregnated CSAC with K2CO3, NaOH and KOH are found to be 10.193, 50.970, 57.864 & 62.619 mg/g for a concentration of 20mol% impregnation. Similar test can be done for 45 °C

Table- 5 Adsorption capacity of samples at 25°C (Sulphur dioxide)

Comparison of adsorbtion capacity of impregnated activated carbon at 25° C and flow rate of 50ml/min						
Materials	particle size	Mass of AC in bed	Mass of AC after adsorption	Mass of adsorbate, SO2	Mass/gram	Adsorption Capacity , mg/g
COCUNUT SHELL AC	4x30	10.98	27.546	16.566	1.509	15.09
5%K2CO3 lm CSAC	4x30	10.34	72.33	61.99	5.995	59.95
10%K2CO3 lmCSAC	4x30	10.547	73.13	62.583	5.933	59.33
15%K2CO3 lm CSAC	4x30	10.69	74.12	63.43	5.934	59.34

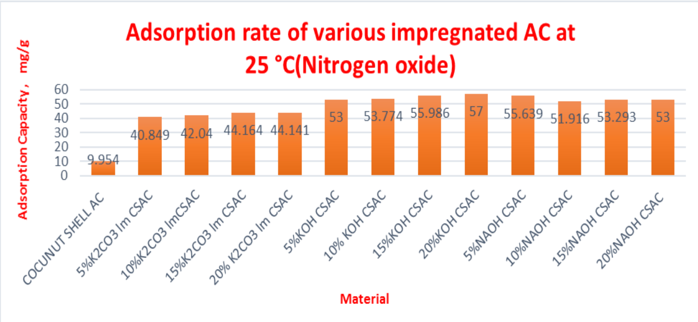
20% K2CO3 lm CSAC	4x30	10.81	78.22	67.41	6.236	62.36
5%KOH CSAC	4x30	11.04	101.020	89.98	8.151	81.51
10% KOH CSAC	4x30	11.21	102.98	91.77	8.186	81.86
15%KOH CSAC	4x30	11.46	105.13	93.67	8.174	81.74
20%KOH CSAC	4x30	11.73	110.01	98.28	8.379	83.79
5%NAOH CSAC	4x30	11.0 04	93.014	82.01	7.453	74.53
10%NAOH CSAC	4x30	11.0 87	95.67	84.583	7.629	76.29
15% NAOH CSAC	4x30	11.2 33	97.45	86.217	7.675	76.75
20%NAOH CSAC	4x30	11.32	99.01	87.69	7.746	77.46



At 25°C maximum adsorption capacity of CSAC & impregnated CSAC with K2CO3, NaOH and KOH are found to be 15.09, 62.36, 77.46 & 83.79 mg/g for a concentration of 20mol% impregnation. Similar datas are computed for 35 °C and 45°C and found maximum to be absorbed for 25 °C.

Table – 6 Adsorption capacity of samples at 25°C (Nitrogen oxide).

Comparison of adsorbtion capacity of impregnated activated carbon at 25° C and flow rate of 50ml/min						
Materials	particle size	Mass of AC in bed	Mass of AC after adsorption	Mass of adsorbate , NO	Mass/gram	Adsorption Capacity , mg/g
COCUNUT SHELL AC	4x30	10.98	24.567	13.587	1.237	12.37
5%K2CO3 lm CSAC	4x30	10.34	70.121	59.781	5.782	57.82
10%K2CO3 lmCSAC	4x30	10.547	71.01	60.463	5.733	57.33
15%K2CO3 lm CSAC	4x30	10.69	72.12	61.43	5.746	57.46
20% K2CO3 lm CSAC	4x30	10.81	75.14	64.33	5.951	59.51
5%KOH CSAC	4x30	11.04	99.043	88.003	7.971	79.71
10% KOH CSAC	4x30	11.21	100.78	89.57	7.990	79.90
15%KOH CSAC	4x30	11.46	104.07	92.61	8.081	80.81
20%KOH CSAC	4x30	11.73	107.96	96.23	8.204	82.04
5%NAOH CSAC	4x30	11.004	92.112	81.108	7.371	73.71
10%NAOH CSAC	4x30	11.087	95.51	84.423	7.615	76.15
15% NAOH CSAC	4x30	11.233	94.56	83.327	7.418	74.18
20%NAOH CSAC	4x30	11.32	97.16	85.84	7.583	75.83



At 25°C maximum adsorption capacity of CSAC & impregnated CSAC with K2CO3, NaOH and KOH are found to be 12.37,59.51, 75.83 & 82.04 mg/g for a concentration of 20mol% impregnation. Similar datas are computed for 35 °C and 45°C and found maximum to be absorbed for 25 °C.

5. CONCLUSION

Air is increasingly getting polluted day by day. It seems that there is no end to it. Unless controlled at this stage itself our city will become a place where from nobody escapes. The capital city of Delhi is only an indication to this. The next city can be Kochi. A possible solution to this is given to us by the Creator himself and that is Activated Coconut Carbon was found to be a very good material for adsorbing common pollutants present in industrial area. It has gained significant interest due to their low cost, low regeneration energy, and ecofriendly characteristics. The current study was focused on the systematic development of CSAC using different types of chemical compounds and adsorption conditions.

The fixed-bed adsorption of CO2, SO2 and NO from CO2, SO2 and NO /N2 mixtures on activated carbon was studied. The single-component adsorption equilibrium of CO2,SO2 and NO and N2 were measured at 25 °C, 35 °C and 45 °C. According to the experimental data results, it was confirmed that the micro pore diffusion is the controlling step for CO2, SO2 and NO adsorption on the microporous activated carbon. From the study it is clear that the adsorption capacity of activated carbon increases with decrease in temperature and also with increase in concentration of impregnation.

Overall, the coconut shell derived ACs showed the best adsorption capacity of 79.207 mg/g, 83.79 mg/g, 82.04 mg/g (at 20 mol % CO2, SO2 and NO in N2 and at decreasing temperature of 25°C). KOH activated carbon with higher surface area and porosity can be considered as the best option for CO2, SO2 and NO capture at atmospheric pressure and low temperature of 25°C for CO2, SO2 and NO.

The capacity of activated carbon to adsorb the pollutants is usually around 10% by weight of the plane carbon. The reason for selecting this material was due to the fact that coconut shells are easily available in Kerala and relatively cheap. However, activated carbon adsorbents are fully regenerated at 100-150 °C while zeolite usually cannot gain their initial adsorption capacity. CO2 SO2 and NO uptake decreases with temperature due to the exothermic nature of CO2, SO2 and NO adsorption.

Thus activated carbon filters are the solution to absorb the smell and other pollutants present in the air. On impregnating, activated coconut carbon with suitable chemicals, all the pollutants can be effectively removed.

Thus we suggest,

Making filters of activated carbon impregnated with 20% KOH for acidic vapours like CO2, SO2 and NO. These filters can be fixed at the outlet of the factories polluting the atmosphere and also be used in vehicles at the outlets of engines and before the carburetor.

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