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Study and Analysis of Regenerated Activated Carbon Filter for removal of Nitrogen Dioxide from air

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Abstract: In present, there are various techniques available for removal of Nitrogen Dioxide by Activated Carbon but in this paper regenerated commercially available activated carbon is used for removal of Nitrogen Dioxide by adsorption technique. For regeneration of activated carbon steam activation is done at specific temperature. Most favorable results have been achieved by using regenerated activated carbon for reducing known concentration of 1000 µg/m3 Nitrogen Dioxide.
Keywords: Activated Carbon (AC), Nitrogen Dioxide, Adsorption technique, Steam activation, Adsorption

I. INTRODUCTION

Indoor air quality has received immense attention in the early 1990s. This is because studies [1] showed that the level of pollutants in indoor environment is actually higher than in outdoor environment. In addition, people generally spend more than 80% of their time in indoors, which contributes a higher risk from inhalation of pollutants than outdoors [2]. In 1995, USEPA identified indoor air pollution is one of the top environmental risk [3]. In general, three methods are suggested to improve indoor air quality, namely source control, increase ventilation and air cleaning. Source control is often ungovernable and unavoidable in metropolis such as Hong Kong. For instance, vehicular exhaust from nearby traffic [4], building materials [6] and the use of cooking utensils [5] were inevitable sources of indoor air pollutants. Increase ventilation might even transport more pollutants from outdoor environment [1].

Thus, air cleaning remains to be the most feasible option to improve indoor air quality. Indoor air quality (IAQ) was ranked by the US Environmental Protection Agency in the top five public health concerns. Indoor air pollutants such as fine particles, bioaerosols and gaseous compounds appear to be important contributors to poor air quality in domestic and various industrial settings, having a negative impact toward human health i.e. causing discomfort, acute and chronic diseases. ‘‘Sick
building syndrome’’ (SBS), manifested by ocular, nasal, coetaneous irritations, allergies, respiratory dysfunction, headache and fatigue is one of the most typical indicators of poor indoor air quality. The adsorption characteristics of activated carbon have been used for a number of years in air cleaning applications. Manufactured as grains or powdered material, activated carbon is particularly suited for the adsorption and removal of gases and odours present in the air. Here an attempt has been made for reducing NO2 concentration at domestic level by using simple AC adsorption technique for this control volume\discharge limit of NO2 generation for specific contact time we have used whose further details are given in material and method.

Table No: 1. National Ambient Air Quality Standards

Pollutants	Time weighted average	Concentration in	Ambient air	
		Industrial, Residential, Rural and other Area	Ecologically sensitive area (notified by central government)	Method of measurement
Nitrogen Dioxide (NO2), µg/m3	Annual * 24 Hours **	40 80	30 80	-Jacob & Hochheiser modified (NaOH-NaAsO2) Method -Gas Phase Chemiluminescence

* Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

II. METHODS

For sampling and testing of NO2 modified Jacob & Hochheiser Method (IS 5182 Part 6 Methods for Measurement of Air Pollution: Oxides of nitrogen) as per CPCB is used .In this method ambient nitrogen dioxide (NO2) is collected by bubbling air through a solution of sodium hydroxide and sodium arsenite. The concentration of nitrite ion (NO2) produced during sampling is determined colorimetrically by reacting the nitrite ion with phosphoric acid, sulfanilamide, and N-(1 naphthyl)-ethylenediamine dihydrochloride (NEDA) and measuring the absorbance of the highly coloured azo-dye at 540 nm.

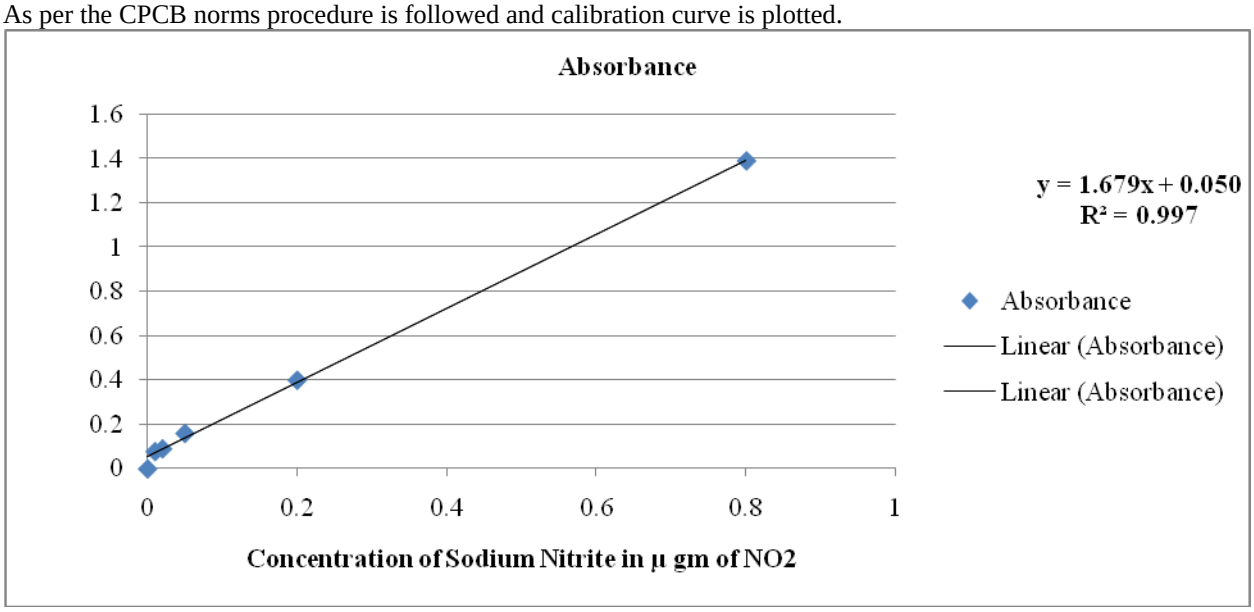
For the sampling of NO2 a limited amount of NO2 is generated by trial and error method for which 1 ml Nitric acid and 0.1 mg of copper is used gives 1020.93µg/m3 concentration this concentration gives stable results that's why it is selected for the further analysis.

III. PROCEDURE FOR REGENERATION USED ACTIVATED CARBON:

Fill the water in Autoclave and assure that it is below the steel bucket. Then place the steel bucket in Autoclave. Fill the used activated carbon in borosilicate glass beaker and placed that beaker in steel bucket. After placing the Activated Carbon close the Autoclave tightly with the arrangement given and close all valves. Fix the temperature at 110 degree celsius, pressure at 15 psi for 20 minutes. After 20 minutes switch off the Autoclave and open it and release all the steam inside. Then place that Activated carbon in Oven for 24 hours. After 24 hours of drying, regeneration of Activated carbon is done and it is ready to use in filter.

Graph No: 1. Calibration Curve

As per the CPCB norms procedure is followed and calibration curve is plotted.



B. Procedure:

IV. RESULTS

For getting constant concentration of NO2 0.1 gm of Copper, 1ml of Nitric Acid, 5 minutes of sampling duration, 25.2 degree Celsius temperature is fixed.

Table No: 2. Before Using Filter:

Sr. No.	Abs. of Sample (As)	Abs. of Reagent blank (Ab)	Vol. of Air Sampled (Va) (m3)	Vol. of Sample (Vs)ml	Vol. of aliquot taken for analysis (Vt)	Calibration factor	Conc. of NO2 in µg/m3
1	0.471	0.06	0.06	30	10	0.596	1004
2	0.454	0.06	0.06	30	10	0.596	962.1
3	0.472	0.06	0.06	30	10	0.596	1006
4	0.477	0.06	0.06	30	10	0.596	1018
5	0.481	0.06	0.06	30	10	0.596	1028
6	0.48	0.06	0.06	30	10	0.596	1026
7	0.46	0.06	0.06	30	10	0.596	976.8
8	0.445	0.06	0.06	30	10	0.596	940.1
9	0.476	0.06	0.06	30	10	0.596	1016
10	0.467	0.06	0.06	30	10	0.596	993.9
						Average :	997

Table No: 3. After Using Filter:

Sr. No.	Abs. of Sample (As)	Abs. of Reagent blank (Ab)	Vol. of Air Sampled (Va) (m3)	Vol. of Sample (Vs)ml	Vol. of aliquot taken for analysis (Vt)	Calibration factor	Conc. of NO2 in µg/m3
1	0.078	0.06	0.06	30	10	0.596	43.95
2	0.085	0.06	0.06	30	10	0.596	61.05
3	0.087	0.06	0.06	30	10	0.596	65.93
4	0.089	0.06	0.06	30	10	0.596	70.82
5	0.087	0.06	0.06	30	10	0.596	65.93
6	0.064	0.06	0.06	30	10	0.596	9.768
7	0.067	0.06	0.06	30	10	0.596	17.09
8	0.07	0.06	0.06	30	10	0.596	24.42
9	0.08	0.06	0.06	30	10	0.596	48.84
10	0.107	0.06	0.06	30	10	0.596	114.8
						Average:	52.26

Average Efficiency of filter = (997-52.26)/997)*100
=94.76%

V. RESULT AND DISCUSSION:

Hence from the above results and experimental work done it has been observed that the indoor air quality can be better improved with AC filter. Before going for any random selection of parameters, as pre-planned method, trials were carried out for getting consistent result based on constant reaction time amount of chemical and surrounding temperature.

For getting consistent NO2 at constant concentration numbers of tests were performed out of which the best result (0.1gm copper, 1ml of Nitric acid, 5 minute sampling duration and 25.2 degree Celsius temperature, etc) were

selected. Once this was finalized, for further analysis the secondary importance was given for removal of gaseous pollutant by devising an air filter and checking its efficiency. For that the AC to be used for making a filter was selected from the domestic household water purifiers. The discarded AC candles were taken into consideration for making air filter. The regeneration was carried out at pressure 15 psi for duration of 20 minutes. The obtained activated carbon is used for making air filter module. The initial average concentration of NO2 for air filter module was 997 µg/m3 with five minutes of sampling duration it gives the final concentration of NO2 52.26 µg/m3 with 94.76% removal efficiency. Hence from the results and experimental analysis the regenerated AC filter shows very good performance with higher efficiency for removal of NO2 gas. For the experimental point of view though the initial concentration was taken around 1000 µg/m3 which actually is not the practical case. Hence one can consider higher efficiencies of these filters for the real time and place for reducing concentration of NO2 and can get higher and higher results than this experimental work.

VI. CONCLUSION

After various trials it has been found that a consistent production of NO2 with 0.1gm of copper and 1ml of Nitric acid over 5 minutes of sampling time can produce average NO2 of 997µg/m3. The regenerated AC filter gives 94% NO2 removal efficiency. Also by referring the results and removal efficiency, it is found that efficiency of % removal goes on increasing with an increase in length of air filter module. As the discarded AC is used after regenerating gives the best removal efficiency which reduces the cost of treatment itself.

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