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Studies on Activated Carbon Produced From Waste Tires

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Abstract: *The disposal of waste tires is increasing day by day at an exponential rate. These waste tires cover large areas of valuable land besides creating the possibility of fire accidents. The world produces 1.5 billion scrap tires annually with India and China accounting for nearly 41% of total production. A viable solution to this environmental problem is to thermally reprocess these waste tires into a useful product like activated charcoal. In this work waste tires from three different sources were burnt and the carbon black produced was studied for use as a possible adsorbent. Purification methods were used which increased the surface area and decreased the amount of contaminants present in the powdered carbon. BET analysis was performed which provided further information on the obtained solid such as specific surface area porosity total pore volume and pore size distribution.*

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I. Introduction:

The environmentally acceptable management of waste tires, which form a category of solid waste, poses a problem of growing concern. In the absence of cost-effective technology to completely reutilize all the materials used in tire manufacture , disposal in landfills remains the most viable solution. However this presents its own set of practical problems. The properties that make them desirable as tires, most notably durability, also make their disposal and reprocessing difficult as they are almost immune to biological degradation. Pyrolysis might be an environmentally friendly process to transform used tires Into useful products. This process can be used to obtain gas, oil and pyrolytic black from used tires. Activated carbon is used widely in water purification batteries and fuel cells. In this work waste tires from three different sources namely bicycles, scooters and cars were burnt to produce carbon black which was studied as a likely adsorbent. The principal aim of this work was to prepare activated carbon from waste tires for adsorbing relatively large molecules. Subsequent improvement of the properties of the obtained carbon was carried out using acidic and basic treatment. Adsorption characteristics of the obtained carbon were also studied with the aim of using it as a suitable adsorbent.

SAMPLE PREPARATION TREATMENT AND ANALYSIS

Tires from three different sources ,namely bicycles scooters and cars were used in this study. The used tires were chopped into bits of uniform size and incinerated in a furnace till carbon black was obtained. The samples of carbon black were analyzed by performing the tests described below.

DENSITY

The density of the prepared activated carbon was determined by weighing 10cc of the sample using a graduated cylinder.

ACTIVITY USING METHYLENE BLUE ADSORPTION METHOD

Exactly 0.1 gm of the prepared activated carbon sample was added to an aqueous solution of 20ppm methylene blue pigment. The solution was shaken for 24 hours at an average temperature of 25C. The absorbance of the solution was determined using a UV-Visible spectrophotometer. The procedure was repeated with different tire samples for comparison. The final concentration of methylene in each activated carbon sample was calculated as the number of milligrams of methylene blue adsorbed by one gram of carbon.

ACID DEMINERALIZATION

Acid demineralization was conducted to decrease inorganic impurities as well as remove undesired ash content in carbon black. 1N HCl and H_2SO_4 were used for acid demineralization which was performed at room temperature for a period of 24 hours.

This was followed by filtration and the samples were thoroughly rinsed with distilled water to remove the residual acid. The samples were then dried in an oven at 110C for 24 hours followed by grinding and sieving through a 45mm sieve. The activation step was completed by drying the oven treated carbon black in a furnace at 900C.

CHEMICAL ACTIVATION WITH KOH

The removal of sulphur in tires improves the adsorption properties of activated carbon. 5gms of activated carbon were mixed with 250mlof1N KOH. The mixture was heated at temperatures between 70-80C for a period of 30-40 minutes with constant stirring, filtered using a filter paper and further washed with distilled water.

The filtered sample was further dried in an oven at 100C for 24 hours washed By stirring with 30ml of 5N HCl for 12 hours. This suspension was then centrifuged at 3500 rpm for 15 minutes washed several times with distilled water and this step was repeated several times. The samples were then dried in an oven at 100C.

BET ANALYSIS

Gas adsorption analysis was used for porosity and sample surface area measurements. The process basically involves exposing solid materials to gases or vapors at varying conditions and evaluating the weight uptake or sample volume. Analysis of this data provides information on the physical characteristics of the solid including specific surface area, porosity, total pore volume and pore size distribution.

A known weight of sample (35mg) was taken in a test tube. A glass rod along with a filter was inserted in the test tube to prevent the sample from entering into the equipment. The test tube was connected to the degasifying unit to remove the atmospheric moisture by passing helium gas at 250C for a period of 3 hours. The test tube was then inserted into the BET equipment and left for a period of 20 hrs. N2 gas was passed and liquid N2 was used to maintain the cryogenic temperature(77K).

PRESENTATIONOFEXPERIMENTAL RESULTS AND DISCUSSION

Sample Data are presented for untreated and treated bicycle tires.

Detailed data tables on bicycle, scooter and car tires are presented in the report of Sohaib Imam et. Al.(1)

RESULTS FOR BICYCLE TIRES

SAMPLE BEFORE TREATMENT

BET TEST

Sample weight	0.0309gm
Standard volume	24.656cc
Dead volume	23.114cc
Equilibrium time	0.0sec
Adsorptive	N2
Apparatus temperature	0.0C
Adsorption temperature	77K
Saturated vapor pressue	94.47kPa
Adsorption cross sectional area	0.162 sq m

TABLE 1: ADSORPTION DATA FOR BICYCLE TIRES (UNTREATED SAMPLE)

NO	Pi kPa	Pe kPa	Pe2 kPa	Po kPa	p/po	Va Cc(STP)/gm
1	0	0.1883	0	94.341	0.0019956	1.6475
2	0	0.4745	0	94.388	0.0050267	2.1988
3	0	1.9274	0	94.342	0.02043	3.2268
4	0	3.9361	0	94.346	0.04172	3.9168
5	0	5.442	0	94.328	0.05769	4.3269

TABLE 2: DESORPTION DATA FOR BICYCLE TIRES (UNTREATED SAMPLE)

NO	Pi kPa	Pe kPa	Pe2 kPa	Po kPa	p/po	Va Cc(STP)/gm
1	0	83.992	0	94.346	0.8903	21.798
2	0	78.303	0	94.346	0.83	16.123
3	0	73.865	0	94.399	0.7825	14.217
4	0	69.341	0	94.442	0.7342	12.946
5	0	64.782	0	94.456	0.6858	12.324s

TABLE 3: BET PLOT DATA FOR BICYCLE TIRES (UNTREATED SAMPLE) SAMPLE POINTS

NO	p/po	p/Va(po-p)
0	0	0
1	0.00199	0.00121
2	0.00503	0.00230
3	0.02043	0.00646
4	0.04172	0.01111
5	0.05770	0.01415

RESULTS FOR BICYCLE TIRES
SAMPLE AFTER TREATMENT
BET TEST

Sample weight	0.0353gm
Standard volume	24.656cc
Dead volume	26.143cc
Equilibrium time	0.0sec
Adsorptive	N2
Apparatus temperature	0.0C
Adsorption temperature	77K
Saturated vapor pressue	100 kpa
Adsorption cross sectional area	0.162 sq m

TABLE 4: ADSORPTION DATA FOR BICYCLE TIRES (TREATED SAMPLE)

NO	Pi kPa	Pe kPa	Pe2 kPa	Po kPa	p/po	Va Cc(STP)/gm
1	0	0.9770	0	100.0	0.00097	3.3316
2	0	0.5177	0	100.0	0.00517	5.0455
3	0	1.9756	0	100.0	0.01976	6.7801
4	0	4.1197	0	100.0	0.04110	8.0256
5	0	5.7424	0	100.0	0.05742	8.7191

TABLE 5: DESORPTION DATA FOR BICYCLE TIRES (TREATED SAMPLE)

NO	Pi kPa	Pe kPa	Pe2 kPa	Po kPa	p/po	Va Cc(STP)/gm
1	0	89.419	0	100.0	0.8942	64.046
2	0	86.516	0	100.0	0.8652	48.855
3	0	84.297	0	100.0	0.8430	41.810
4	0	83.118	0	100.0	0.8312	39.260
5	0	77.950	0	100.0	0.7795	32.402

TABLE 6: BET PLOT DATA FOR BICYCLE TIRES (TREATED SAMPLE) SAMPLE POINTS

NO	p/po	p/Va(po-p)
0	0	0
1	0.000977	0.00029
2	0.005177	0.00103
3	0.019756	0.00297
4	0.041197	0.00535
5	0.057424	0.00698

II. Conclusion

This project is an attempt to obtain and characterize activated carbon from waste tires. Three sources of tires namely bicycle, scooter and car tires were used as experimental samples. The cut tires were processed and a BET analysis was performed on treated and untreated samples. Adsorption isotherms were generated and presented (1). The adsorption isotherms obtained are of type II indicating multi-layer formation after completion of monolayer. Since surface area Is gauged by monolayer coverage of N_2 on the surface only the initial part of the isotherm is used for analysis. Post treatment shows an increase in surface area making it suitable for treatment of waste. Sample data on bicycle tires are also presented. In conclusion we can say that producing activated Carbon from waste tires is a viable way of utilizing waste tires.

References

[1]. ANALYSIS AND IMPROVEMENT OF PROPERTIES OF ACTIVATED CARBON FROM WASTE TIRES BE Project report prepared by Sohaib Imam, Syed Ahmed Jaseem, Mohammed Ahmed and Priyesh Singh, BMS College of Engineering (Affiliated to VTU), Department of Chemical Engineering, May 2018.

RELEVANT NOMEMCLATURE

P Partial pressure of adsorbate gas in equilibrium with the surface at 77.4K (boiling point of liquid nitrogen), pascals.

Po Saturated pressure of adsorbate gas in pascals.

Va Volume of gas adsorbed at STP, cu mm.

Vm Volume of gas adsorbed at STP to produce an apparent monolayer on the sample surface, cu mm.

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