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ADSORPTION OF SO_2 BY MARBLE CHIPS

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ABSTRACT

The present study deals with the experimental investigations carried out for controlling SO_2 by using marble chips (ore of calcium carbonate). It was found that the amount of gas adsorbed by marble chips is 85% at low concentrations and 32% at high concentrations. The experiments are conducted with respect to particle size, with respect to contact time, with respect to initial concentration of SO_2, and with respect to marble chips dosages. The chemical component present in the marble chips is calcium carbonate. The calcium carbonate is highly metallic in nature and they are very stable because of the smaller atomic size and highly electropositive in nature. The calcium carbonate decomposition is favorable above 1000^oC; the adsorption observed in the present conditions indicates physical adsorption. The percentage removal of SO_2 increased with decrease in size, which indicates that greater the surface area, greater is the adsorption. The reaction between marble chips and SO_2 followed first order kinetics and the optimum contact time for the reaction to occur is 60 minutes. The percentage removal of SO_2 increased with increase in marble dosages. The optimum removal of marble chips is achieved by 8 g of adsorbent.

Key words: Adsorbent, Adsorbate, Uni-molecular layer, SO_2, Contact time.

INTRODUCTION

SO_2 is very harmful and its effects may be felt at the source and extended to the far places. SO_2 pollution is becoming an international problem. Today one of the wonders of world, Taj Mahal is slowly dying and pleading before its right to survive. Taj Mahal is losing its luster and developed yellow spots at various places on its translucent white surface. Many scientists and environmentalists found that the greatest polluter causing damage to the Taj Mahal has been refinery at Mathura, which has started functioning in the early 1980's and which is releasing SO_2. By studying all the ill effects caused by SO_2 on Taj Mahal which is made up of marble, Marble chips are selected as adsorbent for the removal of SO_2 by adsorption techniques.

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Material and methods

Selection of adsorbent

The present work, examines the possibility of using a well-known physico-chemical method like adsorption for the removal of SO_2 from air. The initial screening studies have been carried by introducing a known amount of adsorbent into the aqueous solution of SO_2. It was found that marble chips has large capacity to adsorb SO_2. Marble chips and lime stone are the important ores of calcium carbonate. Calcium carbonates ores[4,5,7,8,18,22-26] can be used as adsorbents for controlling sulphur dioxide.

For the present studies adsorption techniques are selected because SO_2 gas and it is incombustible and it is present in very low concentrations. The experiments are carried with respect to particle size, with respect to contact time, with respect to initial concentration of SO_2 gas and with respect to marble chips dosages.

Effect of particle size and contact time

Contact time plays an important role in designing a system. SO_2 gas diluted with N_2 gas of definite concentration is made to pass through a catalytic tube, which consists of 2 g of marble chips. The initial (before adsorption) and final (after adsorption) concentration is determined at regular intervals of time i.e. 15, 30, 45, 60, 120 minutes. The experiments are performed for two particle sizes i.e. 250 mic and 500 mic. The results are given in Table 1, Table 2 and Fig. 1.

Table 1: Variation of contact time between marble chips (500 mic) and SO_2

Particle size: 500 mic
Amount of adsorbent: 2 g
Volume of the gas: 250 mL
Flow rate: 60 mL/min
Surface area: 84 sq. cms

S. No.	Contact time (min)	Initial conc. (mg/m^3)	Final conc. (mg/m^3)	Removed gas	% Removal	% Removal per sq. cms
1	15	78	78	0	0	0
2	30	78	70.4	7.6	9.74	0.1159
3	45	78	67.6	10.4	13.33	0.1586
4	60	78	62.4	15.6	20	0.2380
5	120	78	62.4	15.6	20	0.2380

Table 2: Variation of contact time between marble chips (250 mic) and SO_2

Flow rate: 60 mL/min
Particle size: 250 mic
Amount of adsorbent: 2 g
Volume of the gas: 250 mL
Surface area: 102 sq. cms

S. No.	Contact time (min)	Initial conc. (mg/m^3)	Final conc. (mg/m^3)	Removed gas	% Removal	% Removal per sq. cms
1	15	78	72.8	5.2	6.6	0.0647
2	30	78	67.6	10.4	13	0.1274
3	45	78	20.8	26	33	0.3235
4	60	78	20.8	31.2	40	0.3921
5	120	78	0.8	31.2	40	0.3921

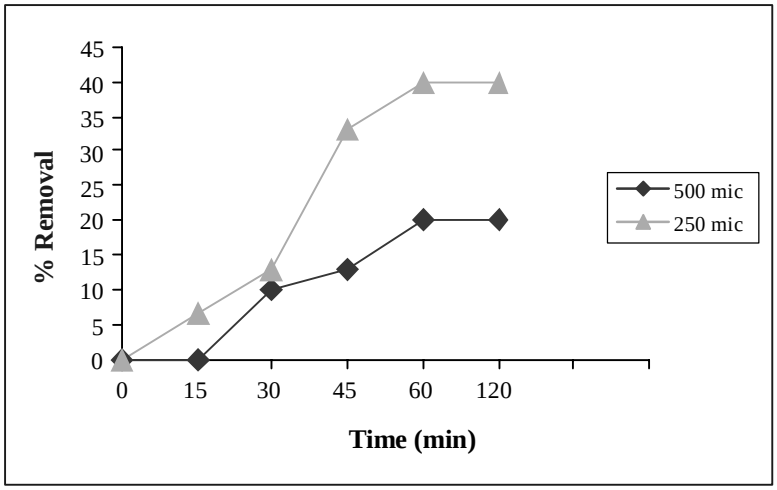

Fig. 1: Variation of contact time

Effect of initial SO_2 gas concentration

Different concentrations of SO_2 gas diluted with N_2 gas is made to pass through a catalytic tube, which consists of a fixed amount of adsorbent. The experiments are carried out with 250 mic particle size and contact time is fixed depending upon contact time experiments. The results are given in Table 3 and Fig. 2.

Table 3: Variation of initial concentrations on marble chips

Particle size: 250 mic
Flow rate: 60 mL/min
Amount of adsorbent: 2 g
Volume of SO_2 gas: 250 mL

S. No.	Initial conc. (mg/m^3) C1	Final conc. (mg/m^3) C2	% Removal	Amount adsorbed A	A*100/C1
1	26	7.8	70	18.2	30
2	52	24.96	52	27.04	48
3	78	46.8	40	31.2	60
4	104	66.3	36.2	37.7	63.75
5	130	119.6	8	37.7	92

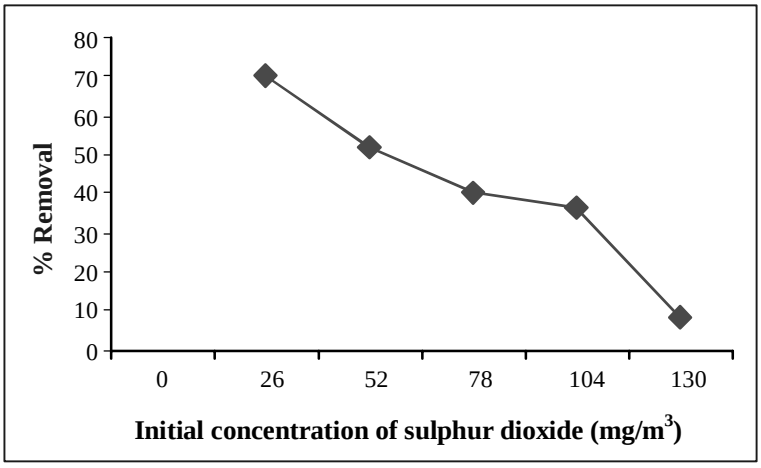

Fig. 2: Variation of initial concentration of sulphur dioxide

Effect of marble chips dosages

Definite concentration of SO_2 gas is made to pass through different amounts of adsorbent dosages i.e. 2 g, 4 g and 6 g, respectively. The experiments are carried out with the 250 mic particle size and contact time of one hour is maintained.

RESULTS AND DISCUSSION

The optimum contact time for the removal of SO_2 is 60 minutes. From Table 1 and

Table 2, it is observed that initially the adsorption of SO_2 increased with the increase in contact time. The initial steep rise in the curve is due to existence of free valencies on the surface of marble chips. After the establishment of equilibrium the lines in the figure becomes parallel to the time axis, this can be explained on the basis of reaching saturation point. The percentage removal of SO_2 with contact time follows a smooth curve, which indicates the monolayer coverage and it also indicates the adsorption between marble chips and SO_2 follows first order kinetics. The percentage removal of SO_2 is increased with the increase of surface area and decrease in particle size[1,2,6,9,12,19,21,28,30]. The percentage removal of SO_2 in case of 250 mic is 40% and in 500 mic it is 20%. The capacity of adsorption by the marble chips is very less because there is no chemical affinity and the binding forces is weak Vander waals force. Marble chips get decomposed only at 900^0C into CaO and CO_2. This CaO reacts with SO_2 to form calcium sulphite. As the present studies are carried out at room temperature, the chemical adsorption is not taking place.

The percentage removal of SO_2 gas decreased with increase in concentrations indicated by the Table 3. The maximum percentage removal of SO_2 is observed at the lower concentrations compared to higher concentrations. This may be due less number of gas molecules compared to the higher concentrations. The absolute amount of adsorbed substance is more at the higher concentrations than at the lower concentrations. This is due to the greater mobility of the molecules at the lower concentrations and the mobility of the molecules decreases with the increase in the concentration. The adsorption capacity increases with the increase in the concentration[10], which is due to the great number of contacts to which the molecules are subjected.

Table 4: Variation of marble chips dosages

Particle size: 250 mic
Flow rate: 60 mL/min
Volume of SO_2: 250 mL

S. No.	Initial conc. (mg/m^3)	% Removal with 2 g	% Removal with 4 g	% Removal with 6 g	% Removal with 8 g
1	26	70	80	85	85
2	52	52	65	74	74
3	78	40	58	64	64
4	104	29	34	40	40
5	130	15	26	32	32

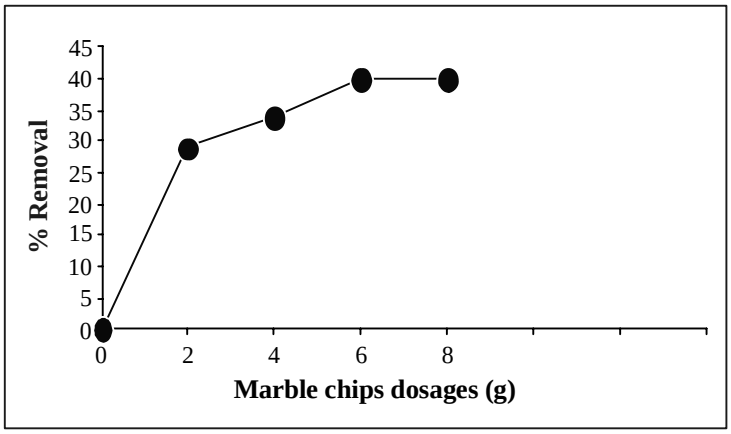

Fig. 3: Variation of marble chips dosages

The percentage removal of the SO_2 increases with increase in marble dosages[3,10,11,13-18,20,27-29]. The rate of the percentage removal has been found to be rapid in the beginning which slowed as marble chips dosages is increased. In all the cases the optimum dose may be attributed to the attainment equilibrium between the marble chips and SO_2 at the existing operation conditions, rendering marble chips in capable of further adsorption. More the active centers more adsorption.

CONCLUSION

Marble chips an ore of calcium carbonate has a capacity to adsorb SO_2. The higher temperature ranging between 30-100^oC does not have any effect on the adsorption of SO_2. Physical forces or Vander waal's forces are binding SO_2 molecules to the surface of marble chips. The percentage removal of SO_2 molecules increased with the increase in concentration, with the increase in adsorbent dosages and decrease in particle size.

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