Research Article

BREAKTHROUGH CURVE STUDIES FOR ADSORPTION OF METHYLENE BLUE ON SBAC, SDAC AND RHAC

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ABSTRACT:
Adsorption is one of the most important operations carried in chemical process industries. It is generally employed for separation of the impurities or components from gas or liquid mixtures. Breakthrough curve study is important for design & scale up of packed column adsorber. The objective of the present work is packed column adsorption studies of methylene blue from dilute aqueous solution using adsorbents synthesized in laboratory from saw dust (SDAC), sugarcane baggasse (SBAC) and rice husk (RHAC) and the comparison of break through curves. The present work has successfully highlighted the efficacy and use of agricultural waste materials as adsorbent for removal of methylene blue from aqueous solution & estimated the breakthrough point, time & concentration for all the adsorbents used. It can be concluded that the loading capacities for methylene blue per gram of adsorbents SDAC, SBAC & RHAC are 0.1802, 0.1904 & 0.1434 gram respectively, thereby indicating the suitability of the adsorbents in removal of methylene blue from aqueous solutions, the SBAC proving the best amongst three.

INTRODUCTION:

Adsorption is one of the most important operations carried in chemical process industries .It is generally employed for separation of the impurities or components from gas or liquid mixtures. Adsorption takes place because of the attractive forces between the molecules of adsorbate & adsorbent. Activated carbon has been quite successful as adsorbent in removal of impurities from exhaust gas and waste water streams. The highly porous nature of the carbon provides a large surface area for contaminants to get deposited. There are many types of activated carbons which exhibit different characteristics depending upon the raw materials and the activation techniques used in their synthesis. Agricultural waste material can effectively be converted in to activated carbon using straw, leaves, stem, seeds & husk.

Introduction to Packed Bed Adsorption Study:

Packed column is the most common type of contacting device used for adsorption. A mixture, either gas or liquid, containing a solute is passed continuously down through a relatively deep bed of adsorbent initially free of adsorbate. In the initial moments of time the uppermost layer of solid, in contact with the strong solution entering, at first adsorbs solute rapidly and effectively, and whatever little solute is left in the solution is substantially all removed by the layers of solid in the lower part of the bed making the effluent leaving from the bottom of the bed practically solute-free. Subsequently for the latter time elements, the depth of the layers of the packed bed will go on increasing where the concentration of solute reached the equilibrium since the quantity of solute adsorbed increases with time. A stage comes when with small additional time interval the complete column height has reached the equilibrium and no further adsorption is possible in the column. The effluent leaving the column has same concentration as that of the incoming feed stream to the column. These observations of concentration studies as a function of time are plotted & result in a typical 'S' shape curve known as breakthrough curve. It is the prerequisite in design & scale up of packed column adsorbers.

Researchers and scientist have been working on synthesis of activated carbon from agricultural waste materials for removal of dyes from the solution. A number of research papers have been reported in the literature. A few related to the present theme include, chemically modified sugarcane baggasse as a potentially low-cost biosorbent for dye removal(1), decolourisation of molasses waste water using activated carbon prepared from cane baggasse(2), preparation and characterization of activated carbons from coconut shell impregnated with phosphoric acid(3), colour removal from textile effluents using hardwood sawdust as an absorbent(4), adsorption of methylene blue onto bamboo-based activated carbon: Kinetics and equilibrium studies (5), use of activated carbons prepared from sawdust and rice-husk for adsorption of acid dyes: a case study of Acid Yellow (6), dye removal from wastewater using activated carbon developed from sawdust: adsorption equilibrium and kinetics(7), adsorption of Cr(VI) on activated rice husk carbon and activated alumina (8), adsorption characteristics of malachite green on activated carbon derived from rice husks produced by chemical–thermal process (9), utilization of various agricultural waste for activated carbon preparation and application for the removal of dyes and metal ions from aqueous solution(10), low cost adsorbent for waste and waste water treatment; a review(11), review on decolourisation of dye solution by low cost adsorbents (12),comparative study on the adsorption kinetics and thermodynamics of dyes onto acid activated low cost carbon(13), elimination of heavy metals from wastewater using agricultural wastes as adsorbents(14), agricultural products and by-products as a low cost adsorbent for heavy metal removal from water and wastewater: A review.(15)

MATERIALS AND METHODS:

The objective of the present work is packed column adsorption studies of methylene blue from dilute aqueous solution using adsorbents synthesized in laboratory from saw dust (SDAC), sugarcane baggasse (SBAC) and rice husk (RHAC) and comparison of break through curves. The work is divided into following parts:

- Standardization of calorimeter using known concentrations of methylene blue in dilute aqueous solution.
- Observations for break through curve studies in lab scale column packed with SDAC, SBAC and RHAC for known initial concentration of methylene blue in dilute solution.
- Comparison of break through curves.

Experimental set up and Procedure:

A glass packed column is used for present study having diameter of 4.5 cm and length of 8.5 cm. Known quantity of activated carbon sample synthesized in laboratory is placed in the column and methylene blue (MB) solution having concentration of 1 gm/litre is continuously passed through it. The outgoing solution is collected in a vessel over time duration of 1 hr. The average concentration of MB in known volume of outing treated water is determined by using colorimeter. The collection of outgoing solution is continued until the initial concentration of MB is obtained. The details of the column dimensions and other constant parameters are as given in table no1. The details of quantity of adsorbents used and the volumetric flow rate of feed stream are given in table no 2. The experimental observations are given in the table no: 3. Figure 1 depicts the standardization curve for methylene blue obtained by plotting colorimetric readings for corresponding known concentration values of methylene blue in aqueous solution.

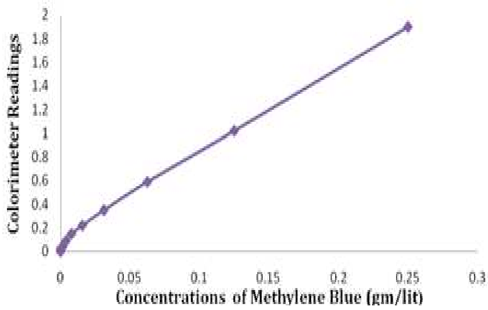

Fig 1: Standardization of calorimeter

Table no 1:

Diameter of the packed column	4.5 cm
Height of the column	8.5 cm
Optical density of water	0.0
Initial concentration of methylene blue solution	1 gm/l

Table no 2: Quantity of adsorbent and volumetric flow rate in break through curve studies

Type of adsorbent	Quantity of adsorbent used (gm)	Volumetric flow rate (ml/min)
SBAC	46	5
RHAC	68	7.14
SDAC	59.2	5.88

Table no 3: Observation of outgoing concentration at different time intervals for the break through curve studies

Time (Hr)	Final concentration of MB (gm/lit)	Time (Hr)	Final concentration of MB (gm/lit)	Time (Hr)	Final concentration of MB (gm/lit)
SBAC		RHAC		SDAC	
1	0	1	0	1	0
2	0	2	0	2	0
3	0	3	0	3	0
4	0	4	0	4	0
5	0	5	0	5	0
6	0	6	0	6	0
7	0	7	0	7	0
8	0	8	0	8	0
9	0	9	0	9	0
10	0	10	0	10	0
11	0	11	0.000125	11	0
12	0	12	0.00125	12	0
13	0	13	0.01125	13	0
14	0	14	0.025625	14	0.0005
15	0	15	0.03625	15	0.00515
16	0.0005	16	0.068125	16	0.0099
16.5	0.0005	17	0.072	17	0.0146
17	0.00515	18	0.0893	18	0.0194
17.5	0.0099	19	0.10625	19	0.0386
18	0.0146	20	0.11875	20	0.05836
18.5	0.0194	21	0.1375	21	0.08365
19	0.0265	22	0.1625	22	0.0965
19.5	0.0386	23	0.16875	23	0.1097
20	0.05836	24	0.19	24	0.123
20.5	0.08365	25	0.2375	25	0.153
21	0.0965	26	1	26	0.1904
21.5	0.1097	27	1	27	0.2327
22	0.123	28	1	28	0.281
22.5	0.153	-	-	29	0.35545
23	0.1904	-	-	30	0.4498
23.5	0.2327	-	-	31	0.539
24	0.281	-	-	32	0.626
25	0.35545	-	-	33	1
26	0.4498	-	-	34	1
27	0.539	-	-	-	-
28	0.626	-	-	-	-
29	1	-	-	-	-
30	1	-	-	-	-

The ratio of outgoing concentration of methylene blue in aqueous solution leaving the packed column to the initial concentration of metrhylene blue in entering feed solution are plotted for different time intervals for SDAC, SBAC and RHAC as shown in figure 2,3 & 4 respectively.

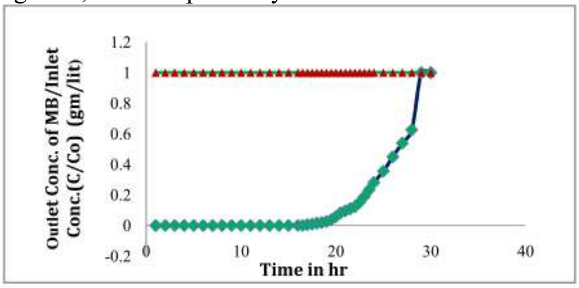

Fig No.2: Break through Curve for SBAC

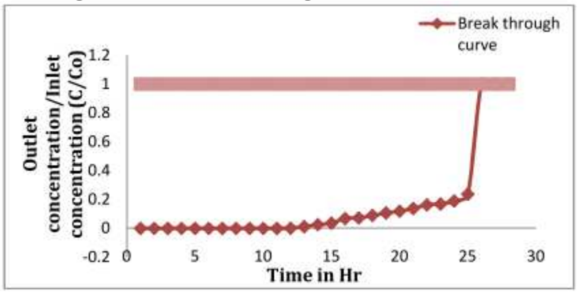

Fig No 3: Break through Curve for RHAC

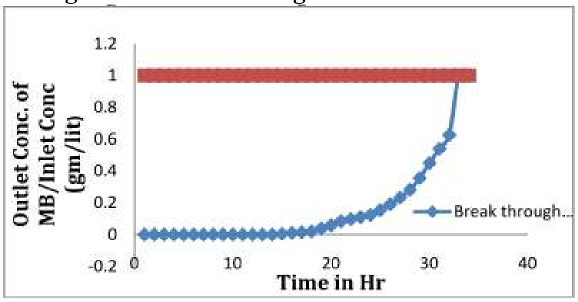

Fig 4: Break through Curve for SDAC

The break through curves obtained for SDAC, SBAC & RHAC are analysed for the cumulative time and cumulative liter are estimated.

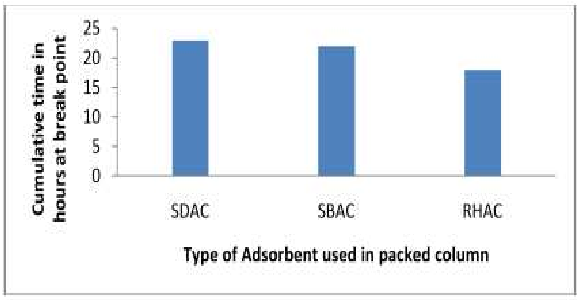

Fig 5: Comparison of cumulative time in hours at break point for SDAC, SBAC and RHAC

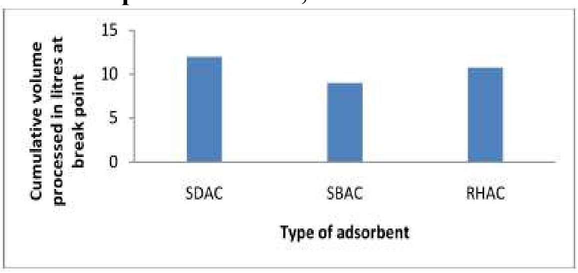

Fig 6: Comparison of cumulative volume processed in litres at break point for SDAC, SBAC and RHAC

Fig 5 & 6 depict the comparison of cumulative time in hours at break point and cumulative volume processed in litres at break point for SDAC, SBAC and RHAC.

Similarly table no 4 shows the comparison amongst SDAC, SBAC and RHAC in terms of their loading capacities.

Table no 4:

Sr no	Adsorbent Type	Quantity Used	Cumulative time	Cumulative Volume	Quantity Adsorbed	Quantity adsorbed/ Quantity of adsorbent
1.	SDAC	59.2	23	11.995	10.67	0.1802
2.	SBAC	46	22	9	8.76	0.190 4
3.	RHAC	68	18	10.71	9.756	0.1434

Fig no 7 depicts the comparison of quantity adsorbed per gm of adsorbent for SDAC, SBAC and RHAC. It can be inferred that SBAC is the best adsorbent for removal of methylene blue from aqueous solution.

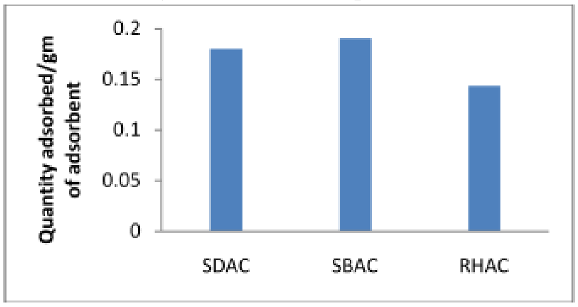

Fig 7: Comparison of Quantity adsorbed per gm of adsorbent for SDAC, SBAC and RHAC

CONCLUSION:

Packed column adsorbers are widely employed in chemical process industries for removal of impurities from gas and liquid mixture. Due to the fixed volume of packed column, the capacity of adsorbent packed in it is limited. Continuous removal of adsorbate from entering feed mixture results in attaining equilibrium & adsorbent is to be regenerated after this stage. Due to this feature, the study of breakthrough curves becomes extremely essential in design and assessment of performance of adsorber.

Present work has highlighted the utility & efficacy of carbon synthesized from agricultural waste materials like saw dust, sugarcane baggasse & rice husk. Based on observations, results and discussion, it can be inferred that the present work has successfully addressed to comparative break through curve studies conducted for different adsorbents under similar adsorption conditions which can be used further for scale up & design. It can be concluded that the loading capacities for methylene blue per gram of adsorbents SDAC, SBAC & RHAC are 0.1802, 0.1904 & 0.1434 gram respectively thereby indicating the suitability of the adsorbents in removal of methylene blue from aqueous solutions, the SBAC proving the best amongst three.

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