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Removal of Lead (Pb^{+2}) From Waste Water by Using Coal Fly Ash as Adsorbent

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ABSTRACT
Coal Fly Ash is produced by coal-fired electric and steam generating plants is the finely divided residue that results from the combustion of pulverized coal. It mainly comprised of oxides having high adsorption capacity. Coal fly ash is used as a low-cost adsorbent to remove heavy metals such as Lead, Chromium, Arsenic, Cadmium etc. from industrial wastewater. Wastewater containing Lead has adverse effects on environment like changing the microbiological balance of soil, soil fertility disorders, contamination of groundwater etc.
The main objective of the present work is to remove Lead from wastewater by using coal fly as adsorbent. The effect of contact time, pH, concentration and dosage of fly ash was studied. The kinetic studies and isotherms were also developed.

KEYWORDS: *Coal fly ash, Lead, XRD analysis, Wastewater, Adsorption technique*

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I. INTRODUCTION

Wastewater is a mixture of several heavy metal ions. Among this lead is very dangerous metal in water which are obtained from industries like pharmaceutical, preparation of batteries, ceramics, amplifiers e.t.c. If people continuously exposed it causes a various effect like nervous system, kidneys, and reproductive system damages [1]. Lead content in water cannot be reduced easily to minor amount [2]. The maximum permissible level of lead in drinking water is about 15ppb. The applications of lead are in building construction materials, cable sheathing and ammunition. It is also obtained through agricultural discharges. It stunted the growth of the plant, decreases photosynthesis rate, chlorosis, blackening of the root system and it leads to disturbed mineral nutrition, water imbalance, and inhibition of enzyme activities [3]. Different methods such as sedimentation, coagulation, precipitation, filtration, adsorption, absorption, chlorination, ion exchange, chemical oxidation, osmosis, reverse osmosis and electrostatic precipitators are utilized to treat the contaminated water. Among all this adsorption technique is used because it is economically low and it is more efficient. Coal fly ash used as cheaper adsorbent to treat wastewater which is collected from thermal power plant. It mainly comprises of some oxides silicon oxide, ferrous oxide. Silicon oxide has a nature of high adsorption capacity of toxic metals from wastewater than other metals. The various parameters have been conducted to control the effectiveness of lead in wastewater by batch and kinetic, isotherms studies.

II. MATERIAL AND METHODS:

2.1 Preparation of the Adsorbent:

Coal fly ash is inexpensive adsorbent which is collected from Rayalaseema thermal power plant. It is used to remove the lead from wastewater. Coal fly ash is further classified into two classes they are Class C fly ash & Class F fly ash. These classifications are based on percentage of silica content. Class C has more amount of silica than Class F fly ash. The coal fly ash used in this project is Class C fly ash it has more silica content.

2.2 Preparation of stock solution:

Lead nitrate is used to prepare synthetic solution. For this purpose, primary solution of lead was prepared about 100mg/l. By diluting the solution different concentration of solutions are prepared (2, 4, 6, 8 and 10) ppm. The concentration of the solutions is determined by using UV adsorption spectroscopy.

2.3 Characterization of coal fly ash:

The figure shows, the XRD pattern obtained on fly ash material (collected from Rayalaseema thermal power plant, India). It mainly consists of SiO2, Fe2O3, Al2O3, CaO, MgO. XRD studies on our sample and compared the XRD data of our sample with the standard JCPDS XRD data of SiO2 and Fe2O3. Finally, the analysis of 2Theta values are matched with the JCPDS patterns of SiO2 (JCPDS card No. 89-1668) and Fe2O3 (JCPDS card No. 89-0598). By comparing, it is concluded the fly ash material majorly of oxides such as SiO2(S) and Fe2O3 (F).

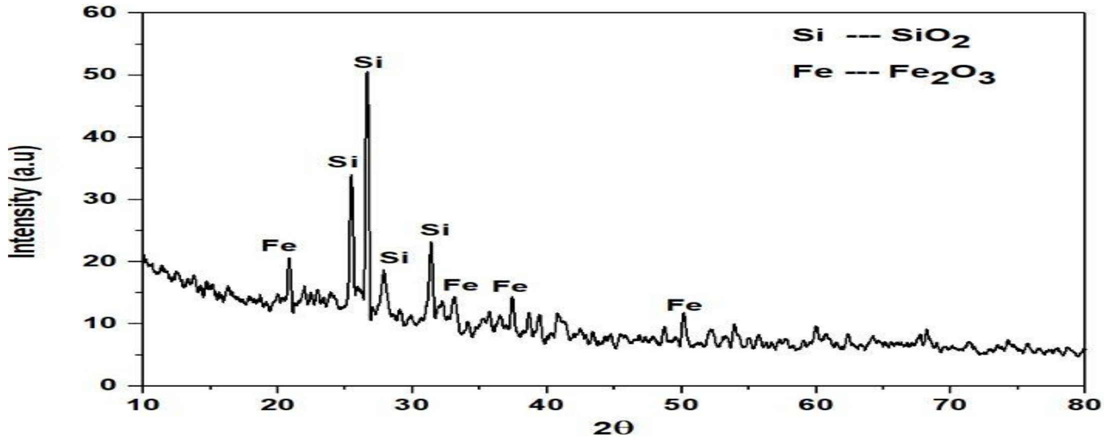

Fig 1.0 XRD analysis of coal fly ash

III. RESULTS AND DISCUSSION:

3.1 Calibration curve:

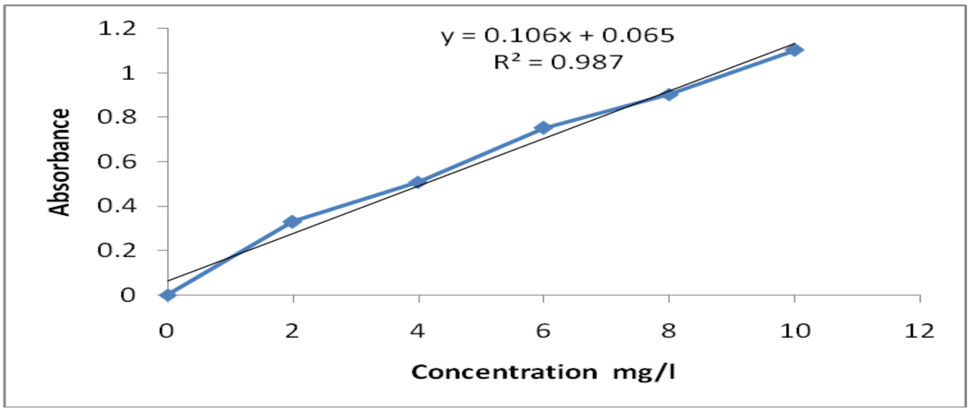

Fig 2.0 Calibration curve of lead solution

3.2 Effect of contact time:

In order to determine the effect of time, the initial concentration of lead 10 mg/L were prepared, then 1gm of coal fly ash added to the solutions and the samples are drawn from sonicator at regular intervals (10 to 60) minutes. The adsorption of lead in the solution was determined. If contact time increases the adsorption of lead is also increases. The maximum percentage removal of lead is observed at 60 minutes which is about 90%. The percentage removal is calculated by using formula.

$$\% \text{ removal} = (C_0 - C_1) * 100 / C_0$$

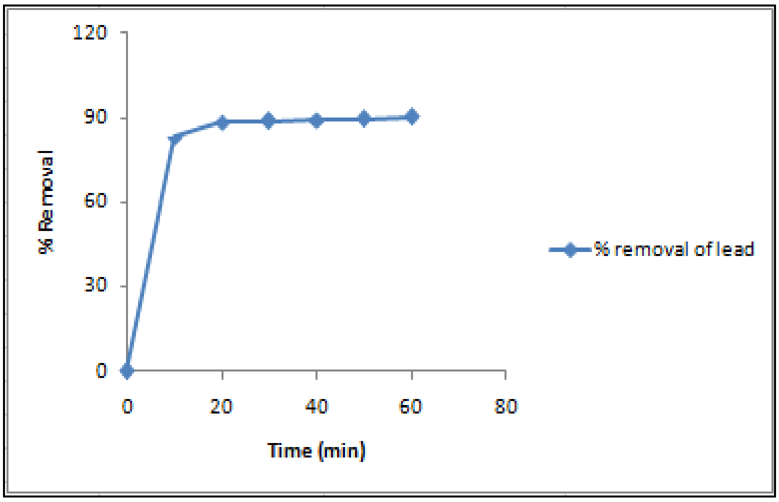

Fig 3.0 Effect of contact time on % removal of lead

3.3 Effect of Dosage on the quantity of lead adsorption:

For this purpose, the dosage of an adsorbent is taken about 1, 2, and 3 g of coal fly ash were added to the initial lead concentration of 10 mg/L. After 60 minutes of contact time, the adsorption of the lead in the solution was determined. Dosage increases then percentage removal of lead increases. It increases due to the inter-particle interaction such as aggregation would lead to decrease in the total surface area of the adsorbent and on increase in diffusional path length. The maximum percentage removal is 94.3% at dosage 3 gm.

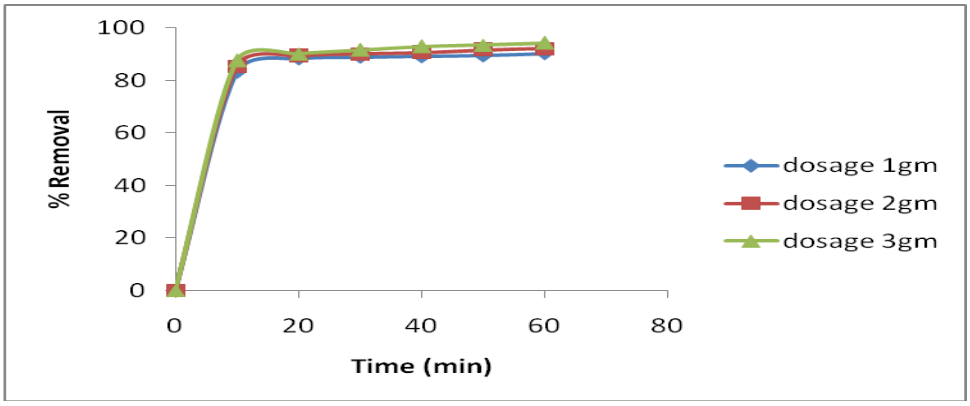

Fig 4.0 Effect of dosage on % removal of lead

3.4 Effect of Concentration on the quantity of lead adsorption:

To find this parameter considering different concentration (10, 50 and 75) ppm and added constant dosage about 1gm of coal fly ash keeping constant time about 60 minutes. The solution will be drawn at regular intervals of time and adsorption of led was analyzed. Concentration increases then percentage removal of lead decreases. It decreases because they are more molecules which do not allow the light to passes through it. The maximum percentage removal is 94.3% at concentration of 10ppm.

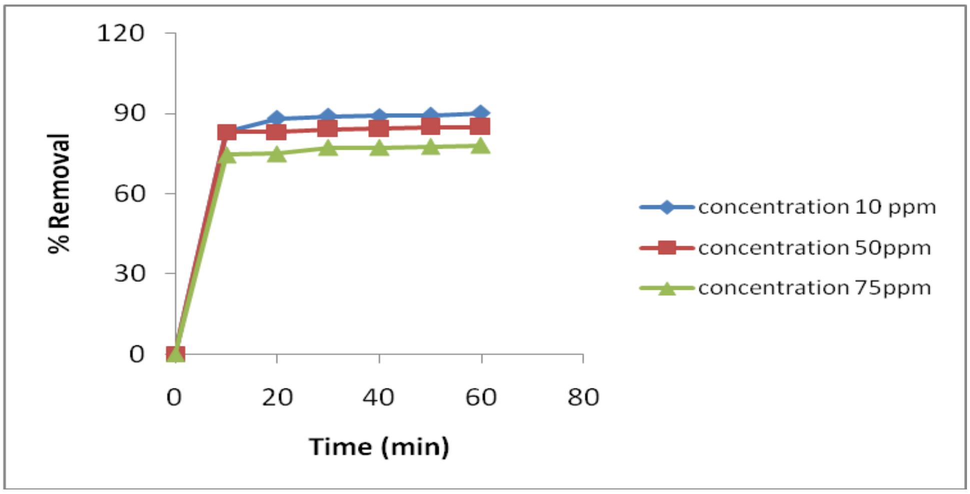

Fig 5.0 Effect of concentration on % removal of lead

3.5 Effect of pH on the quantity of lead adsorption:

To determine the pH its value ranges from 2 to 8. PH value adjusted by using hydrochloric acid and sodium hydroxide solution (0.1 N), 1 g of coal fly ash is added to the lead sample with concentration of 10 mg/L. After 60 minutes, the adsorption of lead was determined. The maximum adsorption will be observed at pH value 6. At higher pH value adsorption decreases due to the concentration of hydroxyl ion in the solution is high and competes with the lead for sitting on the adsorption places so lead adsorption would be decreased.

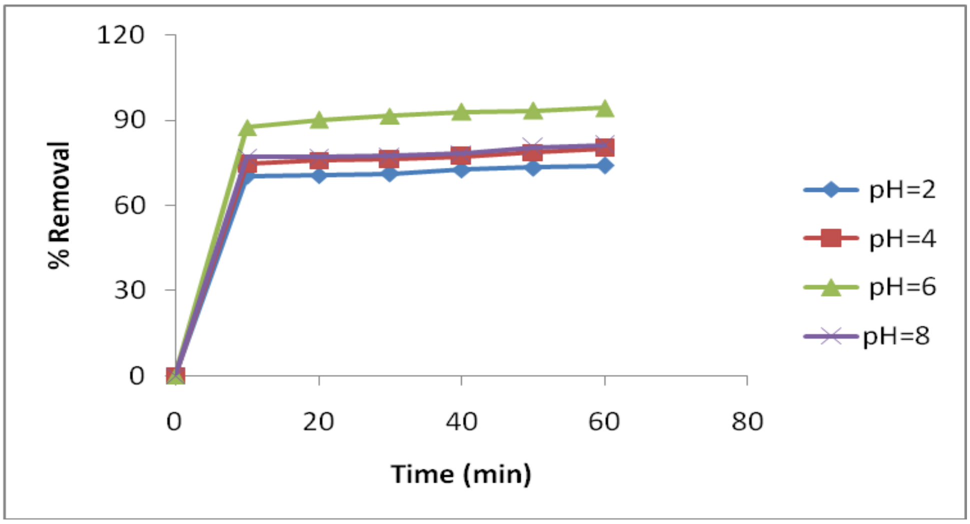

Fig 6.0 Effect of pH on % removal of lead

3.6 Adsorption kinetics:

Kinetics study represents the rate of equation and helps us to find out the rate limiting step. There are two types: pseudo first order kinetics and pseudo second order kinetics.

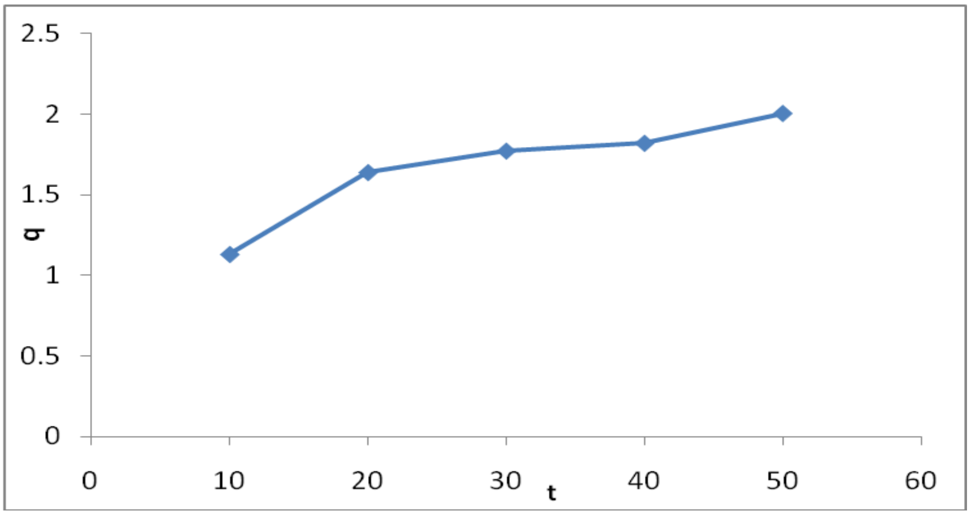

Fig 7.0 Adsorption kinetics

3.6.1 Pseudo first order kinetics:

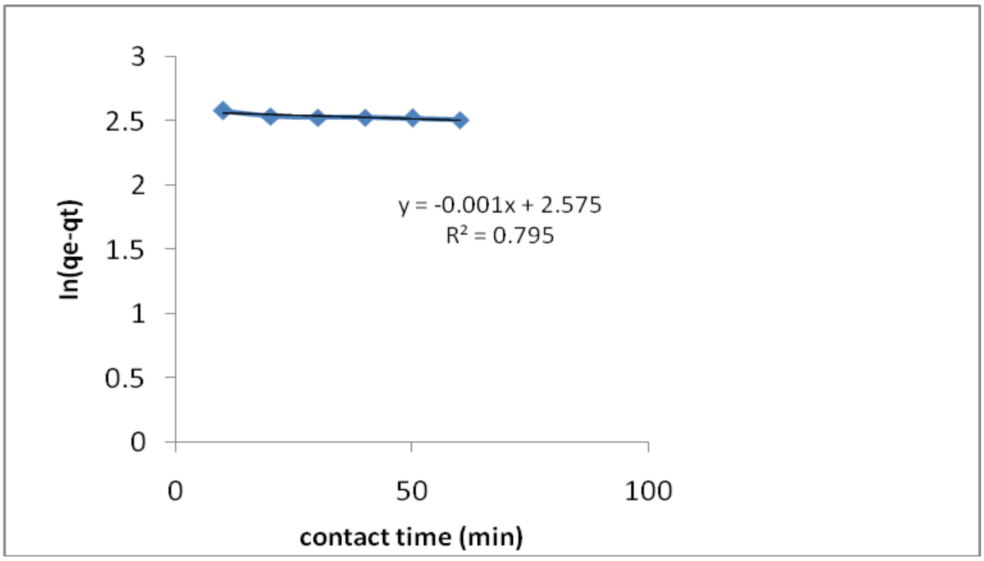

Fig 8.0: Pseudo first order kinetics

3.6.2 Pseudo second order kinetics:

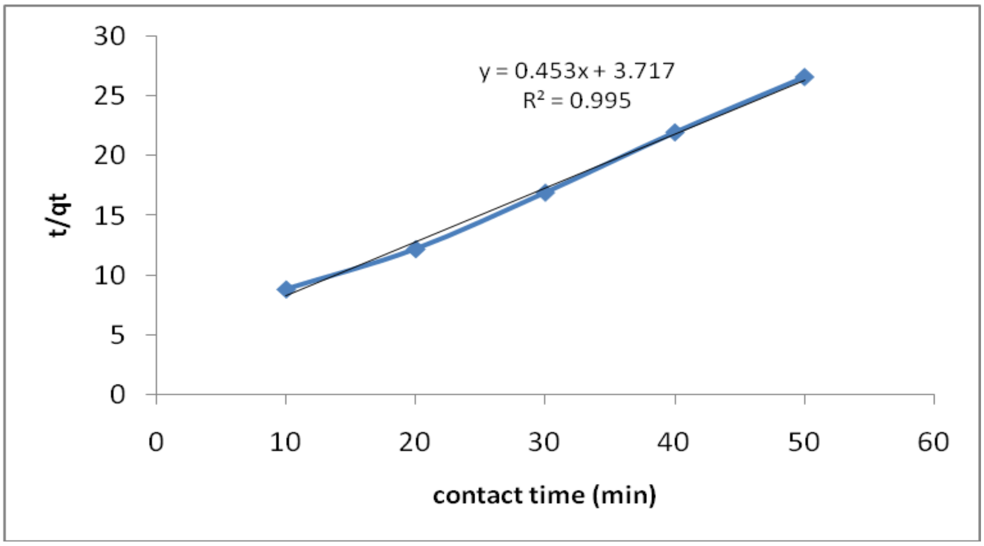

Fig 9.0: Pseudo second order kinetics

It concludes that pseudo second order is well fitted when compared to pseudo first order kinetics, because R^2 value of pseudo second order is higher than pseudo first order.

3.7 Adsorption isotherms:

In adsorption isotherms the graph is plotted for langmuir isotherm and freundlich isotherms. The conclusion is based on R^2 value.

3.7.1 Langmuir isotherm:

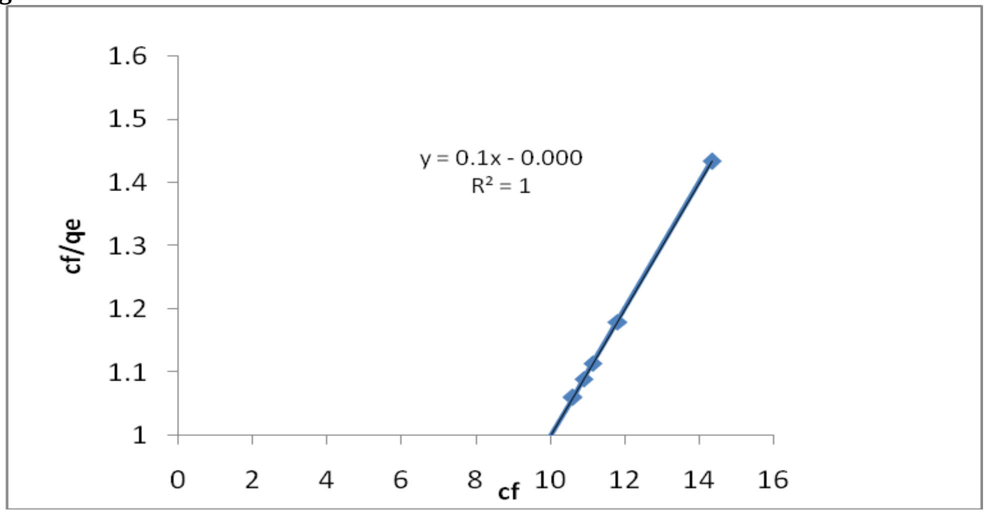

Fig 10 Langmuir isotherm

3.7.2 Freundlich isotherm:

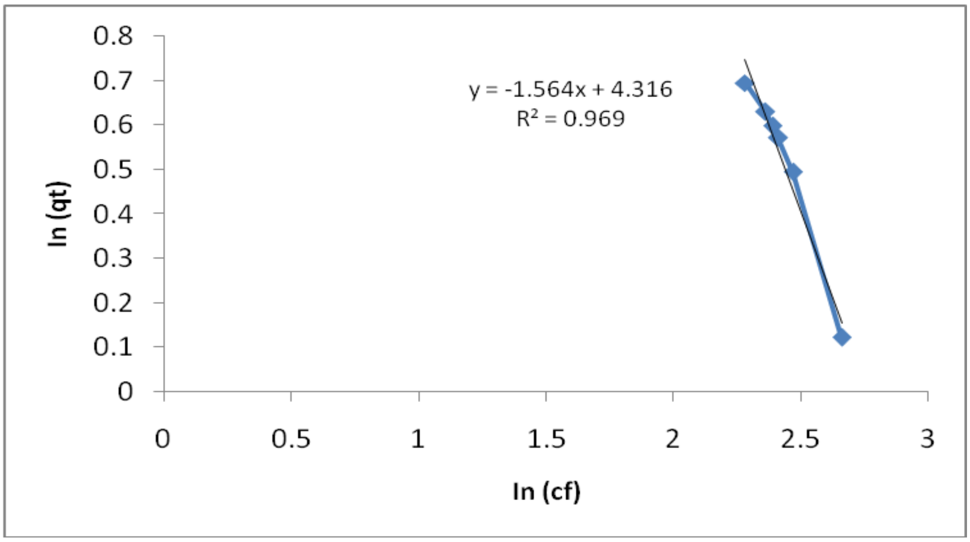

Fig 11 Freundlich isotherm

IV. CONCLUSIONS:

- XRD analysis shows that coal 'Fly ash' contains of SiO_2, Al_2O_3, and Fe_2O_3.
- It is concluded that 94% lead was removed at a pH of 6, fly ash dosage 3 mg/L and contact time of 60 min.
- In adsorption kinetics, R^2 value of Pseudo-second order model is high as compared to the 'pseudo-first order' model. Thus, Pseudo-second order is the best fitting kinetic model.
- In adsorption isotherms model, R^2 value of 'Langmuir isotherm' model is high when compared with 'Freundlich isotherm' model. Thus, it can be concluded that 'Langmuir isotherm' model is best fitting model because it describes monolayer adsorption.

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