SUMMARY & CONCLUSIONS

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The adsorption of dyes from aqueous solutions on oxides and graphite surfaces has been studied as an alternative for eliminating dyes from industrial wastewaters. The oxides selected are silica gel and alumina (neutral and basic). The adsorbents are used in the powdered form and have been activated properly at suitable temperature. The adsorbate studied are cationic dyes (Basic Brown 4, Basic Green 1 and Basic Violet 1 and 2) and anionic dyes (Acid Green 25, Acid Black 1 and Ketone Blue A). The amount of dye adsorbed on the surface is calculated from the difference in the initial and equilibrium concentration of the dye solution measured spectrophotometrically (Spectronic - 20, Bausch & Lomb, USA) at respective λ_{max}

The actual time required to attain equilibrium, depends on the nature of both the adsorbent and adsorbate and also on the amount of the adsorbent used. In general, the time required to attain equilibrium for oxides is about 30 to 40 minutes. It is seen that adsorption on oxides takes less time to attain equilibrium as against that taken by graphite dye systems. The amount of dye adsorbed at this stage represents the maximum adsorption; it remains unaltered on prolongation of contact time even for several hours.

The adsorption capacity is found to be different with different adsorbents. Amongst the adsorbents used in the present study, silica gel comparatively has higher adsorption capacity and graphite has lower adsorption capacity. Neutral alumina has shown appreciable adsorption capacity, although exceptionally large adsorption is found with anionic dye Acid Black 1. On the basis of adsorption capacity, the adsorbents may be arranged in the following order :

Silica gel > neutral alumina > basic alumina > graphite

The time rate of adsorption increases with concentration of the dye solution, but the general nature is seen to be unaffected throughout both at intermediate and at equilibrium stages. 60 - 90% of available dye is removed from the solution using the adsorbents used in the present study.

The time - growth of adsorption is also found to be dependent on the temperature of the system. A change in temperature affects the amount adsorbed both at intermediate and equilibrium stages, though the general characteristics remain essentially the same. A lower temperature is favourable for large adsorption on oxide surfaces whereas reverse is true with the graphite though the rate of adsorption is found to increase with both types of the adsorbents. The energy of activation calculated from the Arrhenius plot is found to be low

for all the systems which indicates that the dye adsorption is an easy and fast process. The values of entropy of activation is found to be uniformly negative and low.

A variation of the pH of the dye solution affects markedly the amount adsorbed and the rate of adsorption. Acidic medium is found to be favourable for adsorption of anionic dyes whereas basic medium favours the adsorption of cationic dyes. However, no change is observed in general nature of the time-variation curve with the change in the pH of the dye solution. The values for specific reaction rate of both the cases (i.e., cationic and anionic dyes) are found to increase with the pH of the medium.

It is evident from the isotherm study that the variation of adsorption increases with concentration of the dye solution. The relative increase is more in low concentration range which slows down later and then reaches towards saturation. Though this characteristic nature is observed in all the systems employed, the extent of adsorption depends on the nature of the constituents of the system. Results obtained in the present study were tested for the applicability of Langmuir and Freundlich adsorption isotherms. The Freundlich isotherm constants K_F and 1/n are calculated from the intercepts and slopes of the straight line

plots of log x/m Vs log C_e . The K values thus obtained are used to compute the affinity ($\Delta\mu$) of dyes.

The straight line plots of C_e/q_e Vs C_e shows the applicability of Langmuir isotherm for most of the systems. The Langmuir isotherm constants Q_o and b are calculated from the slopes and intercepts of the respective plots. A monolayer adsorption could be deduced on the basis of applicability of the Freundlich and Langmuir adsoprtion isotherms for the adsorption of dyes. The thermodynamic parameters such as ΔG, ΔS and ΔH are calculated by using adsorption isotherms. The low value of heat of adsorption is indicative of physical adsorption or weak chemisorption.

The adsorption study has also been made in the presence of electrolyte, surfactants and alcohol (generally used as desorbing agents) and a decrease in adsorption is observed. This may be probably due to the preferential adsorption of the substances used here.

The regeneration of the adsorbents (for reuse) has been investigated by eluting the adsorbed dye from a column of the adsorbent. Desorption to the extent of 50 -60% of the adsorbed dye could be achieved within a reasonable time.

The following conclusions could be drawn from the present study :

(1) Dye adsorption is a reasonably fast process on the surface of oxides and graphite. More than 50% of the dye is adsorbed within 10 minutes. Generally equilibrium is attained within 30 to 40 minutes.

(2) Silica gel favours the adsorption of cationic dyes and neutral alumina adsorbs anionic dyes whereas graphite is found to be suitable for the adsorption of both i.e., cationic as well as anionic dyes from aqueous solutions.

(3) The adsorption of dyes on oxides and graphite surfaces is a first order process with a low activation energy which indicates that the process is rapid.

(4) The Langmuir and Freundlich isotherms are found applicable in the present dye adsorption which is indicative of the formation of monolayer on the surface of the adsorbents.

(5) The negative values of thermodynamic parameters such as ΔH, ΔG and ΔS are respectively indicative of exothermic and spontaneous nature of the process.

(6) By proper choice of the adsorbent and the conditions, the method can be effectively used for the removal of dyes from effluents.

(7) Column elution process for the regeneration of adsorbents using suitable desorbing agent like KCl is found to be an effective method.