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Adsorption-Review

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ABSTRACT

Adsorption is a unique process, which has a vast application in laboratories and industries. Adsorption is a process of substance being accumulated in interface between the phases which may be solid-liquid, liquid-liquid, gas-liquid or gas-solid. Adsorbate is the state were the substance being removed from the liquid phase. The review paper deals with the several theories applied in the process of adsorption. The significant factors involved in adsorption.

Keywords: - *Adsorption, Adsorbate, Interface, Theory, Phase.*

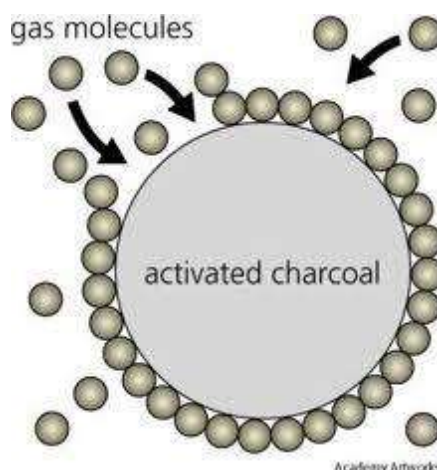
INTRODUCTION

The major development of adsorption processes on a large, industrial scale deals mainly with the solid gas (B.L. Karger, et.al., 1973) and solid liquid (G.D. Parfitt.et.al., 1983) interfaces, but in various laboratory separation techniques all types of interfaces are applied. The term 'fluid' is commonly used to represent gas or liquid in contact with the boundary surface of solids (C.J. King, 1980). A basic concept in adsorption occurring at every interface is the real adsorption system (G.E. Keller, 1983). The real adsorption system can be defined as an equilibrium one including the adsorbent being in contact with the bulk phase and the so-called interfacial layer (R.T. Yang, 1997). This layer consists of two parts: the part of gas residing in the force field of the solid surface and the surface layer of the solid (R.H. Ottawil.et.al., 1983). The term 'adsorption' deal with the process in which molecules accumulate in the interfacial layer, but desorption denotes the converse process. Adsorption hysteresis is said to occur when the adsorption and desorption curves deviate from one another. In such a case the isotherm possesses a hysteresis loop, the shape of which varies from one adsorption system to another. Therefore at present and in the near future, approximate theoretical descriptions requiring definite but realistic models of the adsorption process will still be of great interest in the studies of adsorption at the solid fluid interface. In the widely accepted model of the adsorption system, the real concentration profile is replaced by a step function which 'divides' the fluid phase between the surface and bulk phases. These phases are at thermodynamic equilibrium with the thermodynamically inert adsorbent which creates a potential energy field above the surface (A.W. Adamson, 1990). The inertness of the solid is believed to be true in the case of physical adsorption, but there are several instances when it can be questioned.

What is adsorption?

The physical and/or chemical process in which a substance is accumulated at the interface between the phases which may be solid-liquid, liquid-liquid, gas-liquid or gas-solid. Adsorbate: the substance being removed from

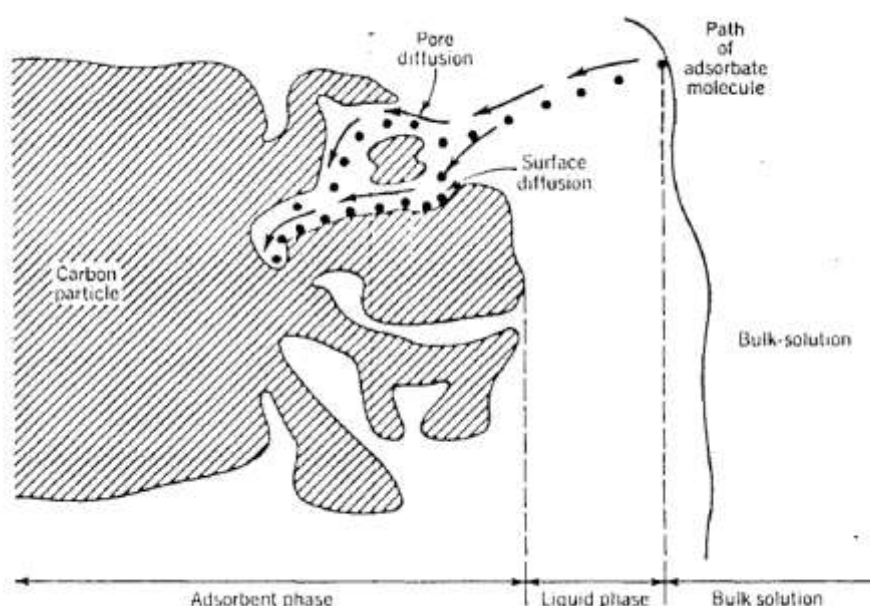
the liquid phase Adsorbent: the solid phase onto which the accumulation takes place. Activated carbon is used exclusively in full scale water treatment.



Historical aspects

The history of adsorption science and technology of adsorbent synthesis as well as the industrial needs that provided the driving force are especially relevant with regard to actual practice. That is because many of the processes now in use, and possibly many future developments, have their origins in earlier discoveries (W. Rudziński et al., 1997). Moreover, in many cases the theoretical concepts, results and usually terminology dealing with physical adsorption date back several decades. Therefore, the state of the art of physisorption will be preceded by a brief review of the main events of the history of physical adsorption, it dwell mainly on physisorption at the solid gas interface (D.D. Do ZEd, 1990). Justification for giving priority to this interface stems from the fact that both experimental and theoretical studies of adsorption at the solid liquid interface preceded those from the gaseous phase. Several equations of isotherms for adsorption at the solid liquid interface, particularly equations that refer to adsorption from diluted solutions, are derived from the theoretical description of single gases and their mixtures on solid surfaces (A. D. Abrowski et al., 1987).

KINETICS OF ADSORPTION



Factors affecting adsorption process

Characteristics of the Adsorbent: Particle size ↓, rate of adsorption↑ (PAC has faster adsorption rate than GAC)

Solubility of Adsorbate: Typically, Solubility↓, adsorption capacity↑

Size of Adsorbate: Size of particles ↑, adsorption capacity↑ **(e) Temperature:** Temperature↑, adsorption (R. Defay.et.al., 1966).

Current state of physical adsorption

The first period of development of adsorption theory and adsorption experiments was based mainly on the Langmuir and BET equations, capillary condensation theory, Polanyi potential theory and the DR equation related to the latter. This first period of adsorption development, named as the 'pioneering age' of adsorption science, ended on the turn of the 1940s and 1950s. At that time the above theories and equations of adsorption isotherms were extensively verified experimentally and improved theoretically (A. Dabrowski.et.al., 1987). The improvements included mainly interactions between adsorbed molecules, localised and mobile-localised adsorption as well as studies of phase transitions in the adsorbed layers (A. Dabrowski.et.al., 1990)

In spite of many improvements of the Langmuir and BET equations, distinct deviations from experiment were observed particularly in the range of small and high relative pressures (D.H. Everett.et.al., 1982). The attempts to fit the experimental isotherms by theoretical equations showed negative deviations from the experimental points at low adsorbate pressure and positive deviations at higher bulk phase pressure (D.H. Everett. et.al., 1973). The most dramatic deviations were observed with regard to the measurements of the enthalpy changes upon adsorption. On the other hand, the theoretically predicted isosteric heats of adsorption should be an increasing function of the surface coverage, but almost all the reported experimental heats showed an opposite trend. The above mentioned disagreements between theory and experiment point out that there must exist an additional physical factor that influences adsorption processes, which can be compared with the effect resulting from interactions in the adsorbed layer; and this factor had not been taken into account by the existing theories. This missing factor deals with the energetic heterogeneity of the most real solid adsorbents (J.J. Kipling.et.al, 1965).

Adsorption isotherms:

Equilibrium study on adsorption provides information on the capacity of the adsorbent. An adsorption isotherm is characterized by certain constant values, which express the surface properties and affinity of the adsorbent and can also be used to compare the adsorptive capacities of the adsorbent for different pollutants (C.E. Brown.et.al., 1975). Equilibrium data can be analyzed using commonly known adsorption systems. Several mathematical models can be used to describe experimental data of adsorption isotherms. The Freundlich, Langmuir and Temkin models are employed to analysis adsorption occurred in the experiment of adsorption isotherms. The Freundlich, Langmuir and Temkin models are employed to analysis adsorption occurred in the experiment (D.H. Everett,.et.al., 1979).

Langmuir model

The Langmuir adsorption model is the most common model used to quantify the amount of adsorbate on an adsorbent as a function of partial pressure or concentration at a given temperature. This equation expressed by relation.

$$C_e/q_e = 1/q_m + 1/q_m b C_e \quad (1)$$

n this equation, q_e (mg. g-1) is the solution was adsorbed the surface and q_e is equilibrium constant of adsorption and b is the capacity of adsorption in saturated single layer and c_e (mg. l-1) is solution in equilibrium state

Freundlich model

The Freundlich equation or Freundlich adsorption isotherm is an adsorption isotherm, which is a curve relating the concentration of a solute on the surface of an adsorbent, to the concentration of the solute in the liquid with which it is in contact (G. Schay.et.al., 1970). In 1909, Freundlich gave an empirical expression representing the isothermal variation of Adsorption of a quantity of gas adsorbed by unit mass of solid adsorbent with pressure (J.H. Davis.et.al., 1979). This equation is known as Freundlich Adsorption Isotherm or Freundlich Adsorption equation. This model is specified with equation.

$$q_e = k_f C_e^{1/n} \rightarrow \ln q_e = \ln k_f + 1/n \ln C_e \quad (2)$$

In this equation, q_e (mg.g-1) is amount of absorbed material in adsorbent surface, K , n in arrangement are adsorption capacity

CONCLUSION

Adsorption is a unique phenomenon, where the molecule or substances are being attached to interface by physical or chemical process. It has major applications in laboratory. Adsorption is based on major theories, and it has a significant application in industries majorly in downstream processing of the product and to acquire a refined product. There are vast applications for the phenomena of adsorption.

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