B.Sc. (Honours) Part-III
Paper-VA

Topic: Freundlich Isotherm

UG
Subject-Chemistry

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Freundlich Isotherm

Adsorption Isotherm

Adsorption process is usually studied through graphs known as adsorption isotherm. Adsorption is the amount of adsorbate on the adsorbent as a function if its pressure or concentration at constant temperature .The quantity adsorbed is nearly always normalized by the mass of the adsorbent to allow comparison of different materials. From the above we can predict that after saturation pressure Ps, adsorption does not occur anymore, that is there are limited numbers of vacancies on the surface of the adsorbent. At high pressure a stage is reached when all the sites are occupied and further increase in pressure does not cause any difference in adsorption process. At high pressure, adsorption is independent of pressure.

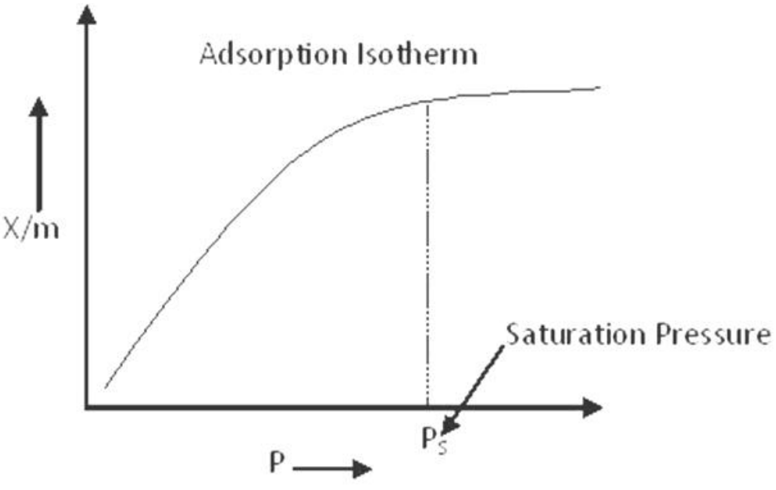

Figure Adsorption Isotherm

As mentioned above, the adsorption of a gas on a solid surface depends on the pressure of the gas. The variation in the amount of gas adsorbed by the adsorbent with pressure at a constant temperature can be expressed by means of a curve termed as adsorption isotherm.

Freundlich adsorption isotherm: Freundlich, in 1909, gave an empirical relationship between the quantity of gas adsorbed by unit mass of solid adsorbent and pressure at a particular temperature. The relationship can be expressed by the following equation:

$$\frac{x}{m} = k.p^{1/n} \ (n > 1) \ldots (1)$$

where x is the mass of the gas adsorbed on mass m of the adsorbent at pressure p. whereas k and n are constants which depend on the nature of the adsorbent and the gas at a particular temperature. The relationship is generally represented in the form of a curve where mass of the gas adsorbed per gram of the adsorbent is plotted against pressure (Fig. 4). These curves indicate that at a fixed pressure, there is a decrease in physical adsorption with increase in temperature. These curves always seem to approach saturation at high pressure.

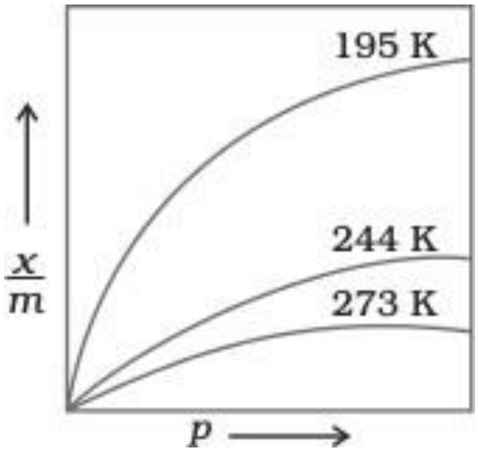

Fig. 4: Adsorption isotherm

Taking logarithm of eq. (1)

log $\frac{x}{m}$ = log k + $\frac{1}{n}$ log p ... (2)

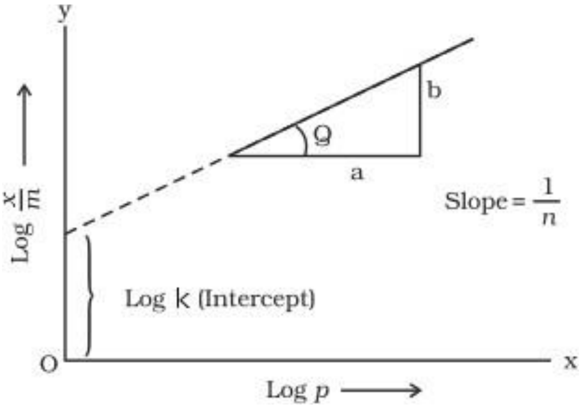

Fig. 5: Freundlich isotherm

The validity of Freundlich isotherm can be verified by plotting log $\frac{x}{m}$ on y-axis (ordinate) and log p on x-axis (abscissa). If it comes to be a straight line, the Freundlich isotherm is valid, otherwise not (Fig. 5). The slope of the straight line gives the value of . The $\frac{1}{n}$ intercept on the y-axis gives the value of log k.

Freundlich isotherm explains the behaviour of adsorption in an approximate manner. The factor $\frac{1}{n}$ can have values between 0 and 1 (probable range 0.1 to 0.5). Thus, equation (2) holds good over a limited range of pressure.

When $\frac{1}{n} = 0$, $\frac{x}{m}$ = constant, the adsorption is independent of pressure.

When $\frac{1}{n} = 1$, $\frac{x}{m} = k\,p$, i.e. $\frac{x}{m} \propto p$, the adsorption varies directly with pressure.

Limitation of Freundlich adsorption isotherm:

Experimentally it was determined that extent of gas adsorption varies directly with pressure and then it directly varies with pressure raised to the power 1/n until saturation pressure P is reached. Beyond that point ,rate of adsorption saturates even after applying higher pressure. Thus, Freundlich adsorption isotherm failed at higher pressure.

Freundlich adsorption isotherm was associated with the following limitations:

- It was an empirical relation; there was no theoretical foundation
- It could explain type I adsorption isotherm only
- It failed at high pressures as the experimental isotherm approached saturation at high pressures, which Freundlich isotherm could not explain
- K and n are not true constants for a particular adsorbate-absorbent system. They show temperature dependence