Lecture
Chem 484/673

Adsorption Isotherms

Some commonly used adsorbents

silica

Activated charcoal

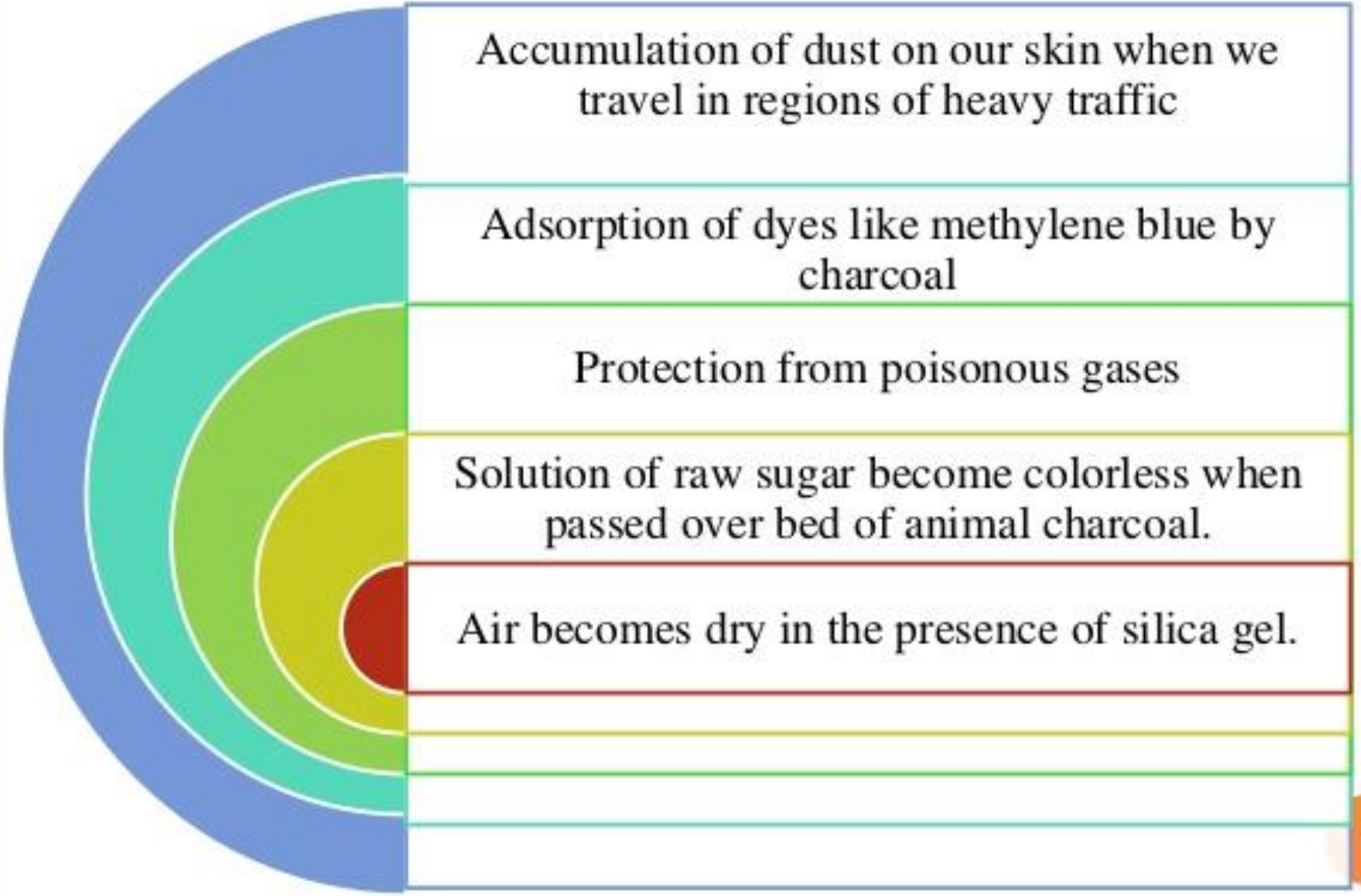
Alumina

Bentonite clay

Zeolites

Bagasse

Examples of adsorption



Adsorption On Solid Surface

Characterisation of adsorption system

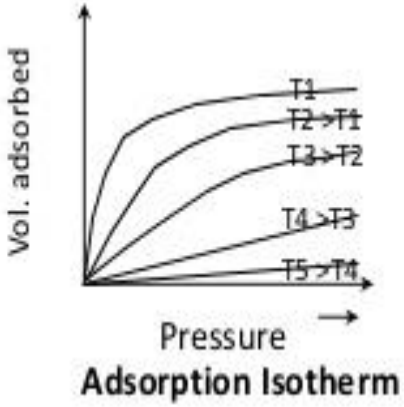
Adsorption isotherm - most commonly used, especially to catalytic reaction system, T=const. The amount of adsorption as a function of pressure at set temperature

Adsorption isobar - (usage related to industrial applications)

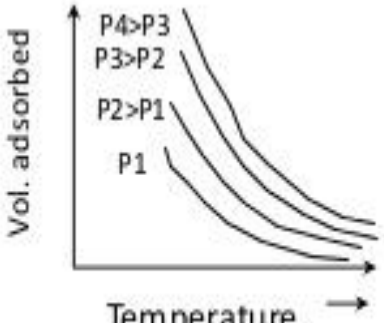
The amount of adsorption as a function of temperature at set pressure

Adsorption Isostere - (usage related to industrial applications)

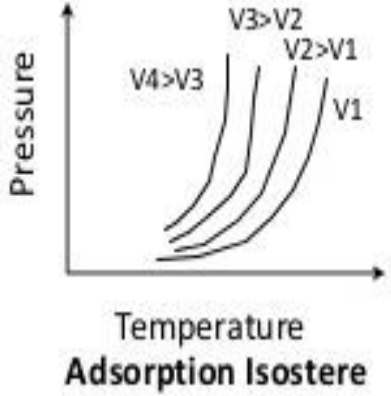
Adsorption pressure as a function of temperature at set volume



Adsorption Isotherm



Adsorption Isobar



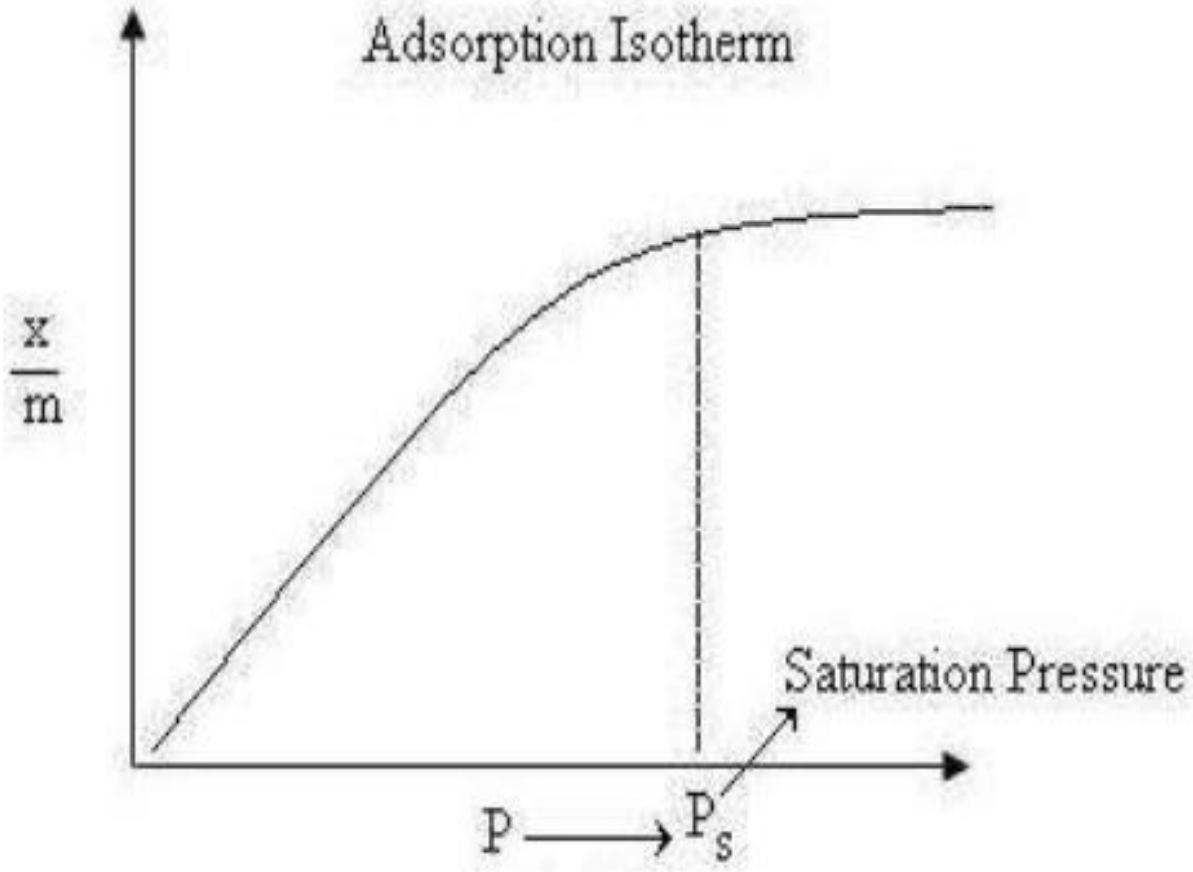
Adsorption Isostere

Basic Adsorption Isotherm

$$\text{Adsorbate} + \text{Adsorbent} \underset{\text{desorption}}{\overset{\text{Adsorption}}{\rightleftharpoons}} \text{Adsorption}$$

$$A + B \rightleftharpoons AB$$

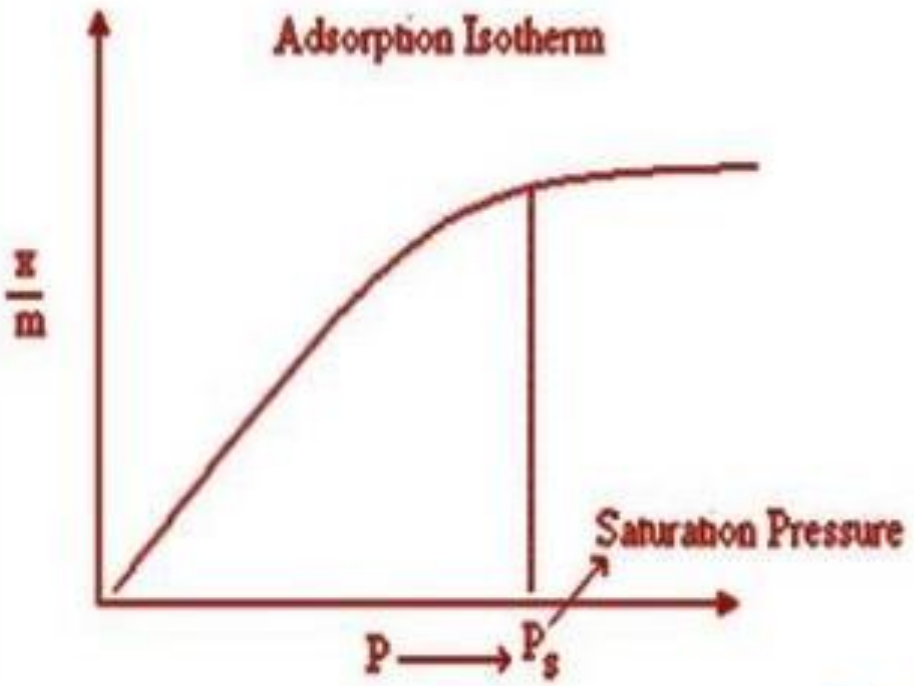
At high pressure a stage is reached when all the sites are occupied and further increase in pressure does not cause any difference in adsorption process. At high pressure, Adsorption is independent of pressure.



Adsorption isotherm

The process of adsorption is studied through graphs know as adsorption isotherms.

Graph between the amounts of adsorbate (x) adsorbed on the surface of adsorbent (m) and pressure (P) at constant temperature.



Continued…

- In adsorption, adsorbate gets adsorbed on adsorbent.
- The direction of equilibrium would shift in that direction where the tension can be relieved.

$$\text{Adsorbate} + \text{Adsorbent} \underset{\text{desorption}}{\overset{\text{Adsorption}}{\rightleftharpoons}} \text{Adsorption}$$

$$A + B \rightleftharpoons AB$$

- In excess of pressure to the equilibrium system, the equilibrium will shift in the direction where the number of molecules decreases.
- Number of molecules decreases in forward direction. Therefore, forward direction of equilibrium will be favored.

Types of Isotherms

Freundlich Adsorption Isotherm

•The Freundlich isotherm is the most important multisite adsorption isotherm for rough surfaces.

•The freundlich equation or freundlich adsorption isotherm , is a curve relating the concentration of a solute on the surface of adsorbent to the concentration of the solute in a liquid with which it is in contact.

• 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. This equation is known as FREUNDLICH ADSORPTION ISOTHERM

$$x/m = k P^{1/n}$$

Where x is the mass of the gas adsorbed on mass m of the adsorbent at pressure p and k, n are constants whose values depend upon adsorbent and gas at particular temperature.

Explanation of Freundlich Adsorption equation

At low pressure, extent of adsorption is directly proportional to pressure (raised to power one).

$$x/m \propto P^{1}$$

At high pressure, extent of adsorption is independent of pressure (raised to power zero).

$$x/m \propto P^{0}$$

Therefore at intermediate value of pressure, adsorption is directly proportional to pressure raised to power 1/n .Here n is a variable whose value is greater than one.

therefore,

$$x/m \propto k P^{1/n}$$

Using constant of proportionality, k, also known as adsorption constant we get

$$x/m = k P^{1/n}$$

The above equation is known as Freundlich adsorption equation.

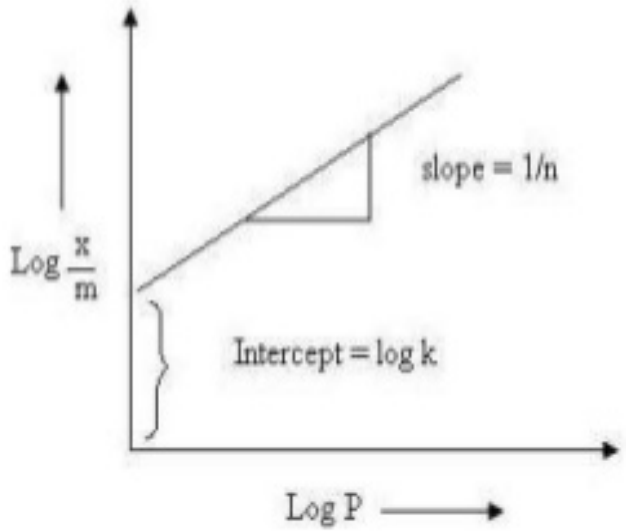
Plotting of Freundlich Adsorption Isotherm

As per Freundlich adsorption equation

$$x/m = k P^{1/n}$$

Taking log both sides of equation, we get,

$$\log \{x/m\} = \log k + 1/n \log p$$



The equation above equation is comparable with comparable with equation of straight line, y = m x + c where, m represents slope of the line and c represents intercept on y axis.

Plotting a graph between log(x/m) and log p, we will get a straight line with value of slope equal to 1/n and log k as y-axis intercept.

It has limited applicability. It can be applied to study adsorption from solutions.

LIMITATION OF FREUNDLCH ADSORPTION EQUATION

- Experimently it was determined that extent of adsorption varies directly with presssure till saturation pressure is reached. Beyond that point rate of adsorption saturates even after applying higher pressure .
- Thus, Freundlich adsorption equation failed at higher pressure.