DETERMINATION OF FREUNDLICH AND LANGMUIR CONSTANTS USING ACTIVATED CHARCOAL

Aim: To find out the monolayer capacity and specific surface area (area per gram) of given power (activated charcoal) by adsorption method.

Requirements:

Chemicals: Distilled water, Activated charcoal, 0.5N Acetic acid, 0.2N Sodium hydroxide, Phenolphthalein.

Apparatus: Reagent bottle, Beakers, Burette, Pipette, Stand, Conical flask, Funnels.

Principle:

Adsorption is a surface phenomenon. In adsorption process the adsorbate is adhered to the surface of the adsorbent.

Freundich studied adsorption of gas on solid and from the experimental data gave the equation y=x/m= kP.1/b

Where y = x/m the amount of adsorbate adorbed by mass 'm' gm of adsorbent at equilibrium pressure 'P' and is determined from the experiment at constant temperature.

K and b are constant indicating adsorption affinity and capacity and is dependent on the nature of the adsorbent and adsorbate and on temperature.

Langmuir's adsorption isotherm

Assumptions:

1. There are active sites on the solid surface at which adsorption takes place.
2. The adsorption is a monolayer adsorption not multilayer adsorption.
3. There is existence of a dynamic equilibrium between adsorbed molecule and free molecules. If adsorption by a solid is from solution,

Langmuir adsorption isotherm is given b

$$C_e \quad = \quad \frac{1 + C}{(x/m) = b.\ y_m}$$

Where y = x/m the amount of adsorbate adsorbed by mass m gm of adsorbent at equilibrium concentration C and is determined from the experiment at constant temperature.

ym = monolayer capacity = mass of adsorbate adsorbed per gm of adsorbent when a monolayer is complete (on the surface of adsorbent)

From ym and the area of one molecule of adsorbate, the surface area of the adsorbent may be estimated.

The specific surface area of charcoal is given by $S = y_m \frac{N \cdot A}{M}$

Where N = Avogadro number = 6×10^{23} / mole

M = Molecular weight of acetic acid = 60

A = Cross sectional area of acetic acid molecule = 18×10^{-16} cm^2

Procedure: Determine the exact normality (N_0) of given acetic acid solution by titrating 10 ml against 0.2N NaOH solution using phenolphthalein indicator (End point: Colorless to pink). Prepare following mixtures of acetic acid and distilled water in five separate dry bottles and keep them in a water bath at room temperature.

Bottle	Volume of distilled water (ml)	Volume of acetic acid (ml)	Normality of acetic acid solution (N_1)
1	00	50	N_0
2	10	40	$4/5N_0=0.8xN_0=$
3	20	30	$3/5N_0= 0.6xN_0=$
4	30	20	$2/5N_0= 0.4xN_0=$
5	40	10	$1/5N_0= 0.2xN_0=$

Add 1 gm of the activated charcoal to each of the five different dry bottles and keep them in a water bath at room temperature. Swirl the bottles for 40 mins to attain adsorption equilibrium. Filter the solution using dry filter paper into five different dry flasks and determine the effective normality of each filtered solution (N_2) by titrating 10ml against standard 0.2N NaOH solution using phenolphthalein indicator (End point: Colorless to pink).

Observation:

Water bath temperature = ^{0}C

Mass of activated charcoal (m) = 1 g

10ml of given acetic acid =V ml of 0.2N NaOH

Exact normality of acetic acid (N_0) = 0.2 V

Bottle no	N_1	T.R	N_2	$N_1 - N_2$	C_e gm/l	x	x/m	**C_e** (x/m)
1								
2								
3								
4								
5								

N_1 = Initial normality = initial concentration in gm equiv/liter

C_e = Equilibrium concentration of acetic acid = N_2 .M gm/l

Where: M = Molecular weight of acetic acid = 60

x = Amount of acetic acid adsorbed per 50ml of the solution

$$= \frac{(N_1 - N_2) \times E \times 50}{1000}$$

$$= \frac{(N_1 - N_2) \times 60 \times 50}{1000}$$

$$= \frac{3000\,(N_1 - N_2)}{1000}$$

$$= 3\,(N_1 - N_2)$$

Where: N_2 = Normality of the solution after adsorption (after filtration)

E = Equivalent weight of acetic acid (adsorbate)

m = Mass of activated charcoal (adsorbent) in gm (x/m) = Amount of acetic acid in gm. Adsorbed per gm. of adsorbent

Graph and Calculation:

At the adsorption equilibrium,

$$C_e = \frac{1 + C_e}{}$$

$$(x/m) = b.\ y_m$$

Where y_m = monolayer capacity 203.

(x/m) = Mass of adsorbate adsorbed per gram of adsorbent to form a monolayer (on the surface of adsorbent)

Plot $C_e/(x/m)$ vs C_e; the slope of the line = $1/\ y_m$

$y_m = 1/(\text{slope})$

The specific surface area of charcoal is given by $S = y_m \frac{N\ .\ A}{M}$

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Report:

Monolayer capacity of activated charcoal was found to be ________

Specific surface area of charcoal was found to be _______ cm^2/g or ________ m^2/g