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SURFACE CHEMISTRY

Adsorption

"The accumulation of a substance at the surface of another substance is called adsorption."

Here, the molecular species or substance, which concentrates or accumulates at the surface of another substance is called adsorbate and the substance on the surface of which the adsorption occurs is called adsorbent.

For example, when a piece of silica gel is placed in humid atmosphere, the air becomes dry due to adsorption of water molecules on the surface of the silica gel.

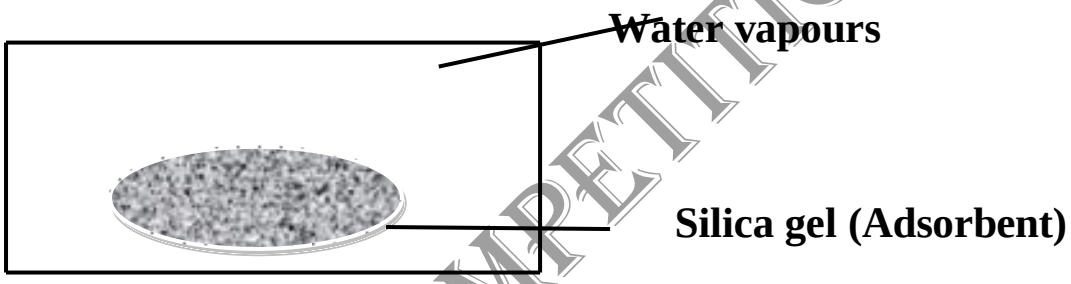


Fig. - Expression of adsorption

Adsorption is a surface phenomenon which occurs only at the surface or interface of two phases.

Solids such as, charcoal, silica gel, alumina gel, clay, colloids, metals etc. in finely divided state, possess a large surface area and therefore, act like good adsorbents.

Adsorption in action

(i) If a gas is taken in a closed vessel containing powdered charcoal, the pressure of the gas decreases due to adsorption of the gaseous molecules at the surface of the charcoal.

(ii) When animal charcoal is added in a solution of an organic dye such as methylene blue and the solution is shaken well, the solution becomes colourless due to the adsorption of the molecules of the dye on the surface of charcoal.

(iii) When aqueous solution of raw sugar is passed over beds of animal charcoal, it becomes colourless as the colouring substances get adsorbed by the charcoal.

(iv) In the presence of silica gel, the air becomes dry because the water molecules get adsorbed on the surface of the gel.

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Desorption

The process of removal of an adsorbed substance from the surface of adsorbent is called desorption.

Distinction between Adsorption and Absorption

The accumulation of a substance at the surface of another substance is called adsorption. It is a surface phenomenon where the substance concentrates only at the surface of adsorbent and does not penetrate to the bulk.

On the other hand, uniform distribution of a substance throughout the bulk of the another substance is called absorbtion. It is a bulk phenomenon.

Thus, in adsorption the concentration of the adsorbate increases only at the surface of the adsorbent, while in absorption the concentration is uniform throughout the bulk of the solid.

For example, when a chalk stick is dipped in ink, the surface retains the colour of the ink due to adsorption of coloured molecules while the solvent of the ink goes deeper into the stick due to absorption. On breaking the chalk stick, it is found to be white from inside.

Similarly, water vapours are absorbed by anhydrous calcium chloride but adsorbed by silica gel.

Sorption

When both adsorption and absorption occur simultaneously then this phenomenon is called sorption.

Mechanism of Adsorption

Adsorption arises due to the fact that the surface particles of the adsorbent are not in the same environment as the particles inside the bulk. Inside the adsorbent all the forces acting between the particles are mutually balanced but on the surface the particles are not surrounded by atoms or molecules of their kind on all sides, and hence they possess an unbalanced or residual attractive forces. These forces of the adsorbent are responsible for attracting the adsorbate particles on its surface.

At a given temperature and pressure, the extent of adsorption increases with the increase of surface area per unit mass of the adsorbent.

Another important factor featuring adsorption is the heat of adsorption. During adsorption, there is always a decrease in residual forces of the surface, i.e., there is decrease in surface energy which appears as heat. Thus, Adsorption is an exothermic process i.e. ΔH of adsorption is always negative.

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When a gas is adsorbed, the freedom of movement of its molecules gets restricted. This accounts to decrease in the entropy of the gas after adsorption, i.e. ΔS is negative.

Thus, adsorption is accompanied by decrease in enthalpy as well as decrease in entropy of the system.

For a process to be spontaneous, the thermodynamic requirement is that, at constant temperature and pressure, ΔG must be negative i.e. there should be a decrease in Gibbs Free energy during the process.

From Gibbs - Helmholtz equation,

$$\Delta G = \Delta H - T\Delta S$$
$$= -\Delta H - T(-\Delta S)$$
$$= -\Delta H + T\Delta S$$

Here, ΔG can only be negative if ΔH has sufficiently high negative value as $T\Delta S$ is positive.

As the adsorption proceeds, ΔH becomes less and less negative and ultimately it becomes equal to $T\Delta S$ and therefore, ΔG becomes zero. At this state equilibrium gets attained.

Types of Adsorption

The adsorption of gases on solids may be mainly of following two type-

(1) Physical adsorption or physisorption

Such adsorption in which weak physical forces (van der Waals' forces) operate between adsorbate and adsorbent is called physical adsorption or physisorption.

Characteristics of physisorption

(i) Lack of specificity

Physical adsorption is non specific i.e. all the adsorbates get adsorbed more or less over the surface of all the adsorbents.

(ii) Nature of adsorbate

The amount of gas adsorbed by a solid depends on the nature of gas. In general, easily liquefiable gases (i.e. gases having higher critical temperatures) are readily adsorbed as van der Waals' forces are stronger near the critical temperatures. Thus, 1g of activated charcoal adsorbs more sulphur dioxide (critical temperature 630K), than methane (critical temperature 190K) and dihydrogen (critical temperature 33K).

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(iii) Reversible nature

Physical adsorption is generally reversible i.e. the adsorbed molecules get easily desorbed on increasing temperature.

Here, on increasing pressure more gas gets adsorbed (Le-Chateliers's principle) but it gets desorbed on decreasing pressure.

Since the adsorption process is exothermic, the physical adsorption occurs readily at low temperature and decreases with increasing temperature (Le-Chatelier's principle).

(iv) Surface area of adsorbent

The extent of adsorption increases with the increase of surface area of the adsorbent. Thus, finely divided metals and porous substances having large surface areas are good adsorbents.

(v) Enthalpy of adsorption

In physisorption very weak van der Waals' forces operate between adsorbate and adsorbent. Hence, the enthalpy of adsorption is relatively low (20-40 kJ mol^{-1}).

(vi) Formation of multimolecular layers

It results in the formation of multimolecular layers of adsorbate over the surface of adsorbent under high pressure.

(2) Chemical adsorption or chemisorption

Such adsorption in which relatively stronger chemical bonds get formed between adsorbate and adsorbent is called chemical adsorption or chemisorption. Here, the chemical bonds may be covalent or ionic in nature.

Chemisorption involves a high energy of activation and is, therefore, it is also called activated adsorption.

Some times both of these two processes occur simultaneously and it is not easy to ascertain the type of adsorption. A physical adsorption occurring at low temperature may pass into chemisorption at high temperature. For example, on nickel surface, dihydrogen is first adsorbed physically by van der Waals' forces but there after these adsorbed molecules get dissociated into hydrogen atoms which get chemically held on the metal surface by chemisorption.

Characteristics of chemisorption

(i) High specificity

Chemisorption is highly specific i.e. a definite adsorbate can adsorbed over the surface of a definite adsorbents. It occurs only if there is some possibility of formation of chemical bonds between adsorbent and adsorbate.

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For example, oxygen is adsorbed on metal surfaces due to formation of metal oxides and hydrogen is adsorbed on transition metals due to formation of metal hydrides.

(ii) Irreversibility

As chemisorption involves compound formation, it is usually irreversible in nature. Chemisorption is also an exothermic process but the process is very slow at low temperatures on account of high energy of activation. Like most chemical changes, adsorption often increases with rise of temperature. Physisorption of a gas adsorbed at low temperature may change into chemisorption at a high temperature. Usually high pressure is also favourable for chemisorption.

(iii) Surface area

Like physical adsorption, chemisorption also increases with increase of surface area of the adsorbent.

(iv) Enthalpy of adsorption

Enthalpy of chemisorption is relatively high (80-240 kJ mol^{-1}) as it involves the formation of strong chemical bonds.

(v) Formation of monomolecular layers

It results in the formation of only monomolecular layer over the surface of adsorbent over the surface of adsorbent.

Difference Between Physisorption and Chemisorption

Physisorption	Chemisorption
1. It involves very weak vander Waals' force between adsorbate and adsorbent.	1. It involves formation of strong chemical bonds between adsorbate and adsorbent.
2. It is non specific in nature specific i.e. all the adsorbates get adsorbed more or less over the surface of all the adsorbents.	2. It is highly specific in nature i.e. a definite adsorbate can only be adsorbed over the surface of a definite adsorbent.
3. It is reversible in nature.	3. It is irreversible in nature.
4. It depends on the nature of gas. more easily liquefiable gases are adsorbed readily.	4. It also depends on the nature of gas. only those gases which can react with the adsorbent show chemisorption.
5. Here, Enthalpy of adsorption is relatively low (20-40 kJ mol^{-1}).	5. Here, Enthalpy of adsorption is relatively high (80-240 kJ mol^{-1}).

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6. Low temperature is favourable for this adsorption. It decreases with increase of temperature.	6. High temperature is favourable for this adsorption. It increases with the increase of temperature.
7. No appreciable activation energy is needed.	7. Usually high activation energy is needed.
8. It depends on the surface area and increases with an increase of surface area.	8. It also depends on the surface area and increases with an increase of surface area.
9. It results in the formation of multimolecular ayers of adsorbate over the surface of adsorbent under high pressure.	9. It results in the formation of only monomolecular layer over the surface of adsorbent.

Adsorption Isotherms

The graph plotted between the amount of gas adsorbed by unit mass of adsorbent and pressure at constant temperature is called adsorption isotherm.

Freundlich adsorption isotherm

Let x g of adsorbate has been adsorbed by m g of adsorbent. Then, mass of adsorbate adsorbed by unit mass of adsorbent = x/m g.

Freundlich plotted the mass of adsorbate adsorbed by unit mass of adsorbent (x/m) against pressure P at a definite temperature and found following isotherm-

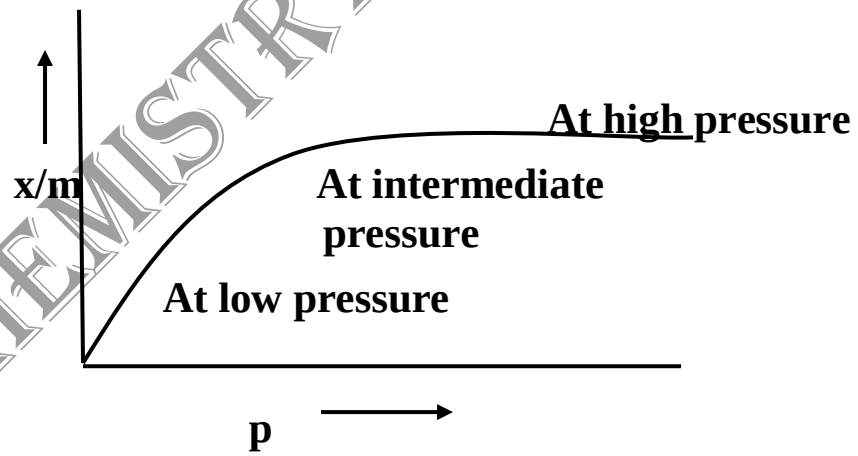


Fig. – Freundlich adsorption isotherm

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From the curve it is clear that,

(a) At low pressure-

$$\log \frac{x}{m} \quad \alpha \quad P^1$$

(b) At high pressure-

$$\log \frac{x}{m} \quad \alpha \quad P^0$$

Thus, at intermediate pressure,

$$\log \frac{x}{m} \quad \alpha \quad P^{1/n}$$

or $$\log \frac{x}{m} = kP^{1/n} \qquad \text{----------} \quad (1)$$

Where, n is an integer and n > 1 & k = Freudlich adsorption co-efficient

The value of *k* and n depends on the nature of the adsorbent and the gas at a particular temperature.

Taking logarithm of eq. 1, we get-

$$\log \frac{x}{m} = \log k + 1/n \log P \quad \text{------} \quad (2)$$

This equation is identical to straight like equation (y = mx + c), hence, if $\log \frac{x}{m}$ is plotted against log P then a straight line with positive slope of 1/n and intercept equal to log k is obtained,

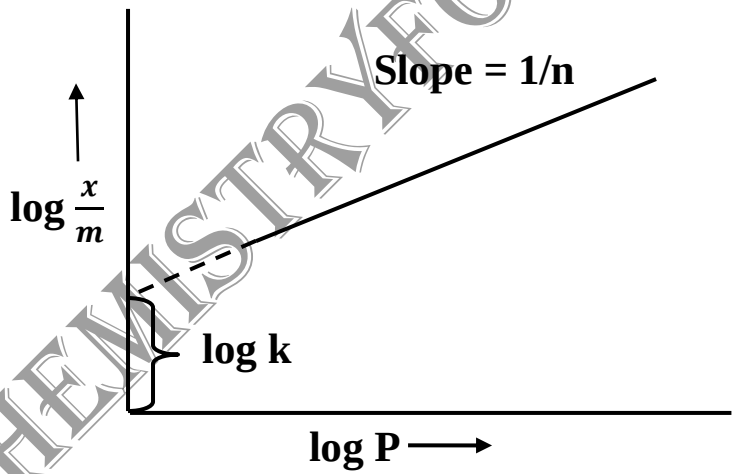


Fig. – Plot of log x/m against log P

The experimental isotherms always approaches saturation at high pressure. This cannot be explained by Freundlich isotherm. Thus, Freundlich isotherm fails at high pressure.

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Adsorption from Solution

When a solid adsorbent adsorbs solutes (adsorbate) from solutions, then it is called adsorption from solution. For example, when a solution of acetic acid in water is shaken with charcoal, a part of the acid is adsorbed by the charcoal and therefore, the concentration of the acid decreases in the solution. Similarly, when the litmus solution is shaken with charcoal it becomes colourless. The precipitate of $Mg(OH)_2$ attains blue colour when precipitated in presence of magneson reagent. The colour is due to adsorption of magneson.

Here, The extent of adsorption depends upon the concentration of the solute in solution as well as the nature of the adsorbent and the adsorbate. It increases with an increase of surface area of the adsorbent but decreases with an increase in temperature.

Applications

(1)Production of high vacuum- The remaining traces of air can be adsorbed by charcoal from a vessel evacuated by a vacuum pump to give a veiy high vacuum.

(ii) Gas masks- Gas mask (a device which consists of activated charcoal or mixture of adsorbents) is usually used for breathing in coal mines to adsorb poisonous gases.

(iii) Control of humidity- Silica and aluminium gels are used as adsorbents for removing moisture and controlling humidity.

(iv) Removal of colouring matter from solutions- Animal charcoal removes colours of solutions by adsorbing coloured impurities.

(v) Heterogeneous catalysis- Adsorption of reactants on the solid surface of the catalysts increases the rate of reaction. There are many gaseous reactions of industrial importance involving solid catalysts. Manufacture of ammonia using iron as a catalyst, manufacture of H_2SO_4 by contact process and use of finely divided nickel in the hydrogenation of oils are excellent examples of heterogeneous catalysis.

(vi) Separation of inert gases- Due to the difference in degree of adsorption of gases by charcoal, a mixture of noble gases can be separated by adsorption on coconut charcoal at different temperatures.

(vii) In curing diseases- A number of drugs are used to kill germs by getting adsorbed on them.

(viii) Froth floatation process- *A* low grade sulphide ore is concentrated by separating it from silica and other earthy matter by this method using pine oil and frothing agent.

(ix) Adsorption indicators- Surfaces of certain precipitates such as silver

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halides have the property of adsorbing some dyes like eosin, fluorescein, etc. and thereby producing a characteristic colour at the end point.

(x) Chromatographic analysis- Chromatographic analysis based on the phenomenon of adsorption. It finds a number of applications in analytical and industrial fields.

COLLOIDAL SOLUTIONS

"Such solutions in which the particles of colloidal size (10^{-4} -10^{-7}cm) called dispersed phase, remain suspended in a suitable solvent called dispersion medium are called colloidal solutions."

Types of colloidal solutions

Depending upon the affinity between dispersed phase and dispersion medium colloids may be of following two types-

(1) Lyophilic colloids

Such colloids which have strong affinity for dispersion medium are called lyophilic colloids. If dispersion medium is water, then these colloids are called hydrophilic colloids.

Here, colloidal solutions get easily formed when dispersed phase comes in contact with the dispersion medium.

All natural colloids are lyophilic (hydrophilic) colloids. For example, starch, gelatin, albumin, gum arabic etc. are hydrophilic colloids.

(2) Lyophobic colloids

Such colloids which have very weak affinity for dispersion medium are called lyophobic colloids. If dispersion medium is water, then these colloids are called hydrophobic colloids.

Here, colloidal solutions do not formed easily when dispersed phase is taken in contact with the dispersion medium. Hence, special methods are used for preparing colloidal solutions of these colloids.

All man made colloids are lyophobic (hydrophobic) colloids. For example, metal sols, metal hydroxide sols, metal sulphide sols etc. are hydrophobic sols.

Properties of Colloidal Solutions

(1) Heterogeneity

Colloidal solutions are heterogeneous in nature. In these solutions particles of dispersed phase and dispersion medium have different sizes.

The heterogeneity of colloidal solutions can be seen using ultra-microscope.

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(2) Brownian motion

In colloidal solutions, the particles of dispersed phase execute zigzag motion called Brownian motion.

Brownian motion is due to imbalanced bombardment of the molecules of dispersion medium over the particles of dispersed phase.

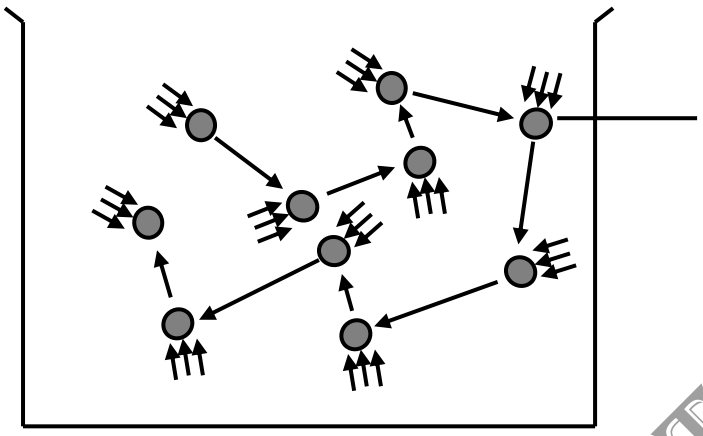


Fig.- Brownian motion of colloidal particles

Brownian motion is commonly found in lyophobic colloidal solutions. Lyophilic colloidal solutions, in general do not show Brownian motion due to relatively bigger size of the colloidal particles.

(3) Tyndall effect

When visible light passes through true solutions, its path is not visible. However, when it is passed through colloidal solutions and its path is observed from right angle to the path of propagation, a blue coloured bright cone is observed in the solution. This cone is called Tyndall cone and this effect is called Tyndall effect.

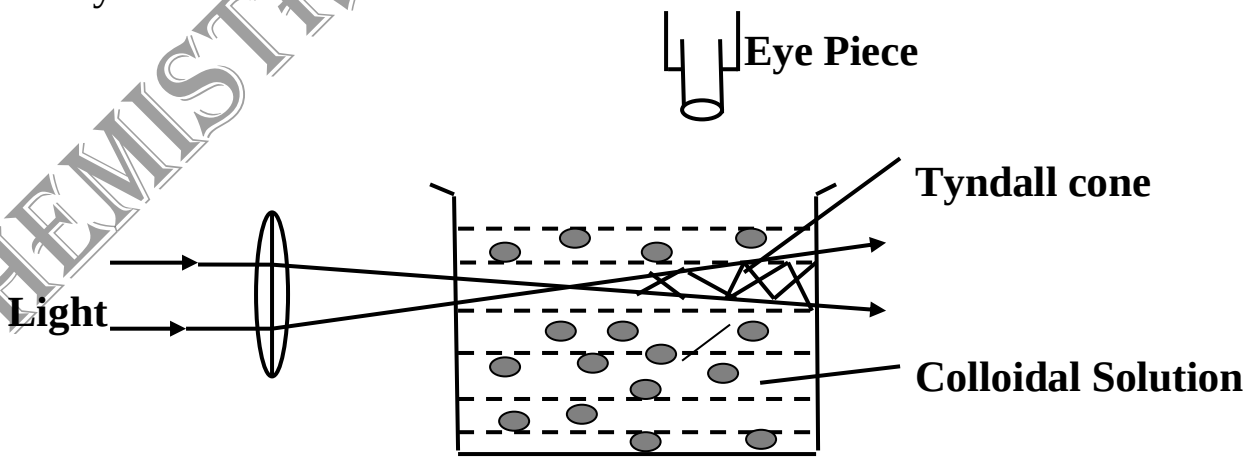


Fig. – Expression of Tyndall effect

Tyndall effect is due to scattering of light by colloidal particles. Since, scattering of light is highest at right angle to the path of propagation, the Tyndall

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cone is only observed when the path is observed from right angle to the path of propagation of light.

The phenomenon of Tyndall effect is mainly shown by Lyophobic colloids and rarely by lyophilic colloids.

The function of ultra-microscope is based on the phenomenon of Tyndall effect.

(4) Electrophoresis

In colloidal solutions, the particles of dispersed phase bear either positive or negative charge. Hence, if external electric field is applied, they move towards oppositely charged electrode. This phenomenon of movement of colloidal particles towards oppositely charged electrode in electric field is called electrophoresis.

Here, movement of cations towards cathode is called cataphoresis while, that of anions towards anode is called anophoresis.

For example, in ferric hydroxide sol, the colloidal particles are positively charged and move towards negatively charged electrode (cathode) in electric field i.e. show the phenomenon of cataphoresis .

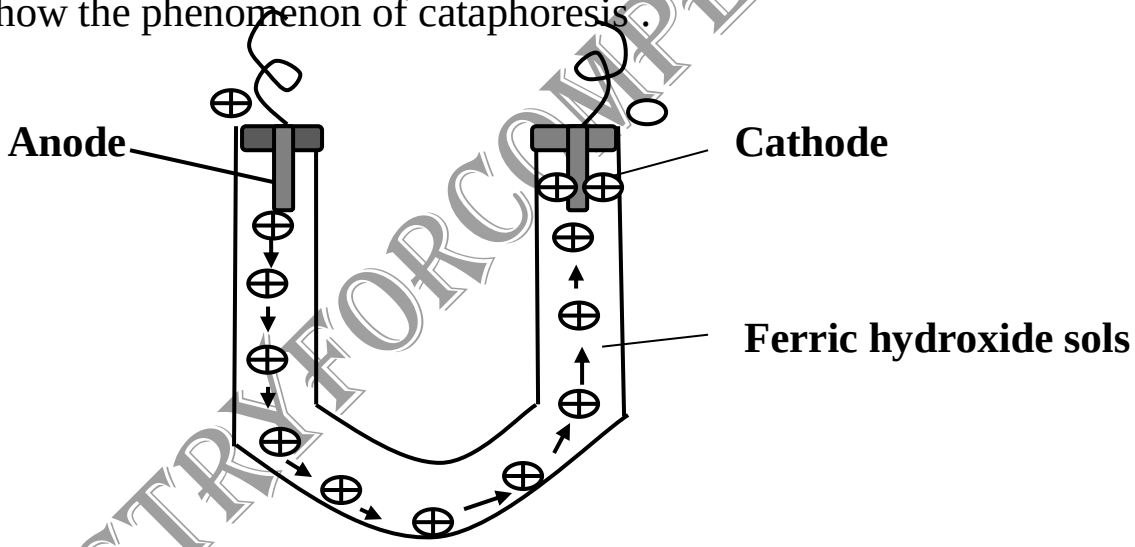


Fig.- Expression of cataphoresis

On the other hand, in arsenic sulphide sol, the colloidal particles are negatively charged and move towards positively charged electrode (anode) in electric field i.e. show the phenomenon of anophoresis.

Electrophoresis is used in determination of charge on colloidal particles.

Methods of Preparation of Colloidal Solutions

Lyophilic colloidal solutions are formed easily on adding lyophilic colloids to the suitable dispersion medium. However, Lyophobic colloidal solutions are not formed easily but require special methods for their preparation.

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Some important methods of preparing lyophobic colloidal solutions are as under-

(1)Bredig's arc method

This method is specially used for preparing metal sols. It is a combination of dispersion as well as condensation methods. Here, two electrodes of the metal whose colloidal solution is to be prepared are taken and are struck together so that it vaporizes to produce metal vapours. These particles condense together in ice cold dispersion medium to form particles of colloidal size.

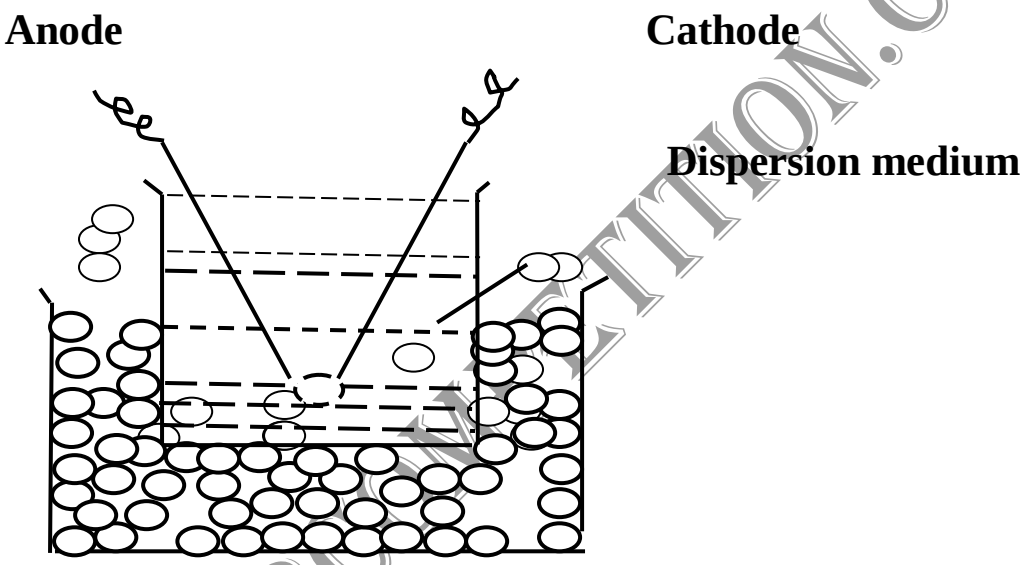


Fig.- Bredig's arc method

A trance amount of acid or alkali present in dispersion medium provides stability to the colloidal solutions.

(2) Peptization

The process of conversion of freshly prepared precipitate into colloidal solutions by adding some suitable reagent called peptizing agent is called Peptization.

For example, when freshly prepared $FeCl_3$ is added to the precipitate of $Fe(OH)_3$, a positively charged sol of ferric hydroxide is formed. Here, Fe^{3+} ions get absorbed over $Fe(OH)_3$ particles, so that these particles acquire colloidal size and become positively charged. Being positively charged, these particles repel one another and therefore, do not settle down but remain suspended in solution.

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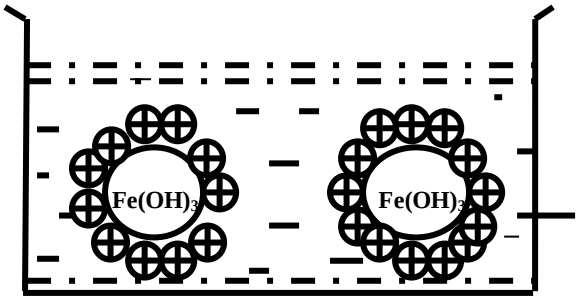


Fig.- Expression of peptization

Similarly, when H_2S gas is passed in freshly prepared precipitate of As_2S_3, the negatively charged sol of As_2S_3 is obtained due to preferential adsorption of S^{2-} ions over As_2S_3 molecules.

(3) Oxidation

This method is specially used for preparing sols of non-metals. For example, when H_2S gas is passed through the aqueous solution of SO_2, sulphur sol is obtained.

$$SO_2 + H_2S \rightarrow \underset{\text{Sulphur sol}}{S} + H_2O$$

(4) Reduction

This method is specially used for preparing metal sols. For example, when aqueous solution of aurric chloride is reduced by aqueous solution of stannous chloride, gold sol is obtained.

$$2AuCl_3 + SnCl_2 \rightarrow \underset{\text{Gold sol}}{2Au} + SnCl_4$$

(5) Hydrolysis

This method is specially used for preparing metal hydroxide sols. For example, when aqueous solution of ferric chloride is boiled, a reddish colored ferric hydroxide sol is obtained.

$$FeCl_3 + 3H_2O \rightarrow \underset{\text{Ferric hydroxide sol}}{Fe(OH)_3} + 3HCl$$

(6) Double decomposition

This method is specially used for preparing metal halide and metal sulphide sols. For example, when H_2S gas is passed through the aqueous solution of As_2O_3, Arsenic sulphide sol is obtained.

$$As_2O_3 + 3H_2S \rightarrow \underset{\text{Arsenic sulphide sol}}{As_2S_3} + 3H_2O$$

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Purification of colloidal solutions

(1) Ultrafiltration

It is one of the most common methods of purification of colloidal solutions. In this method, the colloidal solutions are filtered using ultra filter paper, where colloidal particles being relatively bigger in size, do not pass out and remain left on filter paper as residue, while other particles pass out through the filter paper. The residue thus obtained is mixed in fresh dispersion medium to get pure colloidal solution.

Ultra filter paper is prepared by impregnation of ordinary filter paper with colloidion solution (4% solution of cellulose nitrate in a mixture of alcohol and ether) and its hardening by soaking in formaldehyde and drying. Here, pores of the filter paper become smaller than colloidal particles.

Ultra filtration is very slow process. However, it can be speed up using pressure or suction.

(2) Dialysis

It is one of the most common method of purification of colloidal solutions. In this method the impure colloidal solution is taken in a dialyser or cellophane membrane and is suspended in fresh water, where crystalloid particles being smaller in size diffuse out leaving behind pure colloidal solution inside the dialyser or cellophane membrane.

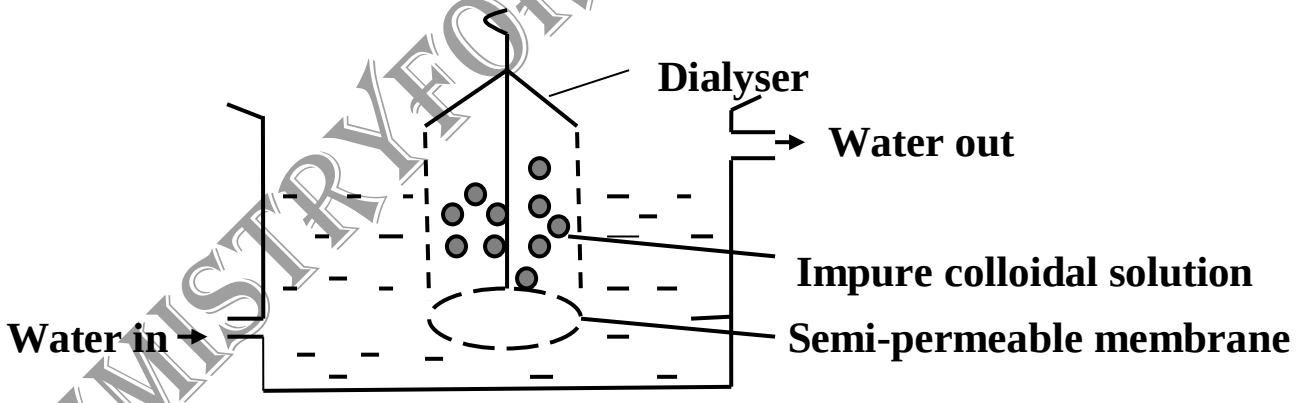


Fig.- Expression of dialysis

(3) Electrodialysis

It is modified form of dialysis and is specially used when the crystalloid particles present in colloidal solutions are charged ions. Here, dialysis is carried out by applying electric field, where the crystalloid particles speedly come out leaving behind pure colloidal solution inside the dialyser.

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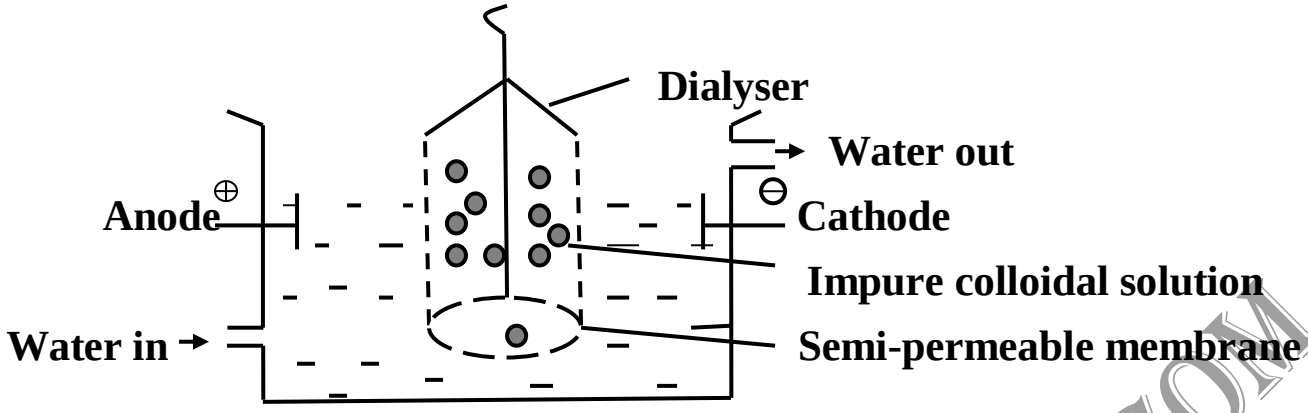


Fig.- Expression of Electro-dialysis

Production of charge on colloidal particles

It is due to preferential adsorption of one of the ions present in colloidal solutions. Usually the ion common to crystal lattice of the colloidal particles are preferentially absorbed. For example,

When freshly prepared $FeCl_3$ is added to the precipitate of $Fe(OH)_3$, a positively charged sol of ferric hydroxide is obtained. Here, Fe^{3+} ions get adsorbed over $Fe(OH)_3$ particles, so that these particles acquire colloidal size and become positively charged. Being positively charged, these particles repel one another and therefore, do not settle down but remain suspended in solution.

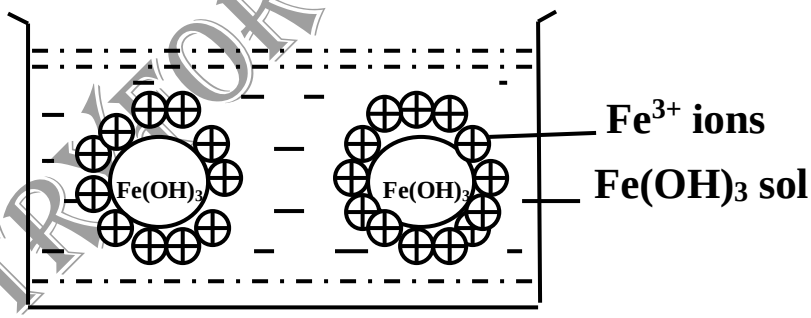


Fig.- Production of charge on colloidal particles

Similarly, when H_2S gas is passed in freshly prepared precipitate of As_2S_3, the negatively charged sol of As_2S_3 is obtained due to preferential adsorption of S^{2-} ions over As_2S_3 molecules.

Coagulation of colloidal solutions

Presence of a trance amount of electrolytes provides stability to the colloidal solutions, but if excess of an electrolyte is added to a colloidal solution, it's oppositely charged ions cause neutralization of the charge on colloidal particles. Hence, these particles come close together, collapse together making

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heavier flocks and finally get precipitated. This phenomenon is called coagulation or flocculation of colloidal solutions.

Hardy-Schultze rule

This rule governs the coagulating power of coagulating ions. According to this rule, "the coagulating power of a coagulating ion is directly proportional to the number of charge present on the ion."

For example, for positively charged colloidal solutions such as $Fe(OH)_3$ sol, negatively charged ions act like coagulating ions and the order of coagulating power of some important negatively charged ions is as under-

$$Fe[(CN)_6]^{4-} > PO_4^{3-} > SO_4^{2-} > Cl^-$$

Similarly, for negatively charged colloidal solutions such as As_2S_3 sol, positively charged ions act like coagulating ions and the order of coagulating power of some important positively charged ions is as under-

$$Sn^{4+} > Al^{3+} > Ba^{2+} > Na^+$$

Protection of Colloidal Solutions

Lyophilic colloids are highly stable and do coagulate easily on adding small amount of an electrolyte. On the other hand, lyophobic colloids are highly unstable and get coagulated easily on adding small amount of electrolyte. However, if a small amount of lyophilic colloids are added to lyophobic colloidal solutions, the stability of these colloids gets increased and they get protected from coagulation. This phenomenon is called protection of lyophobic colloids by lyophilic colloids. Thus, lyophilic colloids are called protecting colloids, while the lyophobic colloids are called protected colloids.

Here particles of lyophobic colloids get absorbed over the particles of lyophilic colloids, hence, they get protected from coagulation.

Gold number

The concept of gold number has been given by Zsigmondy to compare the protecting power of protecting colloids (lyophilic colloids). By definition-

"The amount of a protecting colloid in milligrams, required to prevent the coagulation of 10 ml of standard gold sol by 1 ml of 10% NaCl solution is called gold number of respective protecting colloid."

The protecting power of a protecting colloid is inversely proportional to its gold number. The smaller the value of gold number more is it's protecting power. For example, gelatin having least value of its gold number is considered to be most powerful protecting colloid.

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Emulsions

The colloidal solutions of liquids in liquids are called emulsions. Thus, in emulsions both dispersed phrase and dispersion medium are in liquid phase. These are highly unstable and therefore some suitable substances called emulsifier are required to provide them stability.

Emulsions may be of following two types-

(1) Oil in Water (O/W) emulsions

In these emulsions oils act like dispersed phase, while water acts like dispersion medium. For example, milk, vanishing cream etc. In milk liquid fat remains dispersed in water.

Principal emulsifying agent for this type of emulsions are proteins, gums, natural and synthetic soap etc.

(2) Water in Oil (W/O) emulsions

In these emulsions water act like dispersed phase, while oil acts like dispersion medium. For example, butter, Cream etc.

Principal emulsifying agent for this type of emulsions are heavy metal salts of fatty acids, long chain alcohols, lamp black etc.

Applications of Colloids

(1) Use of potash alum on minor cuts

Blood is negatively charged sol. When potash alum is applied on minor cuts, the positively charged Al^{3+} ions furnished by potash alum cause the coagulation of blood by neutralizing the charge of colloidal particles and therefore, the bleeding gets stopped.

(2) Delta formation

The sand particles present in river water are negatively charged colloidal particles. When the river water meets sea water, the salts of sea water cause the neutralization of the charge of these particles and therefore, they get precipitated forming delta.

(3) Electrostatic Precipitator

OR

Cottrel Precipitator

It is a device which is used for separation of carbon particles from industrial smoke. Here, a number of metal plates remain kept at very high positive voltage in a closed tower.

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In fact, carbon particles present in industrial smoke are negatively charged colloidal particles. When the smoke is passed through the Precipitator, the ash particles being negatively charged are attracted towards the palate (electrodes), neutralized and finally get precipitated, while the warm air free from ash comes out through the chimney.

Theories of Catalysis

Following are three important theories of catalysis-

(1) Intermediate formation theory

This theory is especially useful for explaining homogeneous catalysis. According to this theory, during catalytic reactions, first one of the reactants combines with the catalyst to form reaction intermediate. This reaction intermediate reacts further with another reactant to form final products.

This theory could not explain the role of catalyst promoters and catalyst poison.

(2) Adsorption theory

This theory is especially useful for explaining heterogeneous catalysis. According to this theory, during catalytic reactions, the reactant molecules first get chemically adsorbed over the active sites of the catalyst. Thus, the reactant molecules get strained and the concentration of reactants gets increased at the surface of catalyst. Hence, the rate of the reaction gets increased. Here, the energy released in chemical adsorption of reactant molecules over the active sites of the catalyst acts like energy of activation for other reactant molecules.

(3) New adsorption theory

This theory is a combination of old intermediate formation theory and adsorption theory. According to this theory, the heterogeneous catalysis involves following steps-

(1) Diffusion of reactant molecules on active sites of catalyst.

(2) Chemical adsorption of reactant molecules to the vacant valencies of the catalyst.

(3) Reaction between adsorbed reactant molecules to form products.

(4) Desorption of products from the surface of catalyst leaving vacant valencies for fresh reactant molecules.

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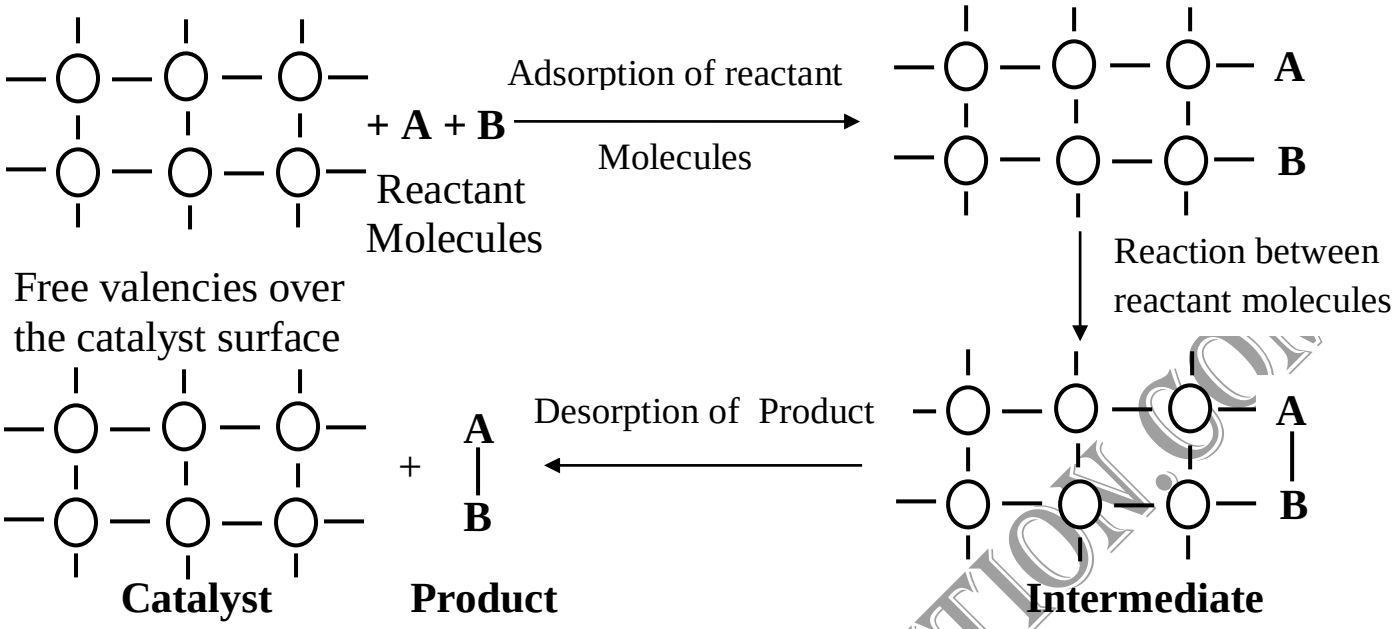


Fig.- Adsorption theory of Heterogeneous catalysis

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