World Journal of Pharmaceutical Sciences
ISSN (Print): 2321-3310; ISSN (Online): 2321-3086
Published by Atom and Cell Publishers
Available online at: http://www.wjpsonline.org/
Editorial

Protective power of colloid is inversely proportional to the gold number

Dr. Dhrubo Jyoti Sen

D. Pharm., B.Sc. (Hons), B.Pharm. (Hons), M.Pharm., Ph.D., FICS, CChem FIC (India), CChem FRSC (UK), CSci (UK), AOM (USA)
Professor, Department of Pharmaceutical Chemistry, Shri Sarvajanik Pharmacy College, Gujarat Technological University, Arvind Baug, Mehsana-384001, Gujarat, India
Phone: 00-91-2762-247711 (Ext-307); Fax: 00-91-2762-247712
Website: http://sspcmsn.org/yahoo_site_admin/assets/Facultyprofiles/drdjsen.pdf
Mobile: 09979132823, E-mail: dhrubosen69@yahoo.com

Recipient of K.K. Acharjee Award, Recipient of Jewel of India Award, Recipient of Rashtriya Vidya Saraswati Puraskar, Recipient of Rashtriya Vidya Jyoti Award and Gold Medal, Recipient of Life Time Achievement Gold Medal Award, Recipient of Eminent Educationist Award, Recipient of International Gold Star Award, Recipient of Vidya Ratan Award, Recipient of Gyan Jyoti Gold Medal Award, Recipient of Bharat Excellence Award & Gold Medal, Recipient of India Inspiration Award & Gold Medal, Recipient of Seva Chakra Puraskar, Recipient of American Order of Merit, Recipient of Golden Educationist of India Award, Recipient of NEHS Global Award of Excellence and Gold Medal of Excellence, Recipient of NEHS Jewel of India Award and NEHS Gold Medal of Excellence, Recipient of Academician of the Year Award..

INTRODUCTION

A **colloid** is a substance in which microscopically dispersed insoluble particles are suspended throughout another substance. Sometimes the dispersed substance alone is called the colloid; the term **colloidal suspension** refers unambiguously to the overall mixture (although a narrower sense of the word *suspension* is contradistinguished from colloids by larger particle size). Unlike a solution, whose solute and solvent constitute only one phase, a colloid has a dispersed phase (the suspended particles) and a continuous phase (the medium of suspension). To qualify as a colloid, the mixture must be one that does not settle or would take a very long time to settle appreciably. The dispersed-phase particles have a diameter of between approximately 1 and 1000 nanometers. Such particles are normally easily visible in an optical microscope, although at the smaller size range ($r<250$ nm), an ultramicroscope or an electron microscope may be required. Homogeneous mixtures with a dispersed phase in this size range may be called *colloidal aerosols*, *colloidal emulsions*, *colloidal foams*, *colloidal dispersions* or *hydrosols*. The dispersed-phase particles or droplets are affected largely by the surface chemistry present in the colloid. Some colloids are translucent because of the Tyndall effect, which is the scattering of light by particles in the colloid. Other colloids may be opaque or have a slight color.

Colloidal suspensions are the subject of interface and colloid science. This field of study was introduced in 1861 by Scottish scientist Thomas Graham. The following forces play an important role in the interaction of colloid particles:

- Excluded volume repulsion: This refers to the impossibility of any overlap between hard particles.
- Electrostatic interaction: Colloidal particles often carry an electrical charge and therefore attract or repel each other. The charges of both the continuous and the dispersed phase, as well as the mobility of the phases are factors affecting this interaction.
- Van der Waals forces: This is due to interaction between two dipoles that are either permanent or induced. Even if the particles do not have a permanent dipole, fluctuations of the electron density gives rise to a temporary dipole in a particle. This temporary dipole induces a dipole in particles nearby. The temporary dipole and the induced dipoles are then attracted to each other. This is known as Van der

Waals force, and is always present (unless the refractive indexes of the dispersed and continuous phases are matched), is short-range and is attractive.

- Entropic forces: According to the second law of thermodynamics, a system progresses to a state in which entropy is maximized. This can result in effective forces even between hard spheres.
- Steric forces between polymer-covered surfaces or in solutions containing non-adsorbing polymer can modulate inter particle forces, producing an additional steric repulsive force (which is predominantly entropic in origin) or an attractive depletion force between them. Such an effect is specifically searched for with tailor-made super plasticizers developed to increase the workability of concrete and to reduce its water content. Biphasic liquid are of two types: Colloids (1-1000 nm) and Coarse suspensions (> 1000 nm) and homogenous liquid True solution (< 1 nm).[1]

Lyophilic Colloids: Lyophilic Colloids are liquid loving colloids (Lyo means solvent and philic means loving). **Lyophobic Colloids**: Lyophobic Colloids are liquid hating colloids (Lyo means solvent and phobic means hating).

Examples

Lyophilic Colloids: Sols of organic substances like gelatin, gum, starch and proteins. **Lyophobic Colloids**: Sols of inorganic substances like Arsenic (As_2S_3), Iron ($Fe(OH)_3$) and Platinum.

Ease of Preparation

Lyophilic Colloids: As these colloids are liquid loving, their sols are easy to prepare and can be prepared directly by mixing colloid with liquid. Additional stabilizers are not required during their preparation.

Lyophobic Colloids: As these colloids are water hating, their sols are easy to prepare and cannot be prepared directly by mixing colloid with liquid. Special methods are employed to prepare Lyophobic Colloids sols and additional stabilizers are required during their preparation.

Stability

Lyophilic Colloids: Lyophilic Colloids sols are relatively stable as strong forces of interaction exist between colloidal particles and liquid. **Lyophobic Colloids**: Lyophobic Colloids sols are less stable as weak forces of interaction exist between colloidal particles and liquid.

Charge

Lyophilic Colloids: The charge on the Lyophilic Colloids sol depends upon pH of the solution and can be negative, positive or neutral. **Lyophobic Colloids**: The charge on Lyophobic Colloids sol can be positive or negative. As_2S_3 sol is negative in nature while $Fe(OH)_3$ sol is positive in nature.

Viscosity

Lyophilic Colloids: The Lyophilic Colloids are highly viscous in nature and have higher viscosity than that of the medium. **Lyophobic Colloids**: The Lyophobic Colloids have almost same viscosity as that of medium.

Reversibility

Lyophilic Colloids: Reversible, because on evaporating the liquid, the residue left will passes into colloidal state on addition of liquid. **Lyophobic Colloids**: Irreversible, because on evaporating the liquid, the residue left cannot be converted into solution on mere addition of liquid.

Electrophoresis

Lyophilic Colloids: Depending on the nature of charge these particles may migrate to cathode or anode or may not move at all. **Lyophobic Colloids**: Depending on the nature of charge these particles migrate to either cathode or anode.

Surface Tension

Lyophilic Colloids: The surface tension of these sols is less than that of dispersion medium. **Lyophobic Colloids**: The surface tension is nearly same as that of dispersion medium.[2]

Zsigmondy introduced a term called **gold number** to describe the protective power of different colloids. This is defined as, "weight of the dried protective agent in milligrams, which when added to 10 ml of a standard gold sol (0.0053-0.0058%) is just sufficient to prevent a colour change from red to blue on the addition of 1 ml of 10 % sodium chloride solution, is equal to the gold number of that protective colloid." Thus, smaller is the gold number; higher is the protective action of the protective agent.

Gold Number is a term used in colloidal chemistry. It is defined as the minimum amount of Lyophilic Colloids in milligrams which prevents the flocculation of 10 ml gold sol by the addition of 1 ml of 10%NaCl solution. Interface and colloid science is an interdisciplinary intersection of branches of chemistry, physics, nanoscience and other fields dealing with colloids, heterogeneous systems consisting of a mechanical mixture of particles between 1 nm and 1000 nm dispersed in a continuous medium. A colloidal solution is a heterogeneous mixture in which the particle size of the substance is intermediate between a true solution and a suspension, i.e. between 1-1000 nm. Smoke from a fire is an example of a colloidal system in which tiny particles of solid float in air. Just like true solutions, colloidal particles are small and cannot be seen by the naked eye. They easily pass through filter paper. But colloidal particles are big enough to be blocked by parchment paper or animal membrane. Interface and colloid science has applications and ramifications in the chemical industry, pharmaceuticals, biotechnology, ceramics, minerals, nanotechnology and microfluidics, among others.

Coagulation of gold sol is indicated by colour change from red to blue when particle size just increases. **More is the gold number, less is the protective power** of the Lyophilic Colloids colloid since it means that the amount required is more:

Protective power ∝ (Gold number)$^{-1}$

It was first used by Richard Adolf Zsigmondy in 1901. The amount is taken in terms of weight in milligrams.[3]

The Gold Number of some colloids are given below:

Protective Colloids	Gold Number
Gelatin	0.005-0.01
Haemoglobin	0.03-0.07
Casein	0.01
Egg Albumin	0.15-0.25
Gum Arabic	0.15-0.25
Potato Starch	25
Dextrin	6-20
Gum Tragacanth	2
Sodium Oleate	1-5

Table-1: Gold Number

Gold Sol is Colloidal Gold. Gold Sol can be produced by boiling a solution of tetracholoroauric acid with a reducing agent. At the beginning of the reduction process the gold atoms are liberated from the chloroauric acid. Chloroauric acid is an inorganic compound with the chemical formula $HAuCl_4$. It is an orange-yellow solid, a common precursor to other gold compounds and an intermediate in the purification of gold metal. Both the trihydrate and tetrahydrate are available commercially. Chloroauric acid is the precursor used in the purification of gold by electrolysis. Liquid-liquid extraction of chloroauric acid is used for the recovery, concentrating, purification and analytical determinations of gold. Of great importance is the extraction of $HAuCl_4$ from hydrochloric medium by oxygen-containing extractant, such as alcohols, ketones, ethers and esters.

The concentration of gold (III) in the extracts may exceed 1 mol/L. Gold sol is a special type of colloid which is known as Lyophobic Colloids sol which are liquid hating or solvent hating i.e., these sols do not have liquid as solvent. In such sols, both the dispersed phase and dispersion medium is solid only. A gold sol may contain particles of various size composed of several atoms of gold and so it is called as multimolecular sol. The formation of uniform gold sols produced by the citrate reduction of auric acid is explored as a function of temperature and reagent concentration. As aurate ions are reduced, the reaction medium changes from black to purple to blue before turning deep red. These color changes are shown to result from a decrease in particle size over the course of the reaction. Electrophoretic and titration studies suggest the colloidal properties of the sols result from a combination of van der Waals, electrostatic and short-range repulsive interaction potentials. Increasing in particle surface potential over the course of the reaction is shown to result from competitive adsorption of citrate and aurate ions. A particle growth model incorporating colloidal stability is postulated.[4]

Zigmondy introduced the term gold number to evaluate quantitatively the protective power of different Lyophilic Colloids. It may be defined as ‘least quantity of protective colloid in milligrams, which is just sufficient to prevent the coagulation of 10 ml of standard gold sol (containing 0.0053% gold) by the rapid addition of 1 ml of 10% NaCl solution. The coagulation of gold sol is indicated by change in color from red to blue. Thus small the gold number, the greater is protective power of Lyophilic Colloids.

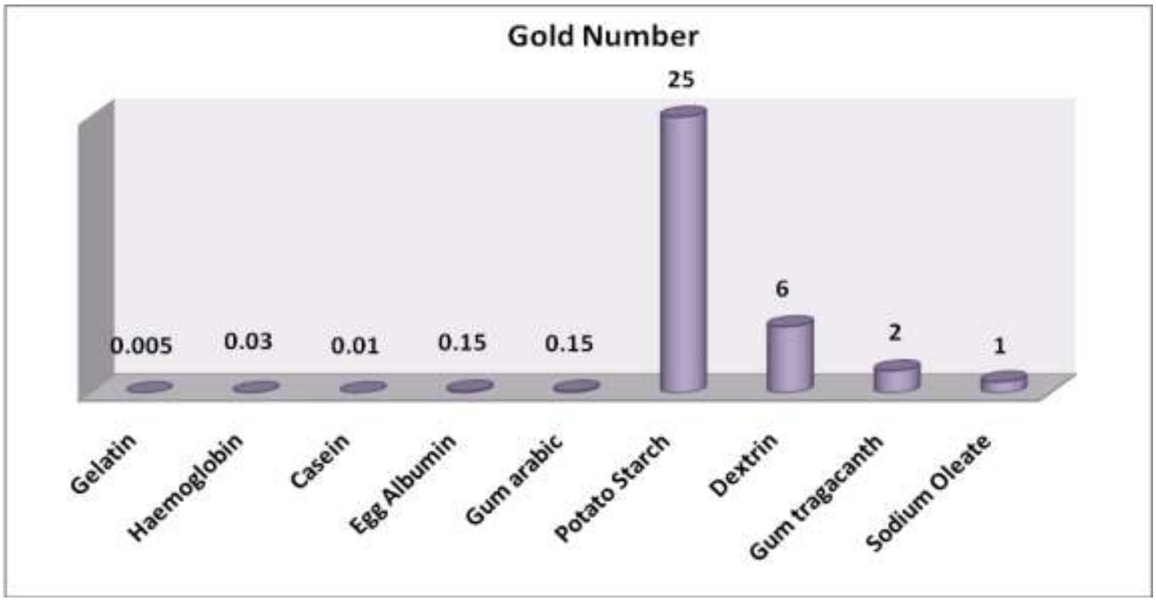

Figure-1: Protective power of colloid is inversely proportional to the Gold Number

The Lyophilic Colloids differ widely in their power of protection. The protective action of different colloids is measured in terms of the Gold number introduced by Zsigmondy. The gold number is defined as:

"The number of milligrams of a Lyophilic Colloids colloid that will just prevent the precipitation of 10 ml of standard gold sol (containing 0.5-0.6 gm of gold per litre) when 1 ml of 10% sodium chloride solution is added". The precipitation of gold sol is indicated by a colour change from red to blue. (When the particle size increases colour changes). The smaller the gold number of Lyophilic Colloids colloid, the greater is its protecting power. Gelatin has small gold number and is an effective protective colloid. In the preparation of ice cream, gelatin is used as protecting agent to the colloidal particles of ice. If the ice particles coagulate, the smooth texture of ice cream is lost.

Gold Number & protection of colloids:

• Lyophilic Colloids sols are more stable than Lyophobic Colloids sols.
• Lyophobic Colloids sols can be easily coagulated by the addition of small quantity of an electrolyte.
• When a Lyophilic Colloids sol is added to any Lyophobic Colloids sol, it becomes less sensitive towards electrolytes. Thus, Lyophilic Colloids can prevent the coagulation of any Lyophobic Colloids sol.

"The phenomenon of preventing the coagulation of a Lyophobic Colloids sol due to the addition of some Lyophilic Colloids colloid is called sol protection or protection of colloids."
• The protecting power of different protective (Lyophilic Colloids) colloids is different. The efficiency of any protective colloid is expressed in terms of gold number.

Gold number: Zsigmondy introduced a term called gold number to describe the protective power of different colloids. This is defined as, "weight of the dried protective agent in milligrams, which when added to 10 ml of a standard gold sol (0.0053-0.0058%) is just sufficient to prevent a colour change from red to blue on the addition of 1 ml of 10 % sodium chloride solution, is equal to the gold number of that protective colloid." Thus, smaller is the gold number; higher is the protective action of the protective agent.

A protective colloid is a colloidal substance that protects other colloids from getting coagulated (precipitated) in the presence of an electrolyte. Lyophobic Colloids sols of metals like Gold (Au), Platinum (Pt), are not very stable, that is they are easily precipitated in the presence of an electrolyte.

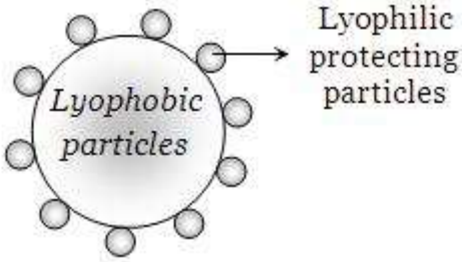

Figure-2: Protective colloid

Lyophilic Colloids sols on the other hand do not get precipitated easily in the presence of an electrolyte. Also, it has been seen that when addition of a Lyophilic Colloids to a Lyophobic Colloids, it resists coagulation or precipitation easily when an electrolyte is added. This process of protecting a Lyophobic Colloids sol from being coagulated on addition of an electrolyte by adding a Lyophilic Colloids colloid to it is called protection and the Lyophilic Colloids that is used in the process is called a protective colloid.

How does the protective colloid exactly protect the Lyophobic Colloids?

We do not know the exact mechanism of the process, but it is generally believed that the protective colloid (Lyophilic Colloids) particles form an envelope around the Lyophobic Colloids sol particles and protect them from the action of electrolyte. For example, addition of gelatin (a Lyophilic Colloids) to a gold sol (Lyophobic Colloids sol), the gelatin molecules surround and envelope the gold sol, protecting it from the action of sodium chloride solution (the electrolyte) and preventing it from being coagulated.[5]

Conclusion

Suspension, Colloidal Solution and True Solution: Based on distinct properties, solutions can be classified into Suspension, Colloidal Solution and True Solution. This classification is necessary to understand concepts of colloidal solutions and distinguish it from rest of the types.

Left (Suspension), Middle (Colloidal Solution), Right (True Solution)

Suspensions: Suspension is a heterogeneous mixture in which particle size of one or more components is greater than 1000 nm. When mud is dissolved in water and stirred vigorously, particles of mud are distributed evenly in water. After some time, the particles of this solution settle under water due to influence of gravity. This solution is an example of Suspension. Contrary to True Solution, particles of suspension are big enough to be seen with naked eye.

Colloidal Solution: Colloidal Solution is a heterogeneous mixture in which particle size of substance is intermediate of true solution and suspension i.e. between 1-1000 nm. Smoke from a fire is example of colloidal system in which tiny particles of solid float in air. Just like true solutions, Colloidal particles are small enough and cannot be seen through naked eye. They easily pass through filter paper but colloidal particles are big enough to be blocked by parchment paper or animal membrane.

True Solution: True Solution is a homogeneous mixture of two or more substances in which substance dissolved (solute) in solvent has the particle size of less than 10^{-9} m or 1 nm. Simple solution of sugar in water is an example of true solution. Particles of true solution cannot be filtered through filter paper and are not visible to naked eye.

Difference between Suspensions, Colloidal Solutions and True Solutions

The table given below summarizes the major properties and points of distinction between each type of solution with respect to different properties.

Property	**Suspensions**	**Colloidal Solutions**	**True Solutions**
Particle size	> 1000 nm	1-1000 nm	< 1 nm
Nature	**Heterogeneous**	**Homogenous**	**Homogenous**
Filterability (Diffusion through parchment paper)	Suspension particles do not pass through filter paper and parchment paper.	Colloidal particles pass through filter paper but not through parchment paper	Particles of true Solution diffuse rapidly through filter paper as well as parchment paper.
Visibility	Suspension particles are big enough to be seen by naked eye.	Colloidal particles are not seen to naked eye but can be studied through ultra microscope.	Particles of True Solution are not visible to naked eye.
Tyndall Effect	Suspension may or may not show Tyndall effect.	Colloids show Tyndall effect.	True Solution does not show Tyndall effect.
Appearance	Opaque	Translucent	Transparent

References

1. Lyklema J. Fundamentals of Interface and Colloid Science, Vol. 2, 3208, 1995.
2. http://www.chemistrylearning.com/difference-between-Lyophobic Colloids-and-Lyophilic Colloids/
3. http://en.wikipedia.org/wiki/Gold_number
4. Makotchenko E.V., Kokovkin V.V.; Solid contact $[AuCl_4]^-$-selective electrode and its application for evaluation of gold(III) in solutions. *Russian Journal of General Chemistry* 80(9): 1733, 2010.
5. http://www.chemistrylearning.com/what-is-gold-number/