10.27: Colloids

Solutions are homogeneous. Dissolved molecules as large as 1000 pm never separate as a result of gravitational forces, even in an ultracentrifuge. When suspended particles reach μm size (10^6 pm), they separate readily under gravity, and we classify the mixture as definitely heterogeneous. Surprisingly, suspensions of particles between these sizes, in the range 5 000 - 200 000 pm, never settle under gravity or centrifugation, yet the mixtures are definitely heterogeneous because beams of light passing though them are visible. If a laser pointer beam passes through a solution, it is invisible, but if it passes through a ***colloidal suspension*** it is easily seen. Laser shows would be invisible if it weren't for the colloidal smoke or fog that renders the beams visible.

Figure 10.27.1: Milk is a colloidal suspension of fat droplets in water. Laser beams made visible by colloidal particles in air

Colloids are stable suspensions of a *dispersed* medium, like the solid particles in smoke or fat particles in milk, in a *continuous medium*, like air or water. The particles and medium may be any combination of solid, liquid, and gas (except that they both can't be gases, because gasses are completely miscible), as the following table [1] shows:

For reference, the table is arranged so that the suspended particles are in the column while the medium the particles are suspended in are on the row. For example, solid foam's medium is solid (row) while the colloid particles are gaseous (column).

Medium	**Gas**	**Liquid**	**Solid**
Gas	*None* (All gases are mutually miscible)	*Liquid Aerosol* Examples: fog[1], mist, hair spray	*Solid Aerosol* Examples: smoke, cloud[1]
Liquid	*Foam* Example: Whipped cream	*Emulsion* Examples: milk, mayonnaise, hand cream	*Sol* Examples: pigmented ink, blood
Solid	*Solid Foam* Examples: aerogel, styrofoam, pumice	*Gel* Examples: agar, gelatin, jelly, silica gel	*Solid Sol* Example: red stained glass

[1] Average water droplets in fogs and clouds are around 0.01 mm in diameter, so they are ten times as big as typical colloids. Clouds "float" mostly because of air updrafts, and the hardly noticeable (~0.3 cm/s) terminal falling velocity of small droplets[2].

Colloids are stable, that is, their particles don't aggregate and precipitate, because the particles all tend to adsorb ions of one charge from solution. The colloidal particles then repel one another electrostatically. The individual particles are kept in suspension by Brownian motion.

When white light passes through a colloidal suspension, light scattering is highly wavelength dependent, so colloids may appear to be brightly colored. This is the case with the gold colloid that is responsible for the deep red color in most stained glass. Colloidal gold is easily made in the laboratory by reducing a gold salt dissolved in water to give elemental gold clusters. As the clusters change in size, the color of the colloid may change through virtually every color of the rainbow.

Red sunsets are due to the selective reflectance of blue light by colloidal particles in the sky, as can be seen in a YouTube video where milk is added to a container of pure water while a beam of white light from a bright flashlight or projector is passed through the suspension and toward a white screen, resulting in the deep red of sunset.

References

1. http://en.Wikipedia.org/wiki/Colloid
2. www.suite101.com/article.cfm/...nce_sky/116567
3. http://en.Wikipedia.org/wiki/Sunset
4. The colloidal sulfur can also be prepared by dissolving sulfur in methanol and adding the solution dropwise to water: www.woodrow.org/teachers/ci/1986/exp14.html

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