

Colloids:

An aquatic colloid is any constituent that provides a molecular milieu into and onto which chemicals can secede from the bulk aqueous solution, while its vertical movement is not significantly affected by gravitational settling Gustafson and Gschwend (L&O, 1997).

Trace molecules (metals, PCBs, DDT) behave differently when in solution vs. when bound to colloids or to sinking particles. They may be less bio-available and may photo-react differently than the solution phase.

The size of colloids is measured in nanometers (nm) and their weights in Kilo Daltons (KD=1000D, 1 molecule of Carbon 12 weighs 12D = $1.6605402 \times 10^{-27}$ kg). Typical sizes of colloid vary from 1→1000nm, the lower size being defined by the smallest scale for which a substance can have a microenvironment different than the solvent in which it resides. This defines an interface into which other chemical can get absorbed or the surface onto which they can be adsorbed. This surface must have an electrostatic field sufficient to stabilize the colloidal substance with respect to spontaneous aggregation with other colloidal or particulate matter. The upper size of colloid is defined by the size where gravity becomes the dominant force acting on the particle.

The mechanisms by which colloid ‘bump’ into each other and into other molecules are Brownian motion and gravitational settling. Their diffusion coefficient due to Brownian motion is given by:

$$D = k_B T / (6\pi\mu a),$$

where k_B is Boltzmann's constant ($1.38 \cdot 10^{-23}$ J/K), T the temperature in Kelvin, μ the fluid viscosity and a the particle's radius. The particle's rms velocity due to Brownian motion is given by:

$$v_{rms} = (3k_B T / m)^{1/2},$$

where m is the particles' mass.

The scavenging of metals by colloids is believed to restrict the availability of some of to phytoplankton (e.g. Iron), thus impacting phytoplankton growth and community structure (Wells, 2002).

Inorganic colloids:

A major class of colloidal particles are the clay minerals (see:

<http://www.pubmedcentral.nih.gov/picrender.fcgi?artid=34275&action=stream&blobtype=pdf> for a review article.)

Clay mineral are plate like with thickness on the order of 2-100nm. The diameter of the plate is often 5→10 times its thickness.

Two forces act on clay particles in the colloidal fraction in an aquatic medium: 1. weak attractive intermolecular van der Waals' force (e.g.

<http://www.chemguide.co.uk/atoms/bonding/vdw.html>, proportional to $1/r^6$) and 2.

repulsive electrical charge or Coulomb force (proportional to q_1q_2/r^2 , where q_1 and q_2 are the electrical charges of the two entities and r the distance between them).

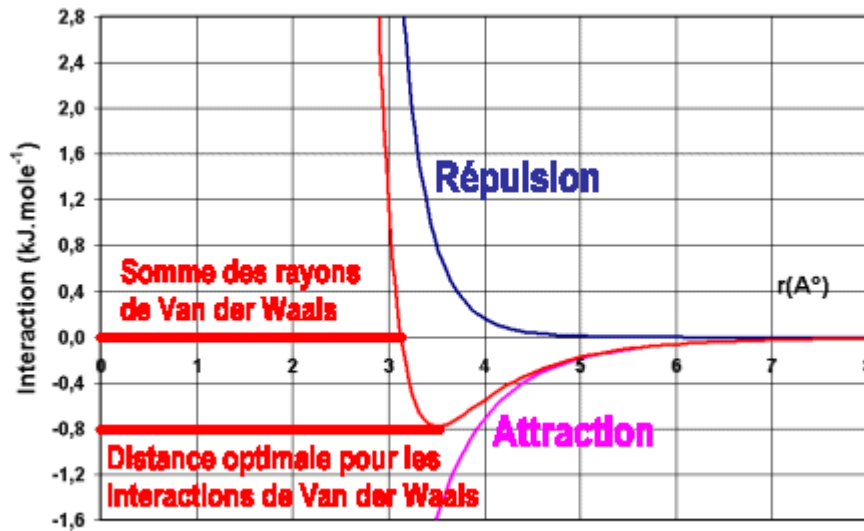


Figure 1. A schematic of the combined attraction due to van der Waals force and the repulsion due to the Culomb force. Depending on the relationship between the two, colloid molecules will be attracted to each other.

Clay minerals have a net negative charge due to: a. vacancies/unbalanced ionic substitutions in the crystal structure, and b. Physical/chemical adsorption of ions on the crystal's face. The net negative charge is balances by electrolyte ions of positive charge, which lie in the solution immediately around the particle. This outer layer forms a halo around the particle which repels similar structures around other clays of the same kind. When the electrolyte concentration in the aquatic medium increases the layer formed around the clay mineral thins, allowing the Van der Waals forces to bring clays together forming flocs.

Ions can be attracted to the surface of a clay particle or taken up within the structure of these minerals. The property of clay minerals that causes ions in solution to be fixed on clay surfaces or within internal sites applies to all types of ions, including organic molecules like pesticides and heavy metals. Thus, Clays can be an important vehicle for transporting and widely dispersing contaminants from one area to another (see: <http://pubs.usgs.gov/info/clays/>).

Organic colloids

A large fraction of dissolved organic carbon is due to waste products of the cycling for carbon fixation and consumption in the aquatic environment. Includes reactive substances such as proteins, polysaccharides, and lipids as well as biologically resistant humic substances and degradation product of the reactive substances. These dissolved substances harbor man sites that can bind cations (trace metals, Ca^{2+} , Mg^{2+}).

TEP- transparent exopolymers particles (coined in 1993 in a paper by Alldredge, Passow and Logan DSR, downloadable from <http://www.engr.psu.edu/ce/enve/logan.htm>). TEP form from dissolved and colloidal polysaccharides by aggregation processes. Especially when running into nutrient limitation, phytoplankton organisms are a source of TEP in pelagic ecosystems as the cells release a significant amount of the assimilated carbon in the form of polysaccharides. Bacteria plankton are also believed to be a source for TEP or its precursors. Due to their stickiness TEP can, through coagulation and aggregation with other elements, be essential for some sedimentation and flux processes in aquatic systems. Although TEPs are transparent they can be stained with alcian blue and thereby be made visible for counting in a microscope or quantified by spectrophotometry with Gum Xanthan as reference.

Biocolloids

Viruses and bacteria are considered are in the colloids size range.

Gels

Gels are dispersions in which the attractive interactions are so strong that the whole system develops a rigid network structure that behave elastically under small stresses (Everett, 1988). This dispersion may consist of solid particles (e.g. clays), macromolecules, or surfactant molecules.

Some additional literature on the subject:

Everett, D. H., 1988. Basic principles of colloid science. Royal Society of Chemistry.

Hunter, R. J. Foundations of colloid science, 1991, 2 volumes, Oxford Science Publications.

Wells, M. 2002. Marine Colloids and Trace Metals. In: Biogeochemistry of Marine Dissolved Organic Matter, Edited by Hansell and Carlson, p. 367-404, Elsevier.