REPUBLIC OF UZBEKISTAN
MINISTRY OF HEALTH
TASHKENT PHARMACEUTICAL INSTITUTE
DEPARTMENT OF “*I*norganic, analytic, physic
and colloid chemistry”
on physic and colloid chemistry

SELF STUDY

SUBJECT: CRUDE DISPERSE SYSTEMS. AEROSOL. POWDER. FOEM.

Done by: Mavlyanova Rukhshona I.P. 1/1
Checked by: Rahmatullayeva M.

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PLAN:

1. Aerosol
2. Powder
3. Suspension
4. Emulsion
5. Foam

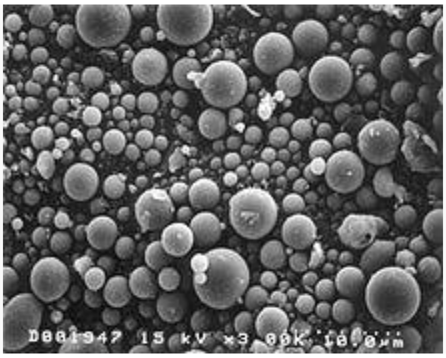
Aerosol

Mist and clouds are aerosols.

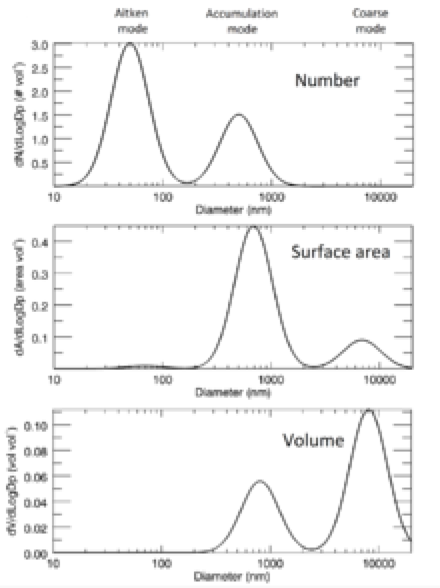
Because dust particles mostly settle to the ground, this visible dust is a suspension, not an aerosol. Very fine dust, common in the Sahara Desert, however, can constitute an aerosol as it travels on the winds for weeks.

An **aerosol** is a colloid of fine solid particles or liquid droplets, in air or another gas.[1] Aerosols can be natural or not. Examples of natural aerosols are fog, forest exudates and geyser steam. Examples of artificial aerosols arehaze, dust, particulate air pollutants and smoke.[1] The liquid or solid particles have diameter mostly smaller than 1 μm or so; larger particles with a significant settling speed make the mixture a suspension, but the distinction is not clear-cut. In general conversation, *aerosol* usually refers to an aerosol spray that delivers a consumer product from a can or similar container. Other technological applications of aerosols include dispersal of pesticides, medical treatment of respiratory illnesses, and combustion technology.[2] Diseases can also spread by means of small droplets in the breath, also called aerosols.

Aerosol science covers generation and removal of aerosols, technological application of aerosols, effects of aerosols on the environment and people, and a wide variety of other topics.



Size distribution



The same hypothetical log-normal aerosol distribution plotted, from top to bottom, as a number vs diameter distribution, a surface area vs diameter distribution, and a volume vs diameter distribution. Typical mode names are shows at the top. Each distribution is normalized so that the total area is 1000.

For a monodisperse aerosol, a single number—the particle diameter—suffices to describe the size of the particles. However, more complicated particle-size distributions describe the sizes of the particles in a polydisperse aerosol. This distribution defines the relative amounts of particles, sorted according to size.[10] One approach to defining the particle size distribution uses a list of the sizes of every particle in a sample. However, this approach proves tedious to ascertain in aerosols with millions of particles and awkward to use. Another approach splits the complete size range into intervals and finds the number (or proportion) of particles in each interval. One then can visualize these data in a histogram with the area of each bar representing the proportion of particles in that size bin, usually normalised by dividing the number of particles in a bin by the width of the interval so that the area of each bar is proportionate to the number of particles in the size range that it represents.[11] If the width of the bins tends to zero, one gets the frequency function:[12]

$$\mathrm{d}f = f(d_p)\,\mathrm{d}d_p$$

where

d_p is the diameter of the particles

$\mathrm{d}f$ is the fraction of particles having diameters between d_p and d_p + $\mathrm{d}d_p$

$f(d_p)$ is the frequency function

Therefore, the area under the frequency curve between two sizes a and *b* represents the total fraction of the particles in that size range:[13]

$$f_{ab} = \int_a^b f(d_p)\,\mathrm{d}d_p$$

It can also be formulated in terms of the total number density *N*:[14]

$$dN = N(d_p)\,\mathrm{d}d_p$$

Assuming spherical aerosol particles, the aerosol surface area per unit volume (*S*) is given by the second moment:[14]

$$S = \pi/2 \int_0^\infty N(d_p) d_p^2\,\mathrm{d}d_p$$

And the third moment gives the total volume concentration (*V*) of the particles:[14]

$$V = \pi/6 \int_0^\infty N(d_p) d_p^3\,\mathrm{d}d_p$$

One also usefully can approximate the particle size distribution using a mathematical function. The normal distribution usually does not suitably describe particle size distributions in aerosols because of the skewness associated a long tail of larger particles. Also for a quantity that varies over a large range, as many aerosol sizes do, the width of the distribution implies negative particles sizes, clearly not physically realistic. However, the normal distribution can be suitable for some aerosols, such as test aerosols, certain pollen grains and spores.[15]

A more widely chosen log-normal distribution gives the number frequency as:[15]

$$\mathrm{d}f = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(d_p - \bar{d}_p)^2}{2\sigma^2}}\,\mathrm{d}d_p$$

where:

σ is the standard deviation of the size distribution and

$\bar{d}_p$ is the arithmetic mean diameter.

POWDER

Iron powder

A **powder** is a dry, bulk solid composed of a large number of very fine particles that may flow freely when shaken or tilted. Powders are a special sub-class of granular materials, although the terms *powder* and *granular* are sometimes used to distinguish separate classes of material. In particular, *powders* refer to those granular materials that have the finer grain sizes, and that therefore have a greater tendency to form clumps when flowing. *Granulars* refers to the coarser granular materials that do not tend to form clumps except when wet.

Types

Examples of powders include flour, ground coffee, powdered milk, cosmetic powders, gunpowder, powdered sugar, fine snow, household dust, volcanic ash, the top layer of the lunar regolith, copy machine toner, and many pharmaceuticals..

Because of their importance to industry, medicine and earth science, powders have been studied in great detail by chemical engineers, mechanical engineers, chemists,physicists, geologists, and researchers in other disciplines.

There are other types of powders such as nasal powders, powder for injection, oral powder, and extemporaneous powders applied to the skin.

Mechanical properties

Typically, a powder can be compacted or loosened into a vastly larger range of bulk densities than can a coarser granular material. When deposited by sprinkling, a powder may be very light and fluffy. When vibrated or compressed it may become very dense and even lose its ability to flow. The bulk density of coarse sand, on the other hand, does not vary over an appreciable range.

The clumping behavior of a powder arises because of the molecular Van der Waals force that causes individual grains to cling to one another. Actually, this force is present not just in powders, but in sand and gravel, too. However, in such coarse granular materials the weight and the inertia of the individual grains are much larger than the very weak Van der Waals forces, and therefore the tiny clinging between grains does not have a dominant effect on the bulk behavior of the material. Only when the grains are very small and lightweight does the Van der Waals force become predominant, causing the material to clump like a powder.

Many other powder behaviors are common to all granular materials. These include segregation, stratification, jamming and unjamming, fragility, loss of kinetic energy,frictional shearing, compaction and Reynolds' dilatancy.

Powder transport[edit]

Powders are transported in the atmosphere differently from a coarse granular material. For one thing, tiny particles have little inertia compared to the drag force of the gas that surrounds them, and so they tend to *go with the flow* instead of traveling in straight lines. For this reason, powders may be an inhalation hazard. Larger particles cannot weave through the body's defenses in the nose and sinus, but will strike and stick to the mucous membranes. The body then moves the mucous out of the body to expel the particles. The smaller particles on the other hand can travel all the way to the lungs from which they cannot be expelled. Serious and sometimes fatal diseases such as silicosis are a result from working with certain powders without adequate respiratory protection.

Also, if powder particles are sufficiently small, they may become suspended in the atmosphere for a very long time. Random motion of the air molecules and turbulenceprovide upward forces that may counteract the downward force of gravity. Coarse granulars, on the other hand, are so heavy that they fall immediately back to the ground. Once disturbed, dust may form huge dust storms that cross continents and oceans before settling back to the surface. This actually explains why there is relatively little hazardous dust in the natural environment. Once aloft, the dust is very likely to stay aloft until it meets water in the form of rain or a body of water. Then it sticks and is washed downstream to settle as mud deposits in a quiet lake or sea. When geological changes later re-expose these deposits to the atmosphere, they may have already cemented together to become mudstone, a type of rock. For comparison, the Moon has neither wind nor water, and so its regolith contains dust but no mudstone.

The cohesive forces between the particles tend to resist their becoming airborne, and the motion of wind across the surface is less likely to disturb a low-lying dust particle than a larger sand grain that protrudes higher into the wind. Mechanical agitation such as vehicle traffic, digging or passing herds of animals is more effective than a steady wind at stirring up a powder.

The aerodynamic properties of powders are often used to transport them in industrial applications. Pneumatic conveying is the transport of powders or grains through a pipe by blowing gas. A gas fluidized bed is a container filled with a powder or granular substance that is *fluffed up* by blowing gas upwardly through it. This is used forfluidized bed combustion, chemically reacting the gas with the powder.'

Fire dangers of powders

Many common powders made in industry are combustible; particularly metals or organic materials such as flour. Since powders have a very high surface area, they can combust with explosive force once ignited. Facilities such as flour mills can be vulnerable to such explosions without proper dust mitigation efforts.

Some metals become especially dangerous in powdered form, notably titanium.

Comparison with other substances

A paste or gel might become a powder after it has been thoroughly dried, but is not considered a powder when it is wet because it does not flow freely. Substances like dried clay, although dry bulk solids composed of very fine particles, are not powders unless they are crushed because they have too much cohesion between the grains, and therefore they do not flow freely like a powder. A liquid flows differently than a powder, because a liquid cannot resist any shear stress and therefore it cannot reside at a tilted angle without flowing (that is, it has zero *angle of repose*.) A powder on the other hand is a solid, not a liquid, because it may support shear stresses and therefore may display an angle of repose.

Suspension (chemistry)

In chemistry, a **suspension** is a heterogeneous mixture containing solid particles that are sufficiently large for sedimentation. Usually they must be larger than one micrometer.[1] The internal phase (solid) is dispersed throughout the external phase (fluid) through mechanical agitation, with the use of certain excipients or suspending agents. Unlike colloids, suspensions will eventually settle. An example of a suspension would be sand in water. The suspended particles are visible under a microscope and will settle over time if left undisturbed. This distinguishes a suspension from a colloid, in which the suspended particles are smaller and do not settle.[2] Colloids and suspensions are different from solutions, in which the dissolved substance (solute) does not exist as a solid, and solvent and solute are homogeneously mixed.

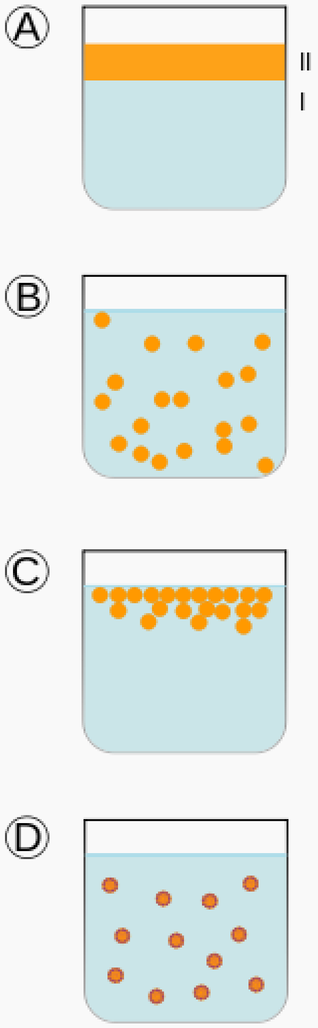
A suspension of liquid droplets or fine solid particles in a gas is called an aerosol or particulate. In the atmosphere these consist of fine dust and soot particles, sea salt,biogenic and volcanogenic sulfates, nitrates, and cloud droplets.

Suspensions are classified on the basis of the dispersed phase and the dispersion medium, where the former is essentially solid while the latter may either be a solid, a liquid, or a gas.

In modern chemical process industries, high shear mixing technology has been used to create many novel suspensions.

Suspensions are unstable from the thermodynamic point of view; however, they can be kinetically stable over a large period of time, which determines their shelf life. This time span needs to be measured to ensure the best product quality to the final consumer. “Dispersion stability refers to the ability of a dispersion to resist change in its properties over time.” D.J. McClements.[3]

Emulsion



A. Two immiscible liquids, not yet emulsified

B. An emulsion of Phase II dispersed in Phase I

C. The unstable emulsion progressively separates

D. The surfactant (outline around particles) positions itself on the interfaces between Phase II and Phase I, stabilizing the emulsion

IUPAC definition

Fluid system in which liquid droplets are dispersed in a liquid.

Note 1: The definition is based on the definition in ref.[1]

Note 2: The droplets may be amorphous, liquid-crystalline, or any mixture thereof.

Note 3: The diameters of the droplets constituting the *dispersed phase* usually range from approximately 10 nm to 100 μm; i.e., the droplets may exceed the usual size limits for colloidal particles.

Note 4: An emulsion is termed an oil/water (o/w) emulsion if the dispersed phase is an organic material and the *continuous phase* is water or an aqueous solution and is termed water/oil (w/o) if the dispersed phase is water or an aqueous solution and the continuous phase is an organic liquid (an "oil").

Note 5: A w/o emulsion is sometimes called an inverse emulsion. The term "inverse emulsion" is misleading, suggesting incorrectly that the emulsion has properties that are the opposite of those of an emulsion. Its use is, therefore, not recommended.[2]

An **emulsion** is a mixture of two or more liquids that are normally immiscible (unmixable or unblendable). Emulsions are part of a more general class of two-phase systems of matter called colloids. Although the terms *colloid* and *emulsion* are sometimes used interchangeably, *emulsion* should be used when both the dispersed and the continuous phase are liquids. In an emulsion, one liquid (the dispersed phase) is dispersed in the other (the continuous phase). Examples of emulsions include vinaigrettes, milk, mayonnaise, and some cutting fluids for metal working.

The word "emulsion" comes from the Latin word for "to milk", as milk is an emulsion of fat and water, among other components.

Two liquids can form different types of emulsions. As an example, oil and water can form, first, an oil-in-water emulsion, wherein the oil is the dispersed phase, and water is the dispersion medium. Second, they can form a water-in-oil emulsion, wherein water is the dispersed phase and oil is the external phase. Multiple emulsions are also possible, including a "water-in-oil-in-water" emulsion and an "oil-in-water-in-oil" emulsion.[3]

Emulsions, being liquids, do not exhibit a static internal structure. The droplets dispersed in the liquid matrix (called the “dispersion medium”) are usually assumed to be statistically distributed.

The term "emulsion" is also used to refer to the photo-sensitive side of photographic film. Such a photographic emulsion consist of silver halide colloidal particles dispersed in a gelatin matrix. Nuclear emulsions are similar to photographic emulsions, but used in particle physics to detect high-energy elementary particles.

Appearance and properties[edit]

Emulsions contain both a dispersed and a continuous phase, with the boundary between the phases called the "interface". Emulsions tend to have a cloudy appearance because the many phase interfaces scatter light as it passes through the emulsion. Emulsions appear white when all light is scattered equally. If the emulsion is dilute enough, higher–frequency and low-wavelength light will be scattered more, and the emulsion will appear bluer – this is called the "Tyndall effect". If the emulsion is concentrated enough, the color will be distorted toward comparatively longer wavelengths, and will appear more yellow. This phenomenon is easily observable when comparing skimmed milk, which contains little fat, to cream, which contains a much higher concentration of milk fat. One example would be a mixture of water and oil.

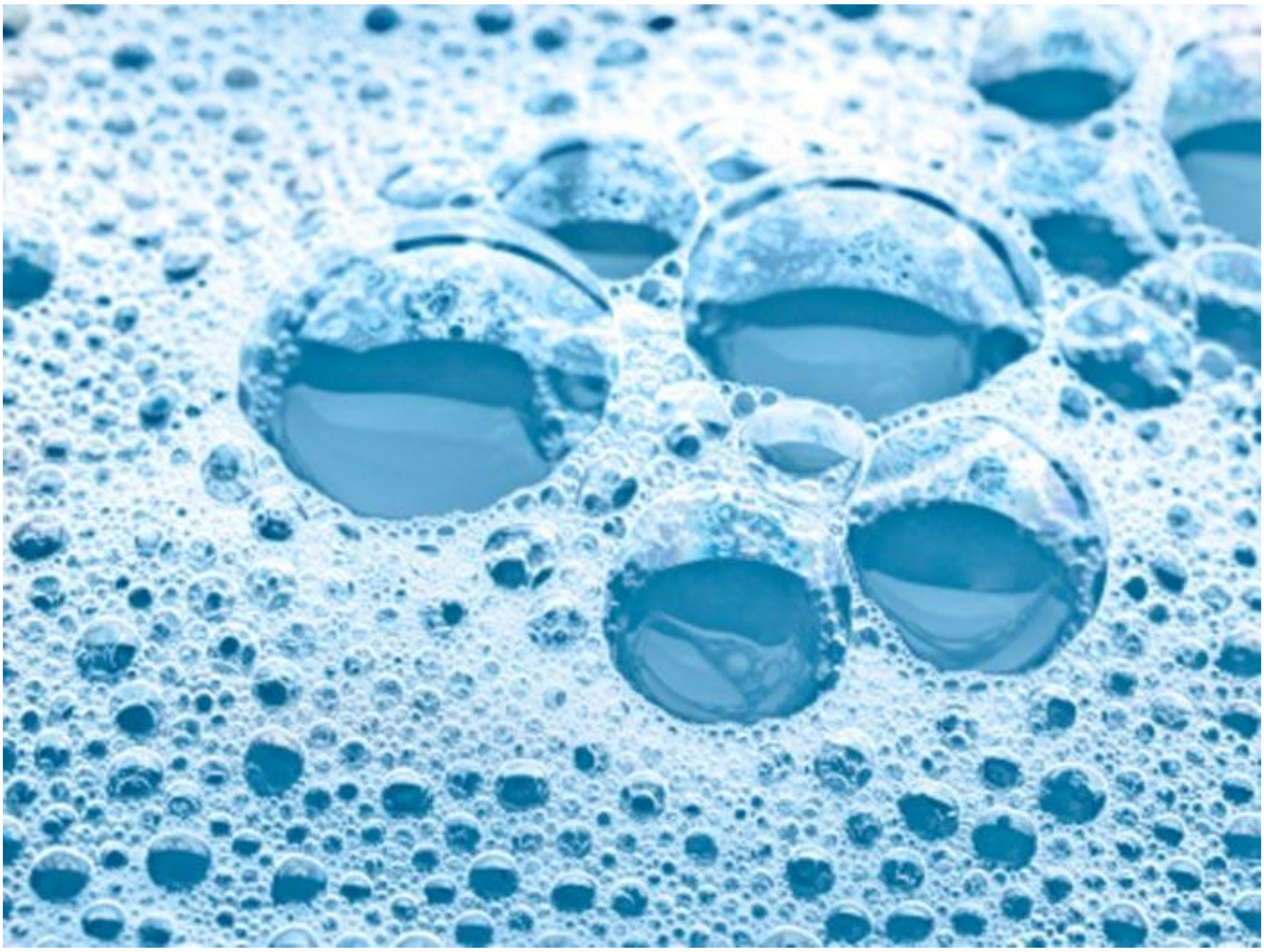
Two special classes of emulsions – microemulsions and nanoemulsions, with droplet sizes below 100 nm – appear translucent.[4] This property is due to the fact that lightwaves are scattered by the droplets only if their sizes exceed about one-quarter of the wavelength of the incident light. Since thevisible spectrum of light is composed of wavelengths between 390 and 750 nanometers (nm), if the droplet sizes in the emulsion are below about 100 nm, the light can penetrate through the emulsion without being scattered.[5] Due to their similarity in appearance, translucent nanoemulsions andmicroemulsions are frequently confused. Unlike translucent nanoemulsions, which require specialized equipment to be produced, microemulsions are spontaneously formed by “solubilizing” oil molecules with a mixture of surfactants, co-surfactants, and co-solvents.[4] The required surfactant concentration in a microemulsion is, however, several times higher than that in a translucent nanoemulsion, and significantly exceeds the concentration of the dispersed phase. Because of many undesirable side-effects caused by surfactants, their presence is disadvantageous or prohibitive in many applications. In addition, the stability of a microemulsion is often easily compromised by dilution, by heating, or by changing pH levels.

Common emulsions are inherently unstable and, thus, do not tend to form spontaneously. Energy input – through shaking, stirring, homogenizing, or exposure to powerultrasound[6] – is needed to form an emulsion. Over time, emulsions tend to revert to the stable state of the phases comprising the emulsion. An example of this is seen in the separation of the oil and vinegar components of vinaigrette, an unstable emulsion that will quickly separate unless shaken almost continuously. There are important exceptions to this rule – microemulsions are thermodynamically stable, while translucent nanoemulsions are kinetically stable.[4]

Whether an emulsion of oil and water turns into a "water-in-oil" emulsion or an "oil-in-water" emulsion depends on the volume fraction of both phases and the type of emulsifier (surfactant) (see *Emulsifier*, below) present. In general, the Bancroft rule applies. Emulsifiers and emulsifying particles tend to promote dispersion of the phase in which they do not dissolve very well. For example, proteins dissolve better in water than in oil, and so tend to form oil-in-water emulsions (that is, they promote the dispersion of oil droplets throughout a continuous phase of water).

The geometric structure of an emulsion mixture of two lyophobic liquids with a large concentration of the secondary component is fractal: Emulsion particles unavoidably form dynamic inhomogeneous structures on small length scale. The geometry of these structures is fractal. The size of elementary irregularities is governed by a universal function which depends on the volume content of the components.

Foam



A **foam** is a substance that is formed by trapping gas in bubbles. Gas is present in large amounts so it will be divided in gas bubbles separated by liquid regions which may form films, thinner and thinner when the liquid phase is drained out of the system.[1] When the scale is small, e.g. for fine foam, this dispersed medium can be considered as a type of colloid.