1. Colloids

Objective

In this experiment, some of the properties and characteristics of *colloidal dispersions* and gels will be investigated.

Introduction

In a true **solution**, particles of solute are homogeneously dispersed among molecules of solvent on an individual *molecular* or *ionic* basis. That is, in a solution, the solute exists as *single,* relatively independent particles. Particles of solute in a solution move freely and randomly throughout the solvent matrix and do not settle out of solution on standing in a closed system. Solute particles in solution have diameters on the order of one nanometer (10^{-9} m).

An opposite situation exists in the type of mixture known as a **suspension**. In a suspension, grossly *large* particles of a nonsoluble substance are mixed with the solvent and shaken to homogenize the mixture *temporarily.* Particles in a suspension are macroscopic and consist of many billions of molecules or ions, with the diameter of the particles greater than one micrometer (10^{-6} m). The particles of a suspension settle out of solution fairly rapidly; most suspensions for use in the laboratory or in the home are labeled "shake well before using" for this reason.

Colloidal dispersions represent an intermediate situation between true solutions and suspensions. The solute particles in a colloid are *not* individual molecules or ions; rather, they are microscopically sized *groups* of molecules or ions, or large intertangled polymeric molecules, with sizes on the order of 10–100 nanometers. Although the solute particles in a colloid do not consist of individual molecules or ions, the particles do *not* settle out of the mixture on standing because of an effect known as **Brownian motion**. The solute particles in a colloid are small enough that irregular, random collisions with rapidly moving solvent molecules are strong enough to *support* the solute particles and prevent them from settling out of the mixture. In suspensions, the particles are too big for collisions with solvent molecules to have much of an effect. The particles of suspension are generally large enough that such collisions are equally probable from all directions (thereby canceling out with time any effect from the collisions).

Colloids generally can be distinguished from true solutions by their interaction with light (**Tyndall effect**). Although the particles in colloids are microscopically small, they are still large enough to scatter light. A concentrated colloid appears *cloudy* because of its ability to scatter light. A very dilute colloid may appear fully clear and transparent to the naked eye under room lighting, but if an intense beam of light is passed through a colloid at right angles to the viewer, the beam of light is clearly visible. This does *not* happen with true solutions because the molecules or ions of a solution are too small to scatter light. The Tyndall effect is observed quite commonly in everyday life. For example, the air in most rooms contains colloidally dispersed dust. A beam of sunlight passing through such dust is clearly visible.

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Under the correct conditions, some colloidal dispersions can be made to form semisolids called **gels**. This is especially true if the colloidal solute is a polymeric species whose long-chain molecules can become tangled and interconnected. For example, common gelatin is a colloidal material that forms a gel when a hot mixture is cooled. In a gel, the long-chain molecules of the colloidal substance form an extended three-dimensional network, in which molecules of the solvent become trapped among the chains of the dispersed substance. In this experiment, you will prepare several gels.

Starch and gelatin form colloidal dispersions in boiling water. The resulting dispersions typically appear cloudy when the mixture is concentrated, but are considerably more clear in dilute mixtures. Starch and gelatin mixtures may exhibit the Tyndall effect when a beam of light is passed through the sample at right angles to the observer. The light beam is scattered by the relatively large particles of the colloid, and the beam of light is clearly visible as it passes through the sample. If the light beam is intense enough, the actual individual particles of the colloid may become visible (but only as small, bright flashes of light). The Brownian motion imparted to the colloidal particles by collision with solvent molecules may thus be observed. The properties of starch and gelatin colloids will be contrasted with the behavior of distilled water and some true solutions when treated and observed in the same manner.

SAFETY PRECAUTIONS

- **Wear safety glasses at all times in the laboratory.**
- **Use tongs or insulated gloves when handling hot solutions.**

Apparatus/Reagents Required

Soluble starch, gelatin powder, glucose, sodium chloride, high-intensity light source, distilled water, square jar, magnifying glass

Procedure

Record all data and observations directly in your notebook in ink.

Heat a 600-mL beaker about half full of water to boiling.

Measure out around 5 g of soluble starch. Transfer the starch to a beaker, add 10–15 mL of water, and stir to make a paste.

When the water in the 600-mL beaker is boiling, stir the starch paste and pour it into the boiling water. Continue boiling the mixture with constant stirring until the mixture *clarifies*; then remove it from the heat and allow it to cool to room temperature.

Set up a second 600-mL beaker about half full of water and heat to boiling.

Measure out about 5 g of gelatin. Transfer to a beaker and add 10–15 mL of cold water. Allow the mixture to stand for 5–10 minutes to soften the gelatin.

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When the water in the 600-mL beaker is boiling, stir the gelatin mixture and pour into the boiling water. Stir the boiling mixture for around 30 seconds, then remove it from the heat and allow it to cool to room temperature.

Obtain about 600 mL of distilled water and filter through a gravity funnel and filter paper to remove any dust that might be present.

Dissolve 5 g of glucose in about 200 mL of the filtered distilled water.

Dissolve 5 g of sodium chloride in a second 200-mL portion of the filtered distilled water.

Set up the high-intensity lamp source in a convenient location so that the light beam from the source will be 2–3 inches above the lab bench.

Obtain a square glass jar or tall-form beaker, and transfer into it some of the starch colloid already prepared. Move the jar or beaker so that the beam of light from the high-intensity lamp passes through the starch. View the starch solution at right angles to the beam of light. The light beam should be clearly visible in the starch. Examine the starch solution with a magnifying glass while it is illuminated by the beam of light; look for evidence of the Brownian motion of the colloid particles (flashes of light).

Clean out the jar or beaker, rinse with distilled water, and repeat the examination of the Tyndall effect in the light beam with the gelatin colloid and with the solutions of glucose and sodium chloride.

Clean out the jar, and fill it with the remaining portion of filtered distilled water. Examine with the light beam for evidence of the Tyndall effect.

Replace the filtered distilled water with samples of tap water and unfiltered distilled water. Examine each sample in the light beam for evidence of the Tyndall effect.

Transfer the beakers containing the remaining portions of starch and gelatin to an ice bath; they will set into gels. Examine the gels, and test with the light source for the Tyndall effect.

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Colloids

Date:	....	Student name:	....
Course:	....	Team members:	....
Section:	....		....
Instructor:	....		....

Prelaboratory Questions

1. The terms *Brownian motion* and *Tyndall effect* are frequently confused. Use your textbook or an encyclopedia to find and write a specific definition for each of these terms.

2. Compare the relative particle size and resulting properties of “true” solutions, colloidal dispersions, and suspensions.

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3. Write a specific definition of *gel colloid* (you may use your textbook or a chemical dictionary).

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Colloids

Date: ....
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Instructor: ....

Student name: ....
Team members: ....

Results/Observations

Gross appearance of starch colloid ....

Gross appearance of gelatin colloid ....

Appearance of starch colloid with high-intensity lamp ....

With magnifying glass ....

Appearance of gelatin colloid with high-intensity lamp ....

With magnifying glass ....

Appearance of glucose solution with high-intensity lamp ....

Appearance of sodium chloride solution with high-intensity lamp ....

Appearance of filtered distilled water with high-intensity lamp ....

Appearance of tap water with high-intensity lamp ....

Observations of starch and gelatin gels ....

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Questions

1. Why was it necessary to use *filtered* distilled water in preparing the solutions for this experiment?

2. Give two examples of suspensions as used in medicine, the home, or the chemistry laboratory. Indicate the active ingredient(s) in each suspension, and the approximate concentration.

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