Separating Mixtures: Techniques and Applications

A mixture is a **combination of two or more pure substances that are not chemically combined**. Mixtures come in several forms. Homogeneous mixtures are uniform in composition and are often called solutions. Heterogeneous mixtures have distinct phases or components. For example, an ice cream sundae, a mechanical mixture, is made of visible phases including ice cream, whipped cream, chocolate syrup and a cherry on top. Other heterogeneous mixtures are more difficult to detect with the naked eye. Colloids contain medium sized particles that are not dissolved, but do not settle out (the fat in milk makes it a colloid). Suspensions contain larger particles that do settle out if given the opportunity and include substances like fresh squeezed lemonade and muddy water.

Even when it is difficult to tell what kind of mixture something is, *mixtures can always be separated by physical means*. Looking at the physical properties of the components in a mixture helps determine the best method for separating the components out and can also be useful information when classifying a mixture as a solution, colloid, suspension or mechanical mixture.

Evaporation, Distillation and Filtration

*Getting salt from sea water*

Seawater is salty because it has dissolved salty solids that come from active volcanoes on the floors of the oceans. One way to recover the salt is through evaporation. Some hot countries build a low wall around a shallow section of the sea. This traps the seawater in an enclosed lagoon. The water evaporates and leaves the salt behind. Evaporation is useful for recovering the solute (dissolved substance) from a solution; however, the solvent (water in this case) is lost.

*Getting pure water from sea water*

Unfortunately, in many countries there is lots of seawater but little fresh water for people to drink. The seawater can be purified in a desalination process in which the seawater is heated until it boils changing the water to steam but leaving the salt behind. The steam is collected and condensed back into water. The pure water is then directed away in pipes, cooled, and collected in a second container.

This process is called distillation. Distillation also works to separate solutions of two or more liquids. In distillation, the substance that boils at the lower temperature is captured, condensed and collected without loosing the other substance.
**Separating Crude Oil**

Distillation is also used to separate a mixture of two or more liquids with different boiling points. This type of distillation, also known as fractional distillation, is used to refine crude oil. Crude oil contains hundreds of different hydrocarbons including diesel, kerosene, and gasoline. Because larger hydrocarbons have much higher boiling points than smaller hydrocarbons, they can be separated by distillation. In oil refineries, the crude oil is heated to very high temperatures vaporizing most of the hydrocarbons. The vaporized hydrocarbons then travel up a long column and are cooled. Each hydrocarbon will condense at a specific height in the column at a very specific temperature. Large trays collect each hydrocarbon at those heights and carry them to different areas to be processed.

**Getting salt from rock salt**

In other countries, salt is obtained from rock salt rather than from the seawater. Rock salt is a mixture of salt and dirt or sand. It was left behind millions of years ago when enormous shallow seas evaporated. To use the salt, it must be separated from the impurities. Here are the steps required to do this:

**Step 1.** Rock salt is crushed into little pieces.

**Step 2.** Water is added. The salt dissolves in the water but the earthy impurities won’t dissolve, they are insoluble.

**Step 3.** The solid sandy bits are separated from the salt solution using **filtration**. The mixture is passed through filter paper held in a funnel. The salt solution can pass through the small holes in the filter paper because all the particles are tiny, but the dirt and sand particles are too big to pass through the holes.

**Step 4.** The liquid is heated so that the water evaporates leaving the salt behind.

Filtration is often used to separate the solid and liquid parts of a mechanical mixture. The liquid part is called the **filtrate** and the solid that remains on the filter paper is called the **residue**.
**Chromatography**

Shifting focus to edible food, some candies and soft drinks are colored using dyes. The dyes are mixed together to make a solution. Some candies and foods may use several different dyes to get the right color. The individual dyes can be separated and compared using a technique called **chromatography**.

*How do we use chromatography?*

In this technique, the dyes from the foods or other substances are dissolved in a little water. A spot of this dye solution is placed on a piece of absorbent paper about a centimeter from the bottom. The paper is then placed in a beaker containing a small amount of water. The paper is like blotting paper and draws water up itself. The dyes are carried up with the water; however, the different dyes have different attractions for the water and move at different speeds. Each dye will travel a unique distance up the paper, and in that way, the individual dyes in each candy spot are split up. The final paper (with streaks of dyes) is called a **chromatogram**.

*Where do the colors end up?*

If a dye from a candy is split up into several smaller spots, then it was a mixture of different dyes. It is possible to find out exactly which dyes the substance had in it by making a chromatogram with both the pure dyes and a mixed dye. The pure dyes will produce single spots on the chromatogram, whereas the mixed dye will produce a number of spots spread up the paper. The same dye will always move the same distance up the paper. Its final position will be the same whether it started in a mixture or as an individual dye. So if one of the pure spots is in the same position as a spot from a mixed dye, then we know that the mixture must have contained that dye.

*Using chromatography*

Paper chromatography can be used to separate and identify the components of **solutions**. Chromatography is also used by doctors to help diagnose illnesses and also in forensic science to analyze ink samples. The picture above shows a chromatogram made from ink on a forged check (X). It also shows four chromatograms made from inks in the pens of the four main suspects (A to D). Whose pen wrote the check?

**The Centrifuge and Decanting**

A centrifuge is used to separate small amounts of a heterogeneous mixture. Test tubes containing the mixture are spun around very fast so that the solid gets flung to the bottom. The mixtures are spun horizontally in balanced containers, and the rotation sets up centripetal forces causing the mixture's components to separate according to their densities.
Separating Blood

A centrifuge is used to separate blood plasma from blood cells. As the test tubes spin, the heavier blood cells sink to the bottom. Centrifuges are useful in laboratories and on an industrial scale for separating solids from suspension in liquids. For example, in the food industry, a centrifuge is used to separate cream from milk or yeast from fermented malt. Usually when the heaviest particles have settled to the bottom, the top liquid is decanted or poured off the to separate the liquid layer from the bottom layer.

Fractional Crystallization

In chemistry, fractional crystallization is a method of refining substances based on differences in solubility. If two or more substances are dissolved in a liquid, they will crystallize out of the solution at different rates. Crystallization is usually caused by changes in temperature – most often, cooling down.

For example, if sugar is dissolved in water and the solution is partially frozen, the liquid portion will taste sweeter than the frozen portion because the sugar will be more soluble, or more likely to dissolve, in the liquid. In addition, if two substances are dissolved in water, such as salt and sugar, and the solution is heated, the substance that is less soluble will form crystals on the sides of the test tube while the other remains dissolved in the solution. At this point, the liquid can be decanted from the newly formed crystals and the mixture is separated.

In geology, fractional crystallization takes place when elements become separated during the slow cooling of magma. Some remain dissolved while other elements separate out.

Content and Images Adapted From…

How Stuff Works – Oil Refining
http://science.howstuffworks.com/oil-refining.htm
School Science – Fossils into Fuels
http://www.schoolscience.co.uk/content/4/chemistry/fossils/p8.html
School Science: Fractional Distillation
http://www.schoolscience.co.uk/content/3/chemistry/materials/match3pg1.html
tiscali.reference – Centrifuge
http://www.tiscali.co.uk/reference/encyclopaedia/hutchinson/m0009940.html
Wikipedia – Fractional Crystallization
http://en.wikipedia.org/wiki/Fractional_crystallization