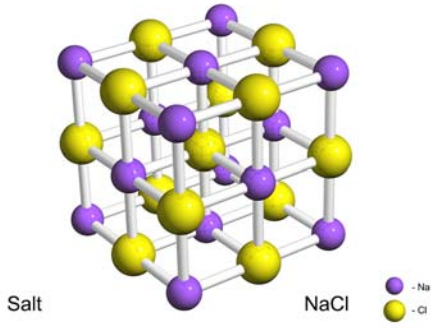
The Flowers of the Mineral World

Crystals have been called the “flowers of the mineral world.” Crystals form in different mediums in various ways. In this discussion, we will look at crystals forming from solutions.

For crystal formation to begin, the solution must become supersaturated. This means that the concentration of solute must become greater than the solubility of the solute in the solution. But how can a solution have more solute than it can hold?

There are two ways to achieve this feat: increase the solute concentration in the solution, or decrease the solubility of the solute. To increase the concentration of the solute, simply allow some of the solvent to evaporate. The solute stays put, so the solute concentration increases as the volume of solvent decreases. The solubility of most substances can be reduced by lowering the teerature. Be careful not to confuse crystallization at reduced temperature with freezing, even though the processes are similar. There is no solvent-solute relationship involved in making ice cubes.



This is a model of the lattice structure of a sodium chloride (NaCl) crystal.

Why doesn’t the solid come out of solution when the concentration equals the solubility? Picture a crystal lattice. In a crystal lattice, the atoms or ions are very precisely arranged in a repeating geometric pattern. They don’t just line up like soldiers when commanded. It is unlikely that the atoms will happen to collide in just the right way as they start to form the lattice structure. The atoms begin to align in a process called *nucleation*. If nucleation is required to form crystals, how does this process happen?

Nucleation can be homogeneous or heterogeneous. Homogeneous nucleation involves the formation of a tiny crystal in the middle of a uniform solution. Homogenous nucleation is difficult to begin, since it requires very small particles to come together to start forming the crystal structure. Heterogeneous nucleation happens when nature or humans lend a hand. The most reliable way is to add a “seed” crystal to the solution. This is just a tiny piece of crystallized solute. This tiny seed gives the crystal a place to start growing. Crystallization can also be encouraged by the presence of any irregular solid surface, like a grain of sand or a scratch in the surface of a glass container.

This homemade rock candy had food coloring added to the sugar-and-water solution.

Nucleation is the slowest step in growing a new crystal. The speed of the crystal growth that follows will be anywhere from somewhat faster to amazingly fast. When crystals form slowly, it is more likely

that they will be large, single crystals with a perfect shape. When they form rapidly, they are more likely to branch out in patterns that resemble a fern leaf or a large snowflake.

Rock candy is an old-fashioned confection that is made by cooling a supersaturated sugar solution in the presence of seed crystals. A wet stick or string is rolled in granulated sugar and allowed to dry. The stick or string is then lowered into a hot sugar solution. As the solution cools, large sugar crystals form on the granulated sugar, which acts as the seed crystals.

The salt flats in Utah were formed as evaporation of the Great Salt Lake increased the salt concentration until crystals formed. Similarly, salt is commercially produced by allowing seawater in large shallow ponds to evaporate until salt crystals begin to form.

Salt will be harvested from these ponds after the seawater evaporates.

Rocks that formed when molten lava cooled are called *igneous* rocks. These rocks often have crystals embedded in them. The crystals are formed by the same process as the one used to make rock candy. In this case, the solvent is liquid rock and the solute is dissolved minerals. By studying the crystals, geologists can tell how rapidly the lava cooled. The larger the crystals, the slower it cooled.

The record for both largest crystal size and slowest crystal growth goes to the Cave of Giant Crystals near Chihuahua, Mexico. These are crystals of calcium sulfate dihydrate ($CaSO_4 \cdot 2H_2O$), also called selenite or gypsum. The largest crystals in the cave are 12 meters long and 1 meter thick. Some of the selenite crystals took one million years to form, growing by only the width of a human hair each century. If you haven't got that kind of time on your hands, you can always settle for making rock candy.