Investigation 2: Form and Function

Supplies

one or more of the following for constructing unit cell models

- Solid State Model Kits*(optional)
- construction sets like K'nex or Tinker Toys
- materials such as styrofoam balls, marshmallow, gumdrops, toothpicks

cobs of corn (optional)

sugar cubes or wooden cubes (optional)

*Available from the Institute for Chemical Education (ICE), University of Wisconsin-Madison, Department of Chemistry, 1101 University Avenue, WI 53706-1396, Phone: 608/262-3033, 800/991-5534, Fax: 608/265-8094, ICE@chem.wisc.edu, http://ice.chem.wisc.edu/.

Teacher Notes

Since an understanding of the features of the shape-memory metal cycle is dependent upon the relationship between the structures of the high- and low-temperature phases of this material, it is suggested that these structures be discussed at an early stage of this unit.

Students should have an opportunity to develop an understanding of the concept of the **unit cell** before proceeding with the investigation. Crystalline materials like NiTi have a repeated pattern of atoms that extends in all directions to the surfaces of the sample. A useful way of describing this pattern is to consider a three-dimensional cube, which, when reproduced and moved along each of its edges by a length equal to that of the edge, generates the entire structure of atoms in the crystal. Such a cube is called a unit cell and it provides a template for the atoms and the empty spaces between the atoms in the structure. See Appendices A and B for a more detailed discussion of unit cells.

Another useful way demonstrating a unit cell is to use a piece of corn. Each kernel could represent a unit cell. All the unit cells are essentially (or generally) the same size and shape. They are repeated over and over again in a regular pattern to form a complete cob.

To build an understanding of the unit cell and the connections between atomic structure and function, students should be given opportunities to see and build simplified unit cells for each phase. Students might view an overhead transparency of the structures as show below. The teacher can build or have students build models of both the austenite (high temperature) and martensite (low temperature) structures using the Solid State Model Kit* that the entire class may view.

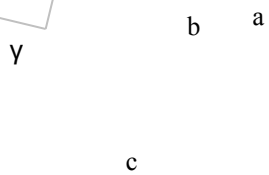
Alternatively, students might use gumdrops (or marshmallows or other appropriate connectors) and toothpicks or other construction sets like K'nex or Tinker Toys (although placing the center nickel atom in the model may be difficult with these construction kits. For simplicity, in the martensite phase, students can make the connections between all the corners the same length. Students should have enough materials so that they can build models for austenite and martensite phases.

In any case, make sure that students do not know in advance of the class discussion, which phase is the high temperature phase and which is the low temperature phase. In this investigation, they will have an opportunity to figure out which phase matches each structure using their observation skills.

Students can then observe the relative strength and flexibility of each model and answer the questions at the end of the investigation. When students have completed their own models, they may join them with others to create a large model of each material.

Unit cells of NiTi in the martensite and austenite phases.

Martensite
(flexible, low temp)



a, b, and c are not equal,
γ is about 96°

Austenite
(rigid, high temp)

CsCl Structure (cubic)
a = b = c
α = β = γ = 90°

Key

Nickel

Titanium