Shape Up!

Summary

Nitinol is memory metal. It will spring back to its original shape when heated. To permanently change the shape of Nitinol, you heat the wire to about 500 °C (932 °F). This will change the arrangement of the metal's atoms.

In this activity, you will train a piece of Nitinol wire to a new shape.

This activity takes about 15 minutes. Parents, please supervise children.

Materials

- Piece of Nitinol wire[1]
- Hairdryer
- Candle
- Matches
- 2 pairs of pliers
- Hot mat

Don't use your fingers!

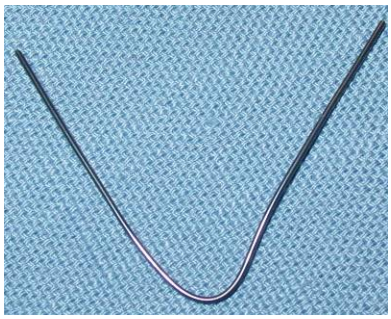
Use pliers!

Pre-activity

Bend the wire into a shape, and then blow on it with a hair dryer. What happens?

Activity

- Ask an adult to help you with the next steps. *Be very careful with the candle flame and hot wire.*
- Light the candle. Hold the ends of your wire with pliers, and place the middle in the candle flame. Try to bend the wire into a V-shape. When it becomes hot enough, you will feel the pressure on your pliers release.
- Remove it from the flame immediately, and set it on the hot mat to cool.
- Wait a minute or two to touch the wire. Bend it into a new shape.
- Blow on the wire with a hair dryer. What happened?



What's going on?

Nitinol wire will bounce back to its original shape when it is heated above its ***transition temperature***. This is why you felt the wire pushing on your pliers as you held it in the V-shape. When enough energy was added to the wire by heating it in the flame, its atoms moved around enough to "reset" its memory. This is why the pressure was released on your pliers. Now the wire has a permanent V-shape, and will return to that shape when bent and heated with a hairdryer.

The Nickel and Titanium ***atoms*** in the Nitinol wire are in an ordered arrangement, or ***crystal structure***. But nothing's perfect. There are mistakes in the way the atoms are arranged, and these mistakes are called ***defects***. These mistakes could be missing atoms, or extra atoms that are trapped in there. When this kind of

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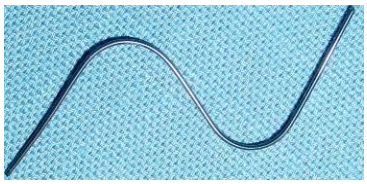
[1] Nitinol wire may be purchased at the following websites, as well as other sources:
Educational Innovations: www.teachersource.com
Images SI, Inc.: www.imagesco.com
Livewire: www.tinialloy.com/livewire.html

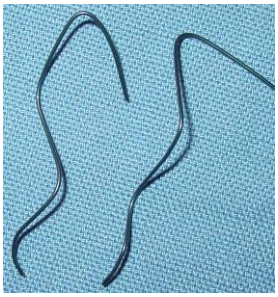
Nitinol wire is at room temperature, it is very easy to bend. Heating it causes it to change to a rigid phase with a different crystal structure. When it cools back down, the atoms go back to exactly their original positions, including defects. Imagine a drawing where, no matter how many times you erase it and draw it again, it comes out the same, including mistakes!

But these mistakes are actually a good thing! It's the position of the defects in this wire that makes it come back to the same shape every time it is cooled and heated. So how did holding the wire in the candle flame change the wire's shape? It gave the metal enough energy that the defects in the crystal structure moved around. When the wire got cooled in this shape, the defects got frozen in their arrangement, and now they make the wire spring back to the V-shape every time it is cooled and reheated.

Extension Activities



- You just made a "V" shape with your wire. What other letters of the alphabet could you make? *Can you make curves <u>and</u> angles?*
- What can you make with your "V" shaped wire?
    - How about antennae or legs for a toy bug? You can bend them in any shape you want, and they will come back every time!
    - What about jewelry?
- Artists have used Nitinol to make statues that move. Make a Nitinol statue by permanently changing a wire's shape and adding things you have around the house, like paper, cloth, tape…



For More Information

- <u>Nitinol Manufacturing</u>, From the Memory-Metalle website:
  http://www.memory-metalle.de/html/07_manufact/01_manufacturing.htm
- <u>Nitinol FAQ</u> from Memry Corporation's website:
  http://www.memry.com/nitinolfaq/nitinolfaq.html
- <u>Crystalline Defects</u>
  http://www.cartage.org.lb/en/themes/Sciences/Physics/SolidStatePhysics/AtomicBonding/CrystalStructure/Crystalline/Crystalline.htm

Vocabulary

Atom: The smallest piece of matter that has all the properties of a certain element. An atom consists of a nucleus with protons and usually neutrons, orbited by a cloud of electrons.

Crystal Structure: The organized arrangement of the atoms within a material.

Defect: An imperfection. In materials science this means an imperfection in the crystal structure of a material.

Nitinol: An alloy of Nickel and Titanium that returns to its previous shape when you heat it up.

Transition temperature: the specific temperature at which Nitinol changes phases.

References:

Teaching General Chemistry: A Materials Science Companion. Arthur B. Ellis, Margret J. Gesselbracht, Brian J. Johnson, George C. Lisensky and William R. Robinson. Published by the American Chemical Society, 1993.