ARBOR SCIENTIFIC

Thermal Conductivity Bars

P6-7090

INSTRUCTIONAL GUIDE

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Recommended for Activity:

- Borosilicate Beaker 400 mL (06-3011-01)
- Hot plate (C5-1550)

Teacher Notes

1. Some discoloration will occur to the parts of the bars immersed. The steel is zinc plated, the aluminum is anodized and the brass and copper are coated with an acrylic lacquer.
2. The bars should be wiped dry with a soft cloth and stored away from direct sunlight.
3. NEVER apply direct heat such as a Bunsen flame to the bars.
4. Immerse only the exposed metal ends in freshly boiled water. DO NOT immerse the plastic cradle or the thermochromic liquid crystal strips. DO NOT continue to heat the water; it should be BELOW BOILING POINT.
5. Never use solvent or abrasive cleaners.
6. The diffraction effects, which cause color changes in the liquid crystals, are best viewed with light falling on the strips from behind or to one side of the viewer. If working by a bright window, turn the apparatus side on to the light.
7. The Conductivity Bars are a cleaner and more informative alternative to traditional melting wax apparatus.
8. What the colors show: The thermochromic liquid crystal used in these Conductivity Bars shows temperatures in the range 35 to 45°C. The lowest temperature indication is a coppery red color at 33ºC and the hottest is a blue color at over 45 °C. The 35 °C to 45°C range is at the outer limits of the green zone.
9. How the liquid crystals work: When cooler than about 30°C, the crystals in the film are solid and do not show any color. At above about 50 °C they melt and also show no color. Behind the film is a black backing sheet and so the film appears black. Between these temperatures something interesting happens. The crystals are in a liquid crystal state called a mesophase or liquid crystal phase. At these temperatures the crystals line up, or polarize, creating optical effects caused by Bragg diffraction.

Activities

Heating
The conductivity of the four metals differs markedly. Students can create a graph with time on the horizontal axis, and on the vertical axis, the distance traveled by the colored zone in the liquid crystal film. This gives a set of lines whose slope is approximately proportional to the conductivity of the metals. At a qualitative level this simple distance/ time graph is a reasonable guide to the comparative conductivity of the metals. The actual thermal conductivity values are printed on the rear label of the apparatus.

Note: The effects of heat loss are noticeable in the steel bar. The heat has trouble reaching the top of the bar because heat is being lost as fast as it is conducted.

Cooling
When the bars have been heated for a few minutes, the liquid crystal films are over their temperature range and appear black. Change the hot water for cold tap water and observe the cooling of the bars. The effects are more complex than for heating but it is still possible to see that the copper sinks its heat into the cold water faster than the other metals. This is an important observation for students who sometimes tend to believe that heat conduction is only about "hotness" travelling into a metal.

More observant students may notice that the difference between the metals is not quite the same as for the heating experiment. This is due to the effects of the heat capacity of the metals.

It is important that the students observe that the color order in the liquid crystal film is reversed for cooling. The bars are now hotter at the top than at the bottom.

Air-cooling
Start the heating experiment again by immersing the lower part of the bars in hot water.

When the colored zone in the steel bar is about halfway up the film, remove the bars from the water and observe the cooling in air. The bars now cool over their entire surface instead of sinking heat rapidly into cold water at one end.

The temperature of the bars now spreads uniformly along their length. The effect is rapid for the copper but much slower for the steel. The steel retains a 'hot spot' for longer.

The Touch Zone
At the top of each bar is an area large enough to be touched by a fingertip. This is an important confirmation to the student of what is happening. They should be encouraged to feel the different temperatures at the top of the bars.

Related Products

Compound Bar (P6-7070) Thin strips of two different metals are laminated together in this simple demonstration, also known as a Bimetallic Strip. Demonstrate thermal expansion.

Ball and Ring Apparatus (33-0630) This brass ball fits easily through the matching ring when they are both at room temperature. Heat the ball in a flame, and experience the results of thermal expansion.

Compound Bar Set (P6-7080) Now take your thermal expansion labs a step further with our set of four different compound bars or bimetallic strips.