HEAT TRANSFER

Metal vs. Ceramic | Aluminum vs. Alumina

GOALS/PURPOSE

- Understand that different types of materials have different thermal conductivities
- Learn the concept of thermal conductivity and heat transfer in a metal vs. a ceramic

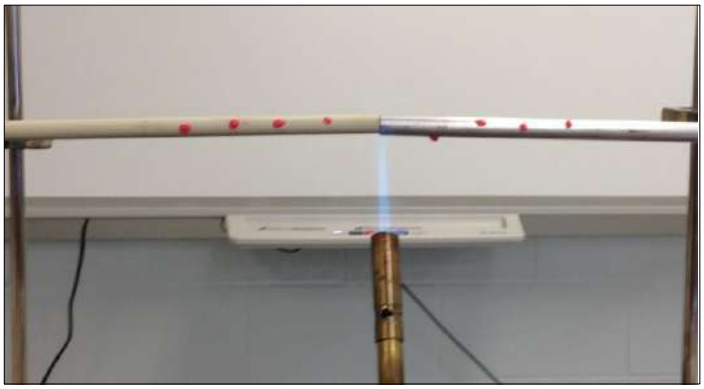

Fig. 3.1 *Alumina (left) and aluminum (right)*

MATERIALS/EQUIPMENT

- Alumina rod ⅜ in. diameter, 8½ in. length
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- 2 ring stands with clamps
- Propane torch or Bunsen burner
- Wax (ex. red candle)

SAFETY

- Do not allow the students to touch the heated rods.

PROCEDURE

1. Place four drops of wax about 1 in. apart on each rod. Or attach four birthday candles 1 in. apart to each rod by heating the base of the candle and holding them in place until they are anchored to the rod. Bright-colored wax, such as red, is needed in order to be visible to the students.
2. Attach each rod to a ring stand with clamps.
3. Align the free ends of each rod to each other. Angle the rods slightly down toward the ring stands so that the melted wax runs away from the flame.
4. Have the students predict the order in which the wax drops will melt (or candles will fall).
5. Slowly bring the lighted torch or Bunsen burner toward the rods until the tip of the flame is on the junction where the two rods meet. Students observe the order the in which the wax drops melt.
6. After the last wax drop melts on the aluminum (metal) rod, turn off the torch or burner.
7. Do not touch the aluminum rod—it will be very hot the entire length of the rod. You may touch the alumina (ceramic) rod next to the clamp and slowly slide your finger along the length of the rod until heat is detected. The warmth is usually felt somewhere between the first and second drop.

INSTRUCTOR NOTES

- Alumina is aluminum oxide (Al_2O_3), a ceramic material and a poor conductor of heat (an insulator).
- One source for the alumina rods is Knife Country USA (ceramic knife sharpening rod):
    1. (Part # AC71; ~ $1.50 each) **http://www.knifecountryusa.com/store/product/141811.141840/accusharp-ac71-ceramic-rod-8-1-2-inch.htmL**

- One source for aluminum rods is Speedy Metal (online industrial metal supply):
    - It is product: ⅜ in. (A) Rd 6061-T6511 Aluminum, Extruded – by the inch. They cut it to length for no extra charge. Order 8 ½" length to match the alumina rod. (Price is ~ $0.55 per rod). Call the company to request the cheapest possible shipping method. **https://www.speedymetals.com/pc-2437-8368-38-rd-6061-t6511-aluminum-extruded.aspx**
- Aluminum rods can also be purchased at Lowe's or Home Depot. They are 3 ft. long and will need to be cut to length to match the alumina ceramic rod.
- Expect the tip of the ceramic rod to glow orange hot. Since ceramics are good insulators (poor conductors) the heat from the torch is concentrated on the end of the rod. The tip of the metal rod will not glow orange hot. Aluminum is a very good conductor of heat so the whole rod gets hot and the heat is not concentrated at the tip. Older or advanced students can handle a discussion of the difference between ionic bonding (ceramic) and metallic bonding (metal) and how this is responsible for the difference in the properties of the rods.
- Do not quench the warm rods in water to cool them. Quenching a hot ceramic may lead to thermal shock and breakage of the rod.
- After several uses, the end of the ceramic rod that has been exposed to heat may crack and fly off. Keep students several feet back from the rods during the demonstration. To reduce the risk of thermal shock, gradually heat the ends of the rods by slowly bringing the lit torch or burner towards the rods.