Electrostatic Styrofoam

Discover the interplay of the electric force and gravity.

NOTE: This activity works best on days with low humidity.

Materials

(Enough for five people working together.)

- sheet of Styrofoam 1 inch thick, 7½ square feet
- ruler
- pencil
- knife (a bread knife works well, but a dinner knife will do the job)
- old newspapers (optional)
- double-sided tape
- wool sock, or other piece of wool (double-check that the material is wool)

Assembly

You'll be making a set of five Styrofoam cubes from 1″ × 1″ × 1″ to 5″ × 5″ × 5″. Here's how:

1. Measure and mark the following on the Styrofoam: one 1-inch square, two 2-inch squares, and so on.

2. Cut out the squares. This can be a bit messy, so do it outdoors or on a surface covered with newspaper. Cut in a sawing fashion.

3. Assemble the cubes by putting a few strips of tape between each two layers of Styrofoam.

To Do and Notice

1. Take your smallest cube and rub one face about twenty times with the wool sock.

2. Stick the cube against a vertical surface such as a whiteboard, a wooden door, or a metal file cabinet. Does it stay stuck?

3. Repeat with the other cubes, going from smallest to largest. What conclusions do you draw?

What's Going On?

Electric Charges

Matter contains positively charged protons and negatively charged electrons. Most things have an equal number of protons and electrons, which makes them electrically neutral. But remove some outer electrons from an object—or add some—and the object becomes electrically charged. When you rub the Styrofoam with the wool sock, electrons are transferred from the sock to the Styrofoam, making the Styrofoam negatively charged. A negatively charged object will be attracted to a positively charged or neutral object, which is why at least some of your Styrofoam cubes can stick to a vertical surface.

Size and Scale

Each larger cube is a scaled-up version of the smaller ones: it's the same shape, but its length, area, and volume have all increased, with volume increasing the most. As you scale something up, area increases in proportion to the square of the length, while volume increases in proportion to the cube of the length. Therefore, small objects have much more surface area relative to their volume than larger objects do.

In the case of your cubes, it's the area that's involved in sticking a cube to something vertical because there's a negative charge only on the surface that you rubbed with the sock. However, the volume of the cube, because it's proportional to its weight, determines the gravitational force on the cube.

You probably found that your largest cube (and maybe your second largest) didn't stick. Because of its low surface-to-volume ratio, gravity triumphs over the electric force, and the cube falls to the floor.

What's the Nanoscale Connection?

Imagine scaling a cube down to a nanometer per side: It would have a large surface area, for its volume. At the nanoscale, surface area is king. Many of the properties of nanoscale materials, such as chemical reactivity, and coloidal suspension are a result of surface effects.

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