

**Teacher Guide****Adhesives & Solubility****Introduction:**

Adhesives are used to hold all kinds of items and materials together. Objects may be constructed from multiple parts attached by adhesive. Broken fragments may also be re-assembled with adhesives. Adhesives can be natural or synthetic and have distinct properties including strength, viscosity, and solubility. In the conservation repair of art objects, the adhesive must be functional as well as reversible, allowing joins to be altered in the future. It is also often necessary to take apart repaired fragments that have been joined in the past. It is therefore important to conduct solubility tests in order to know which solvents will dissolve the adhesive without altering the original object or materials. In this activity, students will use an adhesive to repair a broken tile, and will then determine which solvent(s) can be used to take it apart.

**Objectives:**

- Define solubility
- Demonstrate the effect of temperature on solubility
- Demonstrate the effect of surface area on solubility

**Georgia Performance Standards:**

**SC7.** Students will characterize the properties that describe solutions and the nature of acids and bases.

- a. Explain the process of dissolving in terms of solute/solvent interactions:
  - Observe factors that effect the rate at which a solute dissolves in a specific solvent

**Supplies:**

100 mL beaker or jar with lid	Glass stirring rod
Water, hot and cold	Thin tipped paint brushes
Mineral Spirits	Droppers
Acetone	Ceramic tiles
Super Glue <u>GEL</u>	Large plastic zip-lock bags
Gorilla Glue	Small glass jars or beakers
Gelatin (plain, unflavored)	Hammers
Permanent marker	Hot Plate
Plastic containers (large enough for one tile)	

**NOTE: Gelatin, Superglue, and Gorilla Glue are NOT recommended for or used in the conservation repair of ceramics. These adhesives have been chosen for this activity because they are non-toxic, inexpensive, readily available, and demonstrate different solubilities.**

**Safety:**

Acetone should be used under a fume hood. Gloves and goggles should be worn at all time, especially when handling Super Glue GEL.

**Teacher PreLab:**

- Making the gelatin adhesive:
  1. Dissolve ¼ oz of plain unflavored powder gelatin in approximately 60ml of HOT water. (Prepare gelatin in a beaker or lidded jar, approximately 100ml.)
  2. Stir continuously until completely dissolved.  
\*Gelatin must be used while it is warm; it thickens as it cools. Once cooled, to re-use gelatin, place jar into a larger container of hot water until the gelatin is liquid.

**Procedures:**

Week 1

Preparing the tiles:

(Each student group will prepare three tiles: one repaired with each of the three adhesives.)

1. Break each tile into at least four pieces. Place individual tiles into transparent plastic bags. Working on a hard surface, hit the tiles with a hammer to create enough broken pieces.
2. Glue pieces of each tile together, using one adhesive per tile. Use a thin paint brush or the applicator tips to apply adhesive along the break edges. Also thinly smear a small amount of the adhesive on the surface of each piece of the tile. Be sure that the same adhesive is used for joining and smearing on one tile.  
Note: Before applying Gorilla Glue, the break edges and smear locations must be brushed with water first.
3. Label each tile: #1 gelatin, #2 Gorilla Glue, and #3 Superglue GEL.
4. Allow the tiles to dry for at least 1 week.

Week 2

Testing the solubility of the adhesives:

1. Draw one tile on the worksheet. Examine your joins and note your observations.
2. With a marker, label one smear on each tile with each of the solvents:  
A – acetone, HW – hot water, CW – cold water, MS – Mineral spirits.

- Using a dropper, apply a small drop of each solvent (acetone, cold water, hot water, mineral spirits) onto the corresponding surface smears. Apply only one solvent per smear. Be sure to apply all solvents to each of the three tiles.
- Allow the solvent drops to sit at least 5 minutes.
- Blot off remaining solvent with wipe or paper towel.
- Test whether the smears are tacky by touching each smear with a gloved finger or a wipe. Note your observations.
- Based on your observations, propose which solvent will solubilize each adhesive.
- Expose the joins to the selected solvents. Using a dropper, apply a drop of the selected solvent onto the joins on one tile. The solvent will flow into the cracks. Repeat on other two tiles with the selected solvent for each.
- Allow the solvent drops to sit for at least 5 minutes.
- Blot off remaining solvent.
- Carefully pick up each tile and observe whether joins are loose. Gently manipulate the pieces to see if any move or can be separated. Note your observations.

*Steps 7-10 could be repeated to experience the effect of longer contact between solvent and adhesive.*

*Optional: Continue with steps 11-13 to experience the effect of more solvent action.*

- Expose the tiles to the selected solvent. Tiles may be completely submerged in hot or cold water in a plastic container. For acetone and mineral spirits, create a vapor chamber by enclosing the repaired tile and a small open container of the selected solvent in a sealed bag.
- Allow the tiles to be exposed for at least 10 minutes.
- Carefully remove the tiles and check the joins. Have any of the pieces separated or loosened? Are the effected joins the ones that have excess adhesive, gaps, or uneven alignment? Note your observations.

*Steps 11-13 could be repeated to separate more joins.*

### **Clean up:**

Clean brushes. Properly dispose of solvents. Prepared glues may be stored in sealed containers.

### **Teacher Notes:**

- Solubility:** Superglue GEL is soluble in acetone. Gelatin is soluble in hot water. Gorilla Glue is insoluble in the solvents as used in this activity. The bonds can be undermined by mechanical action and the influence of surface area, temperature, exposure, duration, etc. Thus, even insoluble glues will sometimes release.
- Factors that influence solubility and are demonstrated through this activity:** surface area, polarity of the solvent, temperature, amount of solvent, duration of exposure

**Select Resources:**

- Horie, C.V. (1987), *Materials for Conservation: Organic consolidants, adhesives and coatings*. Butterworth Heinemann.
- Newey, R., Boff, R., Daniels, V., Pascoe, M., and Tennant, N.(1992), *Science for Conservators Vol. 3 Adhesives and Coatings*. Museums & Galleries Commission; London.
- Shiber, Linda (2006). Sticky Situations: The Wonders of Glue. *ChemMatters* (24/4). 8-10. Retrieved July 28, 2021 from:  
<https://www.acs.org/content/dam/acsorg/education/resources/highschool/chemmatters/articlesbytopic/bonding/chemmatters-dec2006-glue.pdf>