

Mentoring Advanced Placement Chemistry



Topic: Adhesives, cross-polymerization

Quick Question:

Cartoon characters often stretch or squeeze and display amazing elasticity. I.e., if a coyote catches an anvil, his hands and arms move with it but the rest of his body remains stationary for a moment before flying after.

Q: What does this say of the speed of sound in cartoon coyote body tissue?

Challenge:

Adhesives are just about everywhere. They are incredibly useful – in furniture making, construction, manufacturing, book binding - but the surface of wood is different from glass and one adhesive will not function in all situations. Accordingly, glue makers and joiners apply a variety of methods.

One common type of adhesion employs cross-polymerization reactions.

A material starts in liquid form. A second is added and the combination gels. At high temperatures the solution is pliable, but below a temperature cutoff it becomes rigid.

- 1.)** How does it aid an adhesive to be fluid? What physical interactions will this expose the adhesive to?
- 2.)** What chemical or physical processes capably describe the solidification below a temperature threshold?

As the name cross-polymerization implies, the bonding process comes from chains of molecules, (polymers), being cross linked – forming a web of linear and lateral bonding.

Elastic Putty: Turpentine
Rosin oil
Linseed oil
Barytes, (barium sulfate)
Whiting, (calcium carbonate)

- 3.)** In this 1934 recipe, what are the molecular chains? What are the cross linking agents?

4.) How would the putty's properties change with more cross linking?

5.) What is the difference between this putty, and epoxy/superglue which hardens permanently after mixing the reagents?

QQ Solution: In solids, the transmission of information on one molecule's location or interactions is relayed to neighboring molecules through the tug of their bonds. For rapid perturbations this transmission is limited by the speed of interaction, a value often close to the speed of sound within the material. Since it can take up to two seconds for information to travel from the coyote's hands to his torso, the speed of sound is perhaps a half meter per second, far below the norm of roughly 300m/s.

Challenge Solution and Discussion:

MAP is acquiring supplies for this activity. The original recipe does not consider mixing or heating instructions necessary, so taking liberty with methods should not have adverse affects.

By weight: Turpentine	5 parts
Rosin oil	8 parts
Linseed oil and drier	5.5
Barium sulfate	8.5
Calcium carbonate	73

Like baking: Make sure to pulverize and mix dry ingredients. Add liquid, mix well, and have fun.

This is a real recipe for putty from an old script of home products.

1.) The exact nature of interaction is varied and often uncertain, but a few theories exist.

- One involves adhesive molecules entering molecular gaps on the substrate surface and then solidifying.
- Another holds that threads of adhesive material integrate with threads/chains of substrate molecule, the aggregate tangling like felted yarn.
- Some adhesives function like gecko feet, and have massive surface area exposure that sticks to substrates through Vanderwaals interactions.

All of these benefit from fluid properties allowing the adhesive to flow in and establish maximized area for interaction. The type of interaction most applicable depends on the materials one wishes to join.

2.) Below a threshold temperature there is no longer enough energy to easily break polymerization bonds. At this point the material may flex, as bonds stretch and rotate, but bond permanence will produce rigid properties.

3.) The oils consist of long hydrocarbon chains. The turpentine likely acts as a diluting agent for the oils and medium for the salts to dissociate, and the ionic salts interact within this colloid, forming cross links.

The elastic properties come from the material's low bond strength and ease of bond formation. Stretching breaks some bonds and stretches others, upon release of the material they re-link.

4.) More cross linking would make the material more rigid, requiring more energy input to stretch.

5.) The solid epoxies form high energy bonds that are very stable at room temperature. The inflexibility of these bonds, and their relative permanence, gives these glues very rigid properties, making them suitable for tasks that one does not wish to revisit.