Educational Innovations Inc®

Activities with

Poly-Ox

Self-Siphoning Gel

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#GB-100A/B

Poly-Ox Self-Siphoning Gel

When a small amount of this white powder is sprinkled into a liquid and water is added, it dissolves, forming a thick, mucous-like gel. When the gel is poured back and forth between two beakers, the gel readily siphons from the higher vessel to the lower one.

Materials:

25 ml of a water soluble anhydrous alcohol (such as methanol or ethanol)
3-4 grams polyethylene oxide
Stirring rod
2 - 600 ml beakers
Fluorescent dye such as fluorescein or rhodamine B (optional)

Procedure:

1. Mix 20-25 ml of a dry alcohol such as anhydrous methanol or ethanol with 3-4 grams of polyethylene oxide in a clean, dry 600 ml beaker. Swirl the mixture to completely wet the resin with alcohol.

2. Add 350-400 ml of tap water into the mixture "in one pour" and stir until the resin has gelled completely.

3. Pour the gel into a second 600 ml beaker and then back and forth between the two beakers. The polyethylene oxide can be made to siphon by raising one beaker above the other while gradually pouring the gel. Once the gel starts to pull, separate the two beakers and turn the upper vessel upright. The gel will move up the sides of the beaker as a thin film which forms thick strands as it falls. This process can be continued indefinitely.

4. Empty the contents of one of the beakers into the other. Add 100 ml of tap water to the empty beaker and coat its sides with the water by swirling. Pour the gel into the water, then back into the original beaker. The siphoning process speeds up considerately, pulling the gel quickly out of the upper beaker. Caution: even small strands can start the siphoning process, emptying the beaker unexpectedly.

5. An interesting variation on this experiment is to add a few crystals of a fluorescent dye such as fluorescein or rhodamine B to the alcohol before adding the polyethylene oxide. The experiment can then be performed in a darkened room if illuminated with a fluorescent light, creating a striking effect.

Clean-up:

The gel can be disposed of in the waste paper basket (it's 99% water). The glassware can be rinsed with plenty of tap water and dried.

Notes:

1. The alcohol acts as a dispersant to separate the resin particles inhibiting the formation of large, insoluble lumps. Any water soluble alcohol can be used as long as it is dry. In addition to methanol and ethanol, isopropyl alcohol, ethylene glycol, propylene glycol, and acetone can also be used as a dispersant.

2. Deionized or distilled water is unnecessary since, being nonionic, the polyethylene oxide gel is not affected by the minerals in ordinary tap water.

3. While the polyethylene oxide resin is a fine powder and some dust is released when massing or mixing the resin with alcohol, it has a very low order of toxicity by all means of exposure, according to its manufacturer. Due to its high molecular weight, it is poorly absorbed by the gastrointestinal tract, and is completely and rapidly eliminated. The resin is neither a skin irritant, nor a sensitizer, nor does it cause eye irritation as the dry powder or as aqueous solution.

Discussion:

Polyethylene oxide, being a polyether, and containing an oxygen as every third atom in the chain, readily hydrogen bonds with water. This large number of oxygen and their two pairs of nonbonded "p" electrons explains its high water solubility for its molecular mass (~4,000,000).

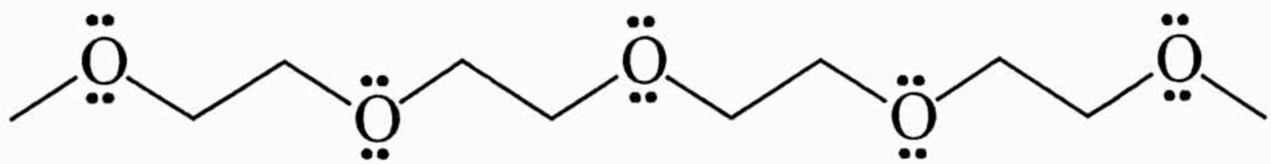
$$HO\text{-}CH_2\text{-}CH_2\text{-}(\text{-}O\text{-}CH_2\text{-}CH_2\text{-})_n\text{-}OH$$

The long strands of gel are formed when these large molecules intertwine much like spaghetti and are cross-linked by water molecules attached to the oxygen on adjacent molecules. The result is a "viscoelastic" gel. That is, like molasses, the gel has a high viscosity due to the large number of hydrogen bonds between the polymer molecules and water, and is elastic since these very long molecules can both straighten when stretched and slide past each other, forming fresh hydrogen bonds as they move.

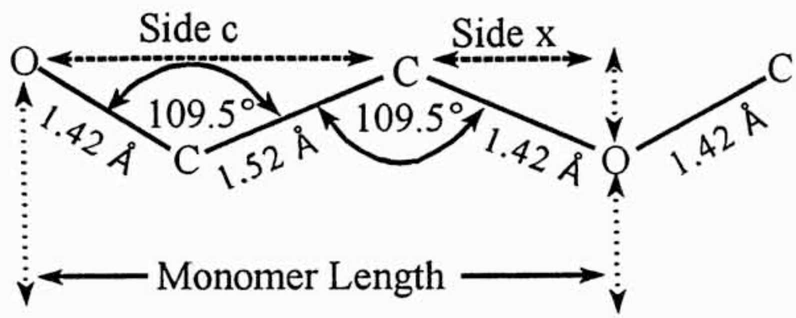
References:

1. http://sprott.physics.wisc.edu/demobook/into.htm, Demonstration 6.10 "Fluorescence"
2. Union Carbide product literature
3. Myerly, Richard C., *J. Chem. Ed.*, 57, pp 437-8 (June 1980).

<u>WHY DOES THE GEL FORM SUCH LONG STRANDS?</u>



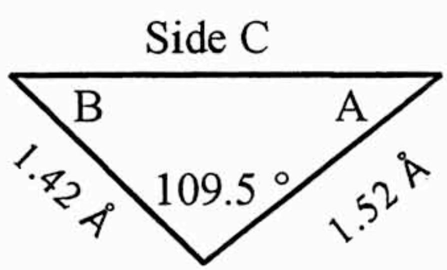
<u>PART I:</u> Length of the Monomer.



$$\text{side } c = \sqrt{a^2 + b^2 - 2ab \cdot \cos \angle C}$$

$$\text{side } c = \sqrt{(1.42\ \text{Å})^2 + (1.52\ \text{Å})^2 - 2(1.42\ \text{Å})(1.52\ \text{Å})\cos 109.5°}$$

$$\text{side } c = 2.40\ \text{Å}$$

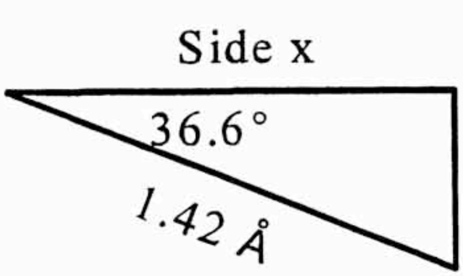


$$\frac{\sin \angle A}{a} = \frac{\sin \angle B}{b} = \frac{\sin \angle C}{c}$$

$$\frac{\sin 109.5°}{2.40\ \text{Å}} = \frac{\sin \angle A}{1.42\ \text{Å}}$$

$$\angle A = 33.9°$$

$$\angle D = 180° - 109.5° - 33.9° = 36.6°$$



$$\cos \angle D = \frac{\text{adjacent side}}{\text{hypotenuse}}$$

$$\cos \angle 36.6° = \frac{\text{side } x}{1.42\ \text{Å}}$$

$$\text{side } x = 1.14\ \text{Å}$$

Therefore, the monomer length = 2.40 Å + 1.14 Å = 3.54Å
Since 1 Å = 1 x 10^{-10} meters, then each monomer = 3.5 x 10^{-10} meters

PART II: Length of each molecule

$$\frac{4{,}000{,}000 \text{ g/mol}}{40 \text{ grams/monomer}} = 100{,}000 \text{ monomer units/molecule}$$

$$100{,}000 \text{ monomer units} \times 3.54 \times 10^{-10} \text{ meters/unit} = 3.5 \times 10^{-5} \text{ meters/molecule}$$

Part III: Length of polymer chains in one drop of resin solution.

$$\frac{4 \text{ grams resin}}{4{,}000{,}000 \text{ g/mol}} = 1 \times 10^{-6} \text{ moles resin in beaker}$$

$$1 \times 10^{-6} \text{ moles resin} \times 6.0 \times 10^{23} \text{ molecules/mol} = 6.0 \times 10^{17} \text{ molecules in the beaker}$$

$$\frac{6.0 \times 10^{17} \text{ molecules}}{400 \text{ ml}} = 1.5 \times 10^{15} \text{ molecules/ml} \times \frac{1 \text{ ml}}{20 \text{ drops}} = 7.5 \times 10^{13} \text{ molecules/dro}$$

$$7.5 \times 10^{13} \text{ molecules/drop} \times 3.5 \times 10^{-5} \text{ meters/molecule} = 2.7 \times 10^{9} \text{ meters of resin/drop}$$

$$\frac{2.7 \times 10^{9} \text{ meters of resin/drop}}{1600 \text{ meters/mile}} = 1{,}700{,}000 \text{ miles of resin/drop}$$

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