NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

How to Remove Makeup:

A Lesson in "Like Dissolves Like"

by
Ying Guo
School of Science and Technology
Georgia Gwinnett College, Lawrenceville, GA

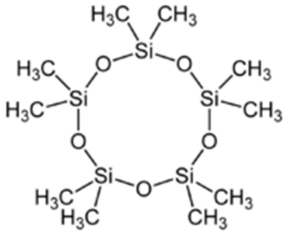
A group of specialists in a marketing department is investigating three types of makeup removers. They want to generate a short presentation explaining their working principles. Please provide support for the marketing specialists with your knowledge of chemistry. Below are the key ingredients and directions for three types of makeup removers. Please discuss with your group members and answer the six questions below. After that, please prepare a five-minute long presentation explaining how these three makeup removers work, and present it in class. You should assume that your target audience has taken a college-level general chemistry course.

Product 1

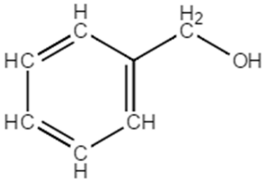
Directions for use:
Shake well. Apply with cotton pad on closed eyelids. Gently rinse with warm water.

Key Ingredients:

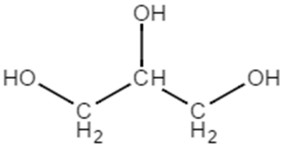
- Water
- Cyclopentasiloxane (a nonpolar molecule)



- Benzyl alcohol



- Glycerol



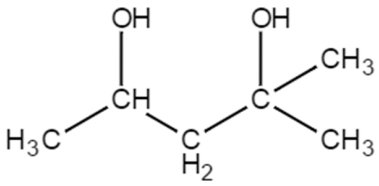
- Potassium phosphate and dipotassium phosphate (adjusting pH)

Product 2

Directions for use:
Sweep cotton ball or pad over closed eyelid and lashes until all traces of makeup are removed.

Key Ingredients:

- Water
- Hexylene glycol



- Disodium cocoamphodiacetate (synthetic surfactant)
- Potassium phosphate and dipotassium phosphate (adjusting pH)
- Sodium laureth 8 sulfate (surfactant)
- Sodium laureth sulfate (surfactant)
- Magnesium laureth 8 sulfate (surfactant)
- Magnesium laureth sulfate (surfactant)

Product 3

Directions for use:
Sweep cotton ball or pad over closed eyelid and lashes until all traces of makeup are removed.

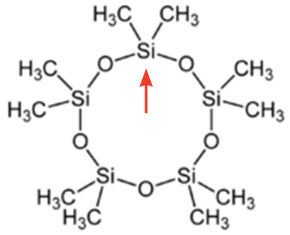
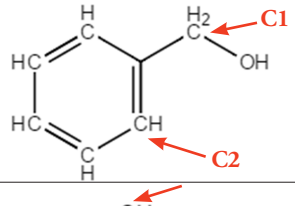
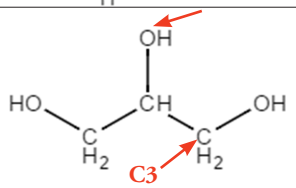
Key Ingredients:

- Mineral oil
- Zea mays (corn) germ oil
- *Carthamus tinctorius* (safflower) seed oil
- Simmondsia chinensis (jojoba) seed oil
- Camellia kissi seed oil
- Macadamia ternifolia seed oil
- Canola oil

**All the oil-based ingredients are considered to be nonpolar molecules.*

Questions

1. Determine the electron and molecular geometries of the labeled atoms (indicated by arrows) in the molecules below.

	Labeled Atom	*Electron Geometry*	*Molecular Geometry*
	Si		
	C1		
	C2		
	C3		
	O		

2. Based on the provided structures, determine whether each of the following molecules is polar or nonpolar. (*Note:* for water, please draw the Lewis dot structure yourself.)
   a. Water

   b. Benzyl alcohol: _____
   c. Glycerol: _____
   d. Hexylene glycerol: _____

3. Nonpolar molecules that repel water molecules are said to be *hydrophobic*; molecules having ion-dipole interaction or that form a hydrogen bond with water molecules are said to be *hydrophilic*. For complicated organic compounds, we normally refer to the nonpolar end (with primarily C and H) as the hydrophobic end, and the region with the multiple polar functional groups (i.e., –OH and –NH_2) as the hydrophilic end. Please determine the hydrophobic and hydrophilic ends for benzyl alcohol.

4. Based on the information provided earlier in the case, please specify which one of the three products is *not* a homogeneous solution.

5. Based on the "like dissolves like" principle, please explain why the product you identified in Question 4 has two different layers. How about the other two products? Why do they form homogeneous solutions?

6. Surfactants are usually organic compounds that are *amphiphilic*, meaning they contain both hydrophobic and hydrophilic groups. Therefore, a surfactant contains both a water-insoluble (or oil-soluble) component and a water-soluble component. If water is mixed with oil, surfactants will diffuse at the interface between oil and water. The water-insoluble hydrophobic group may extend out of the bulk water phase into the oil phase, while the water-soluble head group remains in the water phase. As a result, *micelles* are formed. In micelles, hydrophobic tails form the core and the hydrophilic heads are in contact with the surrounding liquid (see Figure 1). Because oil is trapped in the hydrophobic cores of micelles with no contact with water, a homogeneous solution can form. If we think of makeup as a set of nonpolar molecules to be removed, explain how each of these three products can remove makeup from the face.

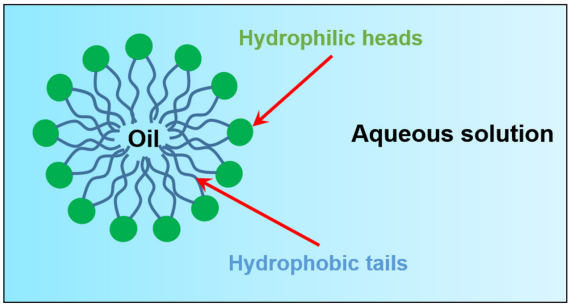


Figure 1. Micelle formed by amphiphilic molecules.