Experiment 14 – Preparation of a Hand Cream

Most lotions and hand creams contain both polar and non-polar ingredients. The purpose of a lotion or a hand cream is to moisten the skin and to prevent it from drying out. Most people do not want to use lotions that feel greasy or oily. However, most lotions do contain oils or other nonpolar ingredients. Lotions also contain a high proportion of water, and as you recall, oils are not soluble in water. Therefore, the oils present in lotions must be emulsified, so they can be distributed throughout the lotion without separating out (and so that the lotion does not have an overall greasy feel).

Some common nonpolar ingredients used in lotions include lanolin and mineral oil. Lanolin is a wax that is obtained from sheep's wool. Mineral oil is a mixture of hydrocarbons that have high molecular weights. Because both lanolin and mineral oil are nonpolar, emulsifying agents are also needed in order to distribute them in the hand cream. Emulsifying agents must have a nonpolar, hydrophobic section that will interact with and dissolve in the nonpolar ingredients. Emulsifying agents must also have charged groups that make them compatible with water. Emulsifying agents behave like soaps and detergents: they form micelles with the nonpolar sections dissolved in the oil droplets, and the charged groups on the exterior, facing the water. Thus, small oil droplets in the form of micelles can be suspended in the water.

The emulsifying agent in this hand cream is made from stearic acid and triethanolamine. When these two compounds are mixed, they undergo an acid-base reaction to yield an ionic compound (a salt). This salt has a nonpolar section and a charged section, so it is a good emulsifying agent.

Other possible ingredients that could be present in hand creams are propylene glycol (1, 2-propanediol) and esters such as methyl stearate. These substances affect the texture of the lotion. You will determine their effects on the texture of a hand cream in this experiment.

In this experiment, you will make four different hand creams. Three of them will contain missing ingredients, and one of them will contain all of the necessary ingredients. You will then compare their properties, evaluate the function of each of the missing ingredients, and explain each function according to the chemical principles involved.

Safety Precautions:

- Wear your safety goggles.

Waste Disposal:

- All waste chemicals must be placed in the **organic** waste containers (which have a pink label) in one of the fume hoods.
- The finished hand creams can be placed in the regular garbage cans when you have finished testing their properties.

Procedure

The following table lists the ingredients in each hand cream mixture. Detailed directions are given in each step, but using this table it is easy to directly compare the different mixtures.

The general idea behind the procedure for each sample is as follows. The nonpolar ingredients will be combined in a small beaker and then heated in a water bath until they melt. The polar ingredients will be combined in a different beaker and heated in the water bath. All ingredients will be removed from the water bath and the nonpolar ingredients will then be slowly poured into the polar ingredients while the mixture is stirred constantly. This same procedure will be followed to make each sample. When all four hand cream mixtures have been prepared, their properties will be compared and the pH of each will be determined.

Ingredients	**Mixture 1**	**Mixture 2**	**Mixture 3**	**Mixture 4**
Polar Ingredients				
Water	25 mL	25 mL	25 mL	25 mL
Triethanolamine	1 mL	1 mL	1 mL	-
Propylene glycol	0.5 mL	0.5 mL	-	0.5 mL
Nonpolar Ingredients				
Stearic Acid	5 g	5 g	5 g	5 g
Methyl Stearate	0.5 g	0.5 g	-	0.5 g
Lanolin	4 g	4 g	4 g	4 g
Mineral Oil	5 mL	-	5 mL	5 mL

Part 1 – Preparation of the Hand Creams

1. Set up a ring stand with an iron ring and a piece of wire gauze over a Bunsen burner. Fill a 400-mL beaker about halfway with tap water and start heating it with the burner.

Hand Cream #1

2. In a 50-mL beaker, place 5 g stearic acid, 0.5 g methyl stearate, 4 g lanolin, and 5 mL mineral oil. (These are all of the nonpolar ingredients.)
3. In a 100-mL beaker, place 25 mL deionized water, 1 mL triethanolamine, and 0.5 mL of propylene glycol. (These are the polar ingredients.)
4. Using a pair of crucible tongs to hold one edge of the beaker, hold the 50-mL beaker of nonpolar ingredients in the water bath until everything in the beaker has melted. Remove this small beaker and set it on the bench top.
5. In the same way, hold the 100-mL beaker of polar ingredients in the hot water bath for 5 minutes. After 5 minutes, remove this beaker and set it on the bench top.
6. If the nonpolar ingredients have solidified by now, re-melt them in the water bath.
7. Slowly pour the melted nonpolar ingredients into the polar ingredients while constantly stirring the mixture with a stirring rod. Keep stirring the mixture for 5 minutes, until it is smooth and uniform. Label this beaker “Mixture #1” and set it aside.

Hand Cream #2

8. In a clean, dry 50-mL beaker, place 5 g stearic acid, 0.5 g methyl stearate, and 4 g lanolin.
9. In a clean 100-mL beaker, place 25 mL deionized water, 1 mL triethanolamine, and 0.5 mL of propylene glycol.
10. Follow steps 4-7 above to heat and combine the mixtures. This time, label the beaker of finished hand cream “Mixture #2” and set it aside.

Hand Cream #3

11. In a clean, dry 50-mL beaker, place 5 g stearic acid, 4 g lanolin, and 5 mL mineral oil.
12. In a clean 100-mL beaker, place 25 mL deionized water and 1 mL triethanolamine.
13. Follow steps 4-7 above to heat and combine the mixtures. This time, label the beaker of finished hand cream "Mixture #3" and set it aside.

Hand Cream #4

14. In a clean, dry 50-mL beaker, place 5 g stearic acid, 0.5 g methyl stearate, 4 g lanolin, and 5 mL mineral oil.
15. In a clean 100-mL beaker, place 25 mL deionized water and 0.5 mL of propylene glycol.
16. Follow steps 4-7 above to heat and combine the mixtures. This time, label the beaker of finished hand cream "Mixture #4" and set it aside.

Part 2 – Characterization of the Hand Creams

17. One by one, stir each of the hand cream mixtures with a stirring rod and touch the stirring rod to a piece of pH paper (not litmus paper). Determine the pH of each sample by comparing the color of the paper to the color scale on the dispenser. Record the pH of each mixture. **Important:** remember to rinse and wipe off the stirring rod between mixtures so as not to contaminate them. This would make your results ambiguous.
18. For each hand cream, rub a small amount between your fingers. Note the smoothness, appearance and homogeneity of each, and record your observations. Pay attention to how the properties of the mixtures differ. After you have tested each one, wash your hands.

Questions

1. Describe the properties of hand cream mixture #1, which contained all of the necessary ingredients.
2. Explain how the properties of hand cream mixture #2 differed from those of #1.
3. Based on your observations, what is the function of mineral oil in a hand cream?
4. Explain how the properties of hand cream mixture #3 differed from those of #1.
5. Based on your observations, what is the function of propylene glycol and methyl stearate in a hand cream?
6. Explain how the properties of hand cream mixture #4 differed from those of #1.
7. Based on your observations, what is the function of triethanolamine in a hand cream?
8. The structure of triethanolamine is $N(CH_2CH_2OH)_3$. Stearic acid is an 18-carbon saturated fatty acid. Write the equation for the acid-base reaction between triethanolamine and stearic acid. Name the salt formed. (This salt is the emulsifying agent in the hand creams you made.)
9. If triethanolamine was omitted in the hand cream, what would be the consequence? Explain in chemical terms.
10. Do you think it would be possible to prepare a hand cream without water? Explain why or why not.
11. Draw the structures of methyl stearate and propylene glycol. Which one is polar, and how can you tell? Which is nonpolar and how can you tell?
12. If a hand cream appeared smooth and uniform after you prepared it, but after a week of storage most of the water and most of the oil separated, what do you think must have gone wrong with the preparation?