Chemistry
Casein Glue - Activity

In this lab, you will separate a mixture and synthesize a new product - glue! Wear your safety glasses and work steadily.

BACKGROUND

Cow's milk contains 4.4% fat, 3.8% protein, and 4.9% lactose. At the normal pH of milk 6.3 - 6.6, the protein remains dispersed evenly in the solution. As the pH is lowered by the addition of an acid, the protein can no longer remain in solution, and it coagulates into an insoluble mass. The pH where this occurs for milk is at about 4.6.

HOMOGENIZED MILK = FAT + PROTEIN (casein) + LACTOSE (sugar)

Pre-lab:
1. Milk is a homogeneous mixture (a solution) and not a compound. Explain this statement.

Milk is NOT a compound because milk can be purchased with different compositions. Whole, 2%, skim, nonfat are all varieties of milk that can be purchased. Compounds always have a definite composition while mixtures can have any % composition.

2. Is milk an acid or a base?

Acid (slightly); pH of less than 7 is acid.

3. What is the purpose of adding vinegar (acetic acid) to the milk?

To lower the pH of the milk and for the protein (casein) to reach its isoelectric pH. When this occurs, the casein will separate from the solution.

4. Could other acids (hydrochloric, HCl or nitric, HNO_3) be used to separate the protein from the solution?

Yes, any acid would work. The purpose is only to lower the pH. In fact, when babies drink milk and throw it up the milk is very often separated into curds (casein) and whey (milk sugar). The stomach acid (hydrochloric acid) caused this separation to occur.

PROCEDURE

1. Pour about 100 mL of nonfat milk into a 400 mL beaker. Add 15 mL of white vinegar (5% acetic acid).

2. Place the mixture on a hot plate and heat - while gently stirring with a thermometer. Observe the mixture carefully and record the temperature of the solution when you begin to see turbidity (chunks floating in the beaker). Stop heating if the temperature of the solution becomes warmer than 60 ^{o}C.

3. Filter the mixture through a folded pieces of paper towel into an Erlenmeyer flask, as shown.

4. Discard the filtrate which contains the whey. Scrape the curds from the filter paper back into the 400 mL beaker.

5. Add about 1 g of $NaHCO_3$ (baking soda) to the beaker and stir. Slowly add drops of water, stirring intermittently, until the consistency of white glue is obtained.

6. Use your glue to fasten together two pieces of paper. Also fasten together two wooden splints. Allow the splints to dry overnight, and then test the joint for *strength.

* If you test the strength of the glue with a spring scale...must be sure to use equal amounts of glue on each joint.

Name ______________________________
Hr _____ Score __________

POST-LAB

1. What would happen if you used whole milk in this lab?

   The fat would remain with the casein. It would be difficult to separate out the protein from the fat. Try to separate out the fat from a candy bar - it is difficult because it has been emulsified (lecithin or egg added) to get the oil and water to mix.

2. Why do we heat the mixture? What would happen if you heated to 95 ^{o}C?

   To speed up the reaction. The heat is merely a catalyst - its speeds up the reaction. The reaction would occur without the addition of heat. Rule of thumb: a 10 ^{o}C increase doubles (2x) the reaction rate.

   To heat too much would cause the protein (casein) to decompose (denature the protein) into amino acids. Our bodies have lipid (fats and oils) membranes which keep body fluids separate. If our internal body temperature becomes too warm (105 ^{o}F) our fat membranes literally melt and our fluids mix...resulting in brain damage and possibly death.

3. How did you know when the milk was separated?

   Turbidity, chunks where floating in the mixture.

4. How would the glue made differ from using whole vs. 2% vs. non-fat milk?

   Theoretically, NO DIFFERENCE...the glue is made from the casein (protein) and not the fat. The fat has nothing to do with the glue. Practically, the more fat in the milk (may interfere with the glues ability to dry thoroughly and) may produce a weaker glue.

5. Why do we add baking soda to the casein?

   Baking soda is a base (a proton acceptor) and neutralizes the acid added to the glue.

6. In this experiment, what happened to the lactose and fat portions of the milk?
   lactose --> whey (carbohydrate = complex sugar)
   fat --> was removed before we got the milk (cottage cheese) we used non-fat milk.

Extension:

   Design the experiment so that you could calculate your % protein recovered in the milk.
   Industrially, how is fat removed from milk to produce skim and non-fat milk?

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