Making Modelling Clay out of Milk

Many types of clays, resins, plastics and glues are liquids or very soft solids when unset and solidify and harden when another reagent is added. In the unset state, some might be monomers, single molecules which, upon addition of another reagent, polymerise. Polymerisation is a process by which the single molecules all link up in an infinite chain and become a polymer. Most plastics are polymers (polyester, polystyrene, polyethylene (polythene)). The prefix 'poly' means 'many' hence polystyrene means 'many styrenes'.

Other types of reagents which harden upon addition of another reagent may do so because the second reagent causes the first to become insoluble. In the following experiment a hitherto soluble protein in milk will be rendered insoluble by the addition of acid in the form of vinegar.

MATERIALS

You will need:

- Half a litre/one pint of milk
- A saucepan
- A sieve
- A mixing spoon
- White wine vinegar (20 cm3)
- Laboratory gloves (or Marigold-type rubber gloves)
- Water
- Safety glasses

HEALTH & SAFETY

You may wish to consider eye protection with approved safety glasses since vinegar can cause eye irritation. You should wear laboratory gloves or Marigold type rubber gloves. Boiling milk can scald.

METHOD

Pour the milk into the saucepan and heat until it simmers. Do not allow it to boil. Add the white wine vinegar carefully as the milk simmers. As you add it you may notice that white rubbery lumps begin to form, the milk is curdling. The milk will turn less cloudy and eventually clear. You now have a saucepan full of 'curds and whey', much beloved by Miss Muffet and which is largely what cottage cheese consists of. Turn off the heat and allow to cool. Sieve the solid from the liquid, which can be discarded down the sink.

Using your gloves you can then handle the solids – the lumps will feel rubbery and soft, not unlike Mozzarella cheese (which is formed by a similar process). The lumps can be modelled into shapes like Plasticine, and once you are happy with the shape can be left to dry. After a few days, they will be very hard, not unlike solid Parmesan cheese, which, as you may have guessed by now, is also formed by a similar process. Incidentally I dislike Parmesan cheese intensely because I think it smells quite offensive.

The smell of Parmesan is caused by butyric (butanoic) acid, which can be detected by smell in humans at concentrations above 10 parts per million. It is the same butyric acid which gives vomit its characteristic smell, and is found in rancid butter. The shapes you have made will be hard and inflexible and can be painted.

EXPLANATION

The soft lumps that form when the vinegar is added to the hot milk are Casein, a protein which is soluble at pH 7 (neutral) and exists in milk as the calcium salt. Casein is insoluble below pH 4.6 (acid), and the vinegar, which is a dilute solution of acetic (ethanoic) acid, makes the milk acid enough to precipitate out the Casein leaving the vinegar as calcium acetate (ethanoate). Casein has a high molecular mass (19,000 – 24,000 depending on which form) which mean it exists as long chains, a bit like the polymers in plastics.

You can try the experiment with other acids. When I was young, I remember thinking that orange squash might taste nice in milk, and added it. When I drank it I noticed that it had a texture (small bits of matter floating around) and it tasted slightly cheesy. The citric acid in the orange squash had caused the casein to precipitate and completely changed the attributes of the milk.