# Making Rainbows from Milk

Science at Home regularly examines the properties of milk for its experiments (Modelling with Milk and The Chemistry of Your Breakfast). Milk has interesting properties of both water and fats. Water and fats normally do not mix, and are described as *immiscible*, one will normally float on the other as in the case of an oil/vinegar salad dressing. In the case of milk, and certain other water/fat combinations the fat is suspended as droplets in the water as an *emulsion*. Other example of emulsions include certain paints, the *crema* head in espresso coffee, mayonnaise, custard and and the formation of an emulsion is responsible for change in the appearance *pastis* (a French alcoholic drink which tastes of liquorice) when water is added to it.

Anything which interacts with either (or better still, both) fat or water might have an interesting effect on milk. Detergents have properties which affect both fats and water. Detergents have a charged 'head' which is attracted to water (hydrophilic, *Gr. water loving*) and a non-charged 'tail' which is attracted to fat and is described as lipophilic (*Gr. fat-loving*). It generally also follows that anything that is hydrophilic is lipophobic and anything that is lipophilic is also hydrophobic. A very few molecules are both, an example being ethyl alcohol, aka ethanol.

Detergents work by removing the oil or grease which causes dirt to adhere to dishes/clothes/skin or hair. The dirt then floats off on its own or is trapped with the grease. The detergent also prevents the dirt re-adhering to the surface from which it was removed by trapping it in a micelle, a circle of detergent molecules.

By introducing detergent molecules into a 'stable' system of drops of food colouring suspended in milk, activity and movement within the milk is caused, leading the disruption of the colours and eventual mixing, causing a beautiful and quick rainbow effect.

## MATERIALS

You will need:

- Food colouring (3-4 colours);
- As many teat pipettes as you have colours of food colouring (or if you can't find pipettes you can try using a very steady hand);
- 1 pint of whole milk, 1 pint semi skimmed and 1 pint of virtually fat-free milk;
- Cotton bud(s);
- Washing-up liquid;
- A dinner plate.

## HEALTH & SAFETY

A laboratory coat or apron/overall should be worn since this experiment involves the use of food colouring which can stain clothes. The residues can be safely disposed of by pouring down the sink.

## METHOD

1. Pour milk onto a dinner plate until the whole of the plate is covered with milk and the level is just below the lip of the plate;
2. Using a separate pipette for each; put a drop of each colour of food colouring at the corner of an imaginary square in the centre of the plate. The square should have sides of about 2 cm;
3. Soak a cotton bud in washing-up liquid. Then touch the tip of the bud into the centre of the imaginary square. There should be an immediate change in the appearance of the milk/food colouring.
4. Repeat the experiment using half fat/skimmed milk/fat free milk and water. What are the similarities and what are the differences observed when using each of these media?

## EXPLANATION

Milk is an emulsion with droplets interspaced by water. The lipophilic tail of detergent tries to dissolve in the fat droplets and move as they attempt to do this. The movement is caused by the attraction of the tail for the fat. As the detergents move the disturb the locality of the food colouring and cause the different areas of the colours to move. The fattier the milk the more pronounced the effect which explains why using whole milk causes a more spectacular colour effect.

Before the advent of synthetic detergents (normally sodium dodecyl sulphate) they were made by boiling animal fat with a strong alkali. The ester groups would be broken leaving glycerol and three fatty acid – these have a charged head and uncharged tail and act like soaps.