Detergency

Introduction
Teachers who have not used the problems before should read the section Using the problems before starting.

Prior knowledge
Cleansing action of soaps and detergents, including an appreciation that these molecules comprise both a hydrophillic ‘head’ and a hydrophobic ‘tail’ in these molecules. A detailed knowledge is unnecessary as students are encouraged to consult textbooks during the exercise.

Resources
Textbooks for reference.

Risk assessment
A risk assessment must be carried out for this problem if practical work is undertaken.

Group size
3–4.

Possible approaches
This is a short problem; if after 10 minutes or so of brainstorming, the idea that detergent molecules can be anionic or cationic has still not emerged, the students should be directed to an appropriate textbook.

There are two main types: anionic detergents contain molecules with a negative head, and cationic detergents contain molecules with a positive head. (See Background information below.)

The jelly-like solid is a precipitate produced when an anionic and cationic detergent are mixed together.

Suggested approach
During trialling the following instructions were given to students and proved to be extremely effective:

1. Working as a group, discuss the problem.
   Such discussion can play a vital role in working out possible solutions to open-ended problems like this. Several minds working on a problem together can stimulate ideas that one on its own could not manage.
2. Write a brief account of your solution.
3. Working as a group, prepare a short (ca 5-minute maximum) presentation to give to the rest of the class. If possible all group members should take part: any method of presentation (such as a blackboard, overhead projector, etc) can be used.

Outline the problem, describe your explanation and explain how you arrived at it. After the presentation, be prepared to accept and answer questions and to discuss what you did with the rest of the class.

Background information

There are four types of detergent:

- anionic – molecules with a negative head such as the alkylbenzene sulphonates. These are used extensively in shampoos because of their excellent foaming and cleansing properties. Soap is also anionic;
- cationic – molecules with a positive head such as a quaternary ammonium group. Because of severe eye irritation they are rarely used in cosmetics and toiletries. Their largest use is in fabric conditioners such as Comfort™ or Lenor™, but they are also used for cleaning and disinfecting culinary equipment in restaurants and hospitals;
- non-ionic – neutral molecules; cleansing action derives from hydrogen bonding to water molecules. They are used to modify the effect of the principal cleaner, eg as viscosity builders, foam modifiers, emulsifiers; and
- amphoteric – contains both anionic and cationic groups; like amino acids, their electrical behaviour is strongly pH dependent (cationic at low pH, anionic at high pH). They are low foaming and have low irritability and are used in low eye-sting baby shampoos.

Practical work

Students could investigate the various different types of detergent through practical work. Knowing that soap is anionic, the types of detergent (anionic, cationic or neutral) could be determined by mixing different detergent solutions to see which mixtures give a precipitate.

The following could also be tried:

- testing the detergents with a variety of inorganic anions and cations to find out if any produce a precipitate;
- electrolysing solutions of detergent in a U-tube. Foaming should occur round the anode for the anionic detergent and round the cathode for the cationic detergent; and
- changing the pH of the detergent solutions (by using buffers) to investigate how this effects their electrical properties.

This could be set as a practical problem-solving exercise, eg given samples of various detergents, determine the principal type of detergent molecule present in each.

Practical results

Superdrug ‘Satin Concentrated Fabric Conditioner’ was tested, as its label showed that it contained only cationic surfactants (15–30 % by mass). Many conditioners contain non-ionic in addition to cationic surfactants. A little of it was mixed with each of the following.

Radion™, a concentrated clothes wash detergent. It contains <5 % nonionic and 5–10 % anionic surfactants. This produced a granular looking scum which floated to the surface in a few minutes.

Persil™ washing-up liquid. It contains >30 % anionic surfactant. This produced a smooth creamy scum which rose slowly to the surface.

Radion™ and Persil™ mixed together gave no visible change. Tesco ‘concentrated lemon dishwasher liquid’ was also tested. This gave a granular looking scum. However, its cleansing action is different as it contains no surfactant – it cleans by brute force! It contains:

phosphate 15–30 %
sodium silicate 15–50 %
sodium carbonate <5 %
sodium hypochlorite <5 %
sodium hydroxide <5 %
perfume <5 %
soap <0.2 %.

This formulation demonstrates why the instructions state that this brand is unsuitable for delicate crockery and why repeated washing of glass erodes the glass giving it a matt finish – at a high temperature the strongly alkaline liquid dissolves the sodium silicate content of the glass.

Detergency

Explain the following observations.
A problem arose when the reservoir of a car windscreen washer was refilled with water and detergent. Sometimes a mushy jelly-like solid was produced which blocked the jets. This only happened when a partly full reservoir was topped up with fresh water and detergent.

On laboratory investigation, it was found that the solid was produced only when certain detergents were mixed together; other combinations presented no problems. It made no difference whether the water was hard or soft, hot or cold. This problem gives little information.

To solve it textbooks will probably have to be consulted to find out detailed information about detergents. You should refer to any sources of information that you think might help such as your notebooks, textbooks and data books. Ask for assistance if you get stuck.