Research Article

Teaching Primary Science and Technology
Shower Gel Manufacture

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During the production of a science INSET programme for primary teachers, at the Open University, UK, the 'Shower gel' project was developed with staff at Unilever Research, Port Sunlight Laboratory, UK. Since then, the project has been used extensively with primary teachers on science Continuing Professional Development (CPD) courses, as well as students ranging in age and abilities from junior children to adult learners. All participants agree the project is stimulating, interesting and fun. Here, the project is described, including some background science and the technical details are included. If you want to try it, perhaps you might contact science colleagues at a nearby High School for materials and support(!!), or the Department of Primary Education at the University of Malta.

Project brief - the problem
You are in the research and development laboratory of a medium-sized company that sells personal washing products (soaps, shampoos, etc.). The company's marketing department has recently received information that one of your main competitors is test-marketing a new shower gel in a small area of the UK. They are concerned that your sales of soap will drop when the competitor's product is launched nationally. They have obtained a sample of the competitor's product and want you to develop a shower gel that is similar in appearance and properties so that you can rapidly respond with a 'counter-attack', by selling a new gel product alongside your soap. Your current customers may then stay loyal to your brand, and buy your gel for the shower as well as soap for the bathroom. Your company has a basic mixture, or formulation, for a gel product that was developed in this way - a basic formulation is produced but is not marketed at the time. They are often covered by patents, and hence become useful starting-points for new products in the future. The new product should be based on this basic formulation.

Whilst you are developing your new gel product, the marketing department will conduct trials to determine the perfume and colour for the new product. You will need to consult them before finalising your product.

While this investigation could be part of a broader topic exploring the science of soaps and detergents, this activity alone provides a stimulating and interesting session that could also be used to explore school-industry links or properties of materials within the classroom or as part of a CPD session for either primary or secondary teachers. Start where the individual is, and offer different levels of input to meet individual needs. Children can identify with the issue as can teachers on a CPD course. Work can be completed at novice or expert level. What is important is that individuals are given the opportunity to learn a great deal from the experience - both in terms of scientific problem solving and experimentation, coming to appreciate concepts important in chemistry as well as issues important to the chemical industry.

(CAUTION - Eye protection and rubber gloves must be worn when handling the shower gel ingredients and when testing the final product.)

Making a shower gel
The basic mixture of a shower gel comprises:
(i) surfactant and co-surfactant - these are the cleaning agents: the surfactant causes the lather, and the co-surfactant prevents too much lather forming
(ii) pH adjuster (citric acid solution) - body products need to be adjusted to give a pH of between 6.5 and 7
(iii) salt (sodium chloride) - this is used as a thickening agent in detergents
(iv) preservative (usually formaldehyde)
(v) water (deionized) to dilute the basic mixture.

The tasks are: (a) to develop a method of making and testing gels from a given formulation, optimising the amount of salt required to produce the required viscosity; (b) to finalise the details of the gel product, which includes deciding on its colour and perfume; and (c) to research and develop a marketing campaign for the product.

At this point encourage planning. Think about equipment, method and recording results. The best way of making a batch of gel is in a container or glass beaker, using a simple stirrer, such as a lollipop stick. For initial experiments, samples can be made either in a test-tube or in a small beaker, provided the weighing is accurate. From this, the most promising formulations can be found for manufacture on a larger scale.

A basic gel formulation for testing can be made simply by using surfactant, co-surfactant, water and salt. At this stage there is no need to add pH adjuster or preservative. An appropriate amount of basic formulation made initially can be say 100 cm^3. This formulation should consist of 13% surfactant, 2% co-surfactant, with the remainder being made up of deionized water. To this is added a small amount of salt to obtain a gel of the required viscosity. The task is to use this basic formulation to achieve the gel with the necessary properties.

At this stage, input can be at different levels depending on the starting point of the students. Advice can be given relating to appropriate quantities of salt, experimental technique, collaborative work, type of equipment available, and so on depending on the planned outcomes to be achieved. Questions can be asked relating to the stability of the viscosity, its measurement and even the viscosity of competitor products. However, students should be alerted to, and be able to provide a response for the question

"As they continued to add salt to the mixture, what did they notice about its viscosity?"

They should have noticed that the increase in viscosity can be quite sudden (it may vary slightly depending on the composition of the basic formulation): a little less than 4% salt by mass should give about the right viscosity - above this level the viscosity will start to reduce again. For many students, this is unexpected. Their predictions support the idea that the mixture will become increasingly viscous - and this often leads them to check and question their experimental technique.

Once the optimum amount of salt for the gel has been established, two other factors need to be considered. Commercial shower gels often contain a colouring agent and usually some perfume. To finalise the product, various food colourings and perfumed oils can be used to colour and perfume the gel. However, the marketing department needs to be consulted before making the final decision on colour and perfume.

The viscosity of the gel needs to be checked after adding colour and perfume and the amount of salt adjusted if necessary. The pH of the product can also be checked at this point.

The research department of a company has the responsibility of developing the shower gel. However, it cannot work in isolation. Since the product needs to be a commercial success it has to meet customer demands, and the research and development section of the company needs to know these requirements before finalising the formulation of the product. Input from other departments can be considerable in terms of: colour and perfume of product; design and packaging for the product; advertising campaign; and cost of final product. The scientists and chemical engineers need to be aware of these different aspects to development.

There are many different opportunities for students to get involved in thinking about the 'human and commercial' side of science and working in a collaborative way gives meaning and purpose to their project.

Why the viscosity increase?

The surfactant molecule consists of two different parts: a water-loving, or polar part, and a water-hating, or non-polar part. These parts absorb strongly at water/oil interfaces since the polar part can be surrounded by water while the non-polar part resides in the oil. Solutions of highly active surface molecules (that is, detergent solutions) exhibit unusual physical properties. At some concentrations, surfactant molecules aggregate to form structures known as micelles. In these aggregates the (water-hating) hydrocarbon tails lie towards the centre, while the water-soluble polar ends are at the surface of the micelle.

Most surfactants for small micelles of approximately spherical or ellipsoidal shape that contain roughly 40 to 200 molecules. However, if the solution's conditions, such as pH, temperature or electrolyte concentration, change, then the size and shape of the micelles are altered.

Thus surfactants can cluster into a variety of structures in aqueous solutions - and these can transform from one to another as the solution's conditions change. Adding salt to the basic shower gel formulation changes the structure of the micelles. The higher the viscosity, the larger is the structure. As salt continues to be added, the structure becomes unstable and breaks down. This has the visible effect of reducing the viscosity of the solution.

Notes

1. The surfactant should be diluted from 70% paste to a 25% w/w solution in water for ease of handling.
2. The co-surfactant should be available as a 30% w/w solution in water.
3. If citric acid is used, use saturated citric acid solution so that the concentration is the same each time.
4. A basic formulation for testing can be made simply by using surfactant, co-surfactant and salt.
5. When an approximate sale quantity has been established, it is better to add it as a solution since it mixes better. Remember that the water quantity must be adjusted accordingly.
6. If EMGS is used it must be molten to disperse effectively in the surfactant system.
7. To calculate the amount of water to add, the amount of water already in the product as a result of the other raw materials needs to be

Technical details - shower gel formulation

Surfactant (sodium lauryl ether sulphate, 3 EO) EMPICOL 0251/7	% by weight as pure material
Co-surfactant (amine oxide) EMPIGEN OB	Up to 6%
pH adjuster (citric acid solution)	To give pH 6.5-7.
Opacifier either ethylene glycol monostearate (EMPILAN EGM)	at 2%
or euperlan PK771	at 4%
Salt (sodium chloride)	As required for thickening
Preservative (formaldehyde)	0.1%
Water (deionised)	Balance to 100%

calculated and this quantity deducted from the total water required.

If required, students can obtain technical brochures and safety data sheets from the suppliers of the raw materials, along with the current cost of raw materials.

Handling and safety

1. Eye protection, gloves and laboratory coat are advised when handling the shower gel ingredients.
2. The final product should only be tested when wearing rubber gloves.
3. All products should be disposed safely.