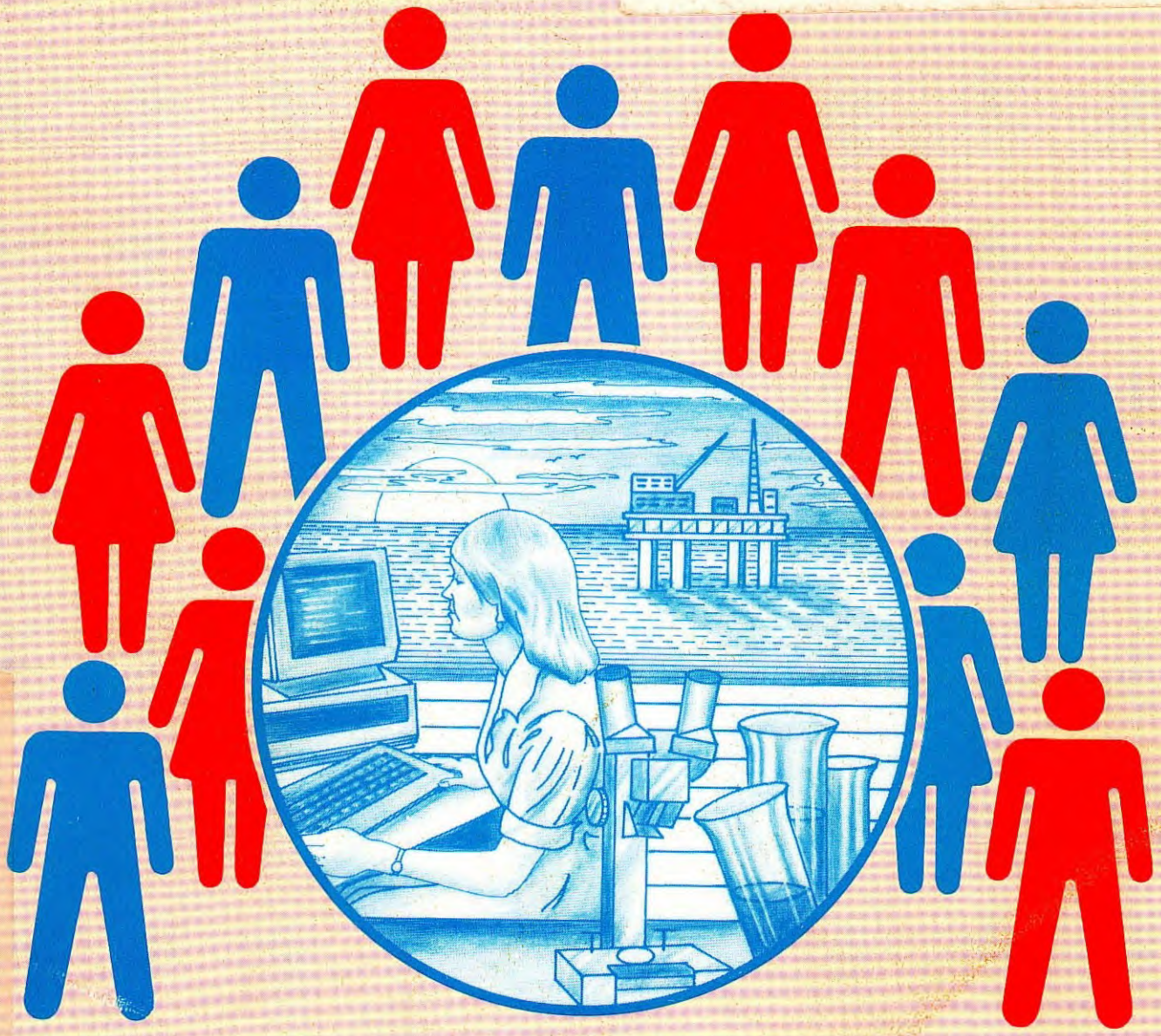
SCIENCE & TECHNOLOGY IN SOCIETY

1



SATIS

ABOUT SATIS

Science and Technology in Society units are designed to be used in conjunction with conventional science courses, particularly those leading to GCSE examinations. Each unit has links to major science topics as well as exploring important social and technological applications and issues.

The units are self-contained and generally require about 2 periods (around 75 minutes) of classroom time. Each unit comprises Teachers' Notes (blue sheets) and Students' materials (white sheets). Full guidance on use is given in the Teachers' Notes accompanying each unit, which also include background information and suggest further resources.

Each SATIS book contains ten units. The units are numbered in a system giving the number of the book followed by the number of the unit within that book. Thus the first unit in the first SATIS book is numbered 101.

In addition to the SATIS books, a General Guide for Teachers is available, giving guidance on some of the teaching techniques involved as well as ideas for further activities.

Many people from schools, universities, industry and the professions have contributed to the writing, development and trials of the SATIS project. A full list of contributors appears in the General Guide for Teachers.

First published 1986 by The Association for Science Education
Reprinted 1987

SATIS 1

List of units in this book

Sulphurcrete

Contents: Reading, questions and experimental work on the use of sulphur as a building material.

Time: 2 periods.

Intended use: GCSE Chemistry and Integrated Science courses. Links with work on the properties, structure and allotropy of sulphur.

Aims:

- To revise and complement prior work on the properties, structure and allotropy of sulphur.
- To develop awareness of the importance of the recovery of sulphur from fuels as a measure for the control of acid rain.
- To show the dependence of choice of materials on the properties of those materials, to illustrate the search for new and better materials, and the ability of chemists to modify the properties of materials.
- To develop awareness of the need for careful use of resources.
- To provide an opportunity to practise reading and comprehension skills, and certain laboratory skills.

Requirements: Students' worksheets No. 101. For laboratory requirements, see below.

This unit follows on well from work on the allotropy of sulphur. If time is short, the practical work could be omitted, though students gain a good deal of satisfaction from making and testing their own sulphur concrete.

Requirements for experimental work

Each group of pupils will require:

3 hard-glass test tubes
a small metal container – an old crown bottle-cap is ideal, but the plastic inner liner must first be removed by heating
spatula
tongs
test tube holder
tripod, gauze, bunsen
access to pliers
access to fume cupboard
safety spectacles
clean sand
powdered roll sulphur
dilute hydrochloric acid
a small piece of ordinary concrete (for example, a chip off a concrete paving slab)

The sulphur must be heated *very* gently, otherwise it will ignite. The molten sulphur must *not* be allowed to reach the red, viscous stage – this will happen if it is heated too strongly.

Notes on some of the questions

Q.2 Acid rain has harmful effects on forests and fish in particular, and many forms of life in general. It damages buildings, particularly when these are made of limestone. However, the acid rain problem is extremely complex, and not all these effects are directly attributable to sulphur dioxide emission.

Q.7 The students' sulphur concrete is likely to be hard, but more brittle than ordinary concrete.

Qs.8,9 Sulphur concrete, unlike ordinary concrete, does not react with acid. This has led to its use in chemical works, particularly where acid is involved.

Q.10 After a few days, sulphur concrete tends to become yellow and powdery on its surface.

Q.11 The brittleness of sulphur concrete is due to the crystallization of monoclinic sulphur, which later changes to the rhombic form. This crystallization can be prevented by certain additives, for example, dicyclopentadiene. Such additives disrupt the regular shape of the S_8 rings, making crystallization more difficult.

Q.12 The reversion of plastic sulphur to the hard solid form is due to the crystallization of the S_8 molecules which remain in considerable numbers even in the plastic form. Later, the long-chain polymers which give the sulphur its plasticity slowly revert to S_8 rings. Certain additives can prevent the crystallization of the S_8 form and also ensure that the polymeric form persists, giving a permanent plastic sulphur.

Q.14 Teachers might wish to explore the question of whether it is wise to use such an indispensable raw material as sulphur as a building material.

Q.15 There are of course many examples, such as the use of plastic instead of metal for buckets, drain pipes, etc.

Extension work

If time permits, teachers might like to attempt some more open-ended investigations of sulphur concrete. For example:

1 Try making sulphur concrete with different proportions of sand and sulphur. Devise a method for testing the concrete and so find out the mixture which gives the strongest product.

2 Try comparing the strength of sulphur concrete and ordinary concrete:

Make a beam-shaped mould about 2cm × 2cm × 10cm and line it with aluminium foil. Use an old tin to make sulphur concrete on a larger scale and cast it in the mould.

Re-line the mould. This time make normal concrete from cement (1 part) and sand (5 parts) mixed in an old yoghurt pot with enough water to give a creamy paste. Pour this into the mould and leave to set overnight.

Devise a method for comparing the strength of the sulphur concrete and concrete beams.

Acknowledgement Figures 1 and 4 supplied by The Sulphur Institute, Washington DC.

SULPHURCRETE

Part 1 Introduction: Sulphur and sulphur concrete

Read this, then answer questions 1 to 4.

You have probably seen sulphur and investigated its properties. You may have looked at the way sulphur's properties change when it is heated. But can we *use* sulphur in any way?

You may well know that a lot of sulphur is used to make sulphuric acid. But you might be surprised to discover that sulphur can also be used as a *building material*. In this unit of work you will find out why.

The story starts not with sulphur, but with coal and oil. These fossil fuels contain a lot of sulphur compounds – crude oil from the Middle East contains particularly large amounts of sulphur. When the fuels are burned, the sulphur turns to sulphur dioxide. Sulphur dioxide is an acid gas, and if it is allowed to get into the air, it causes pollution. Sulphur dioxide made by burning fossil fuels is one of the main causes of acid rain.

For many years, oil companies have had to 'recover' sulphur from crude oil before the oil can be used. As society becomes more concerned about acid rain, more and more sulphur is likely to be recovered from fuels, and from the chimneys of power stations where the fuels are burned. This means that more and more sulphur is becoming available, and sulphur has become quite cheap. For example, between 1968 and 1972, the price of sulphur fell from $70 a tonne to $6 a tonne. In Canada alone, stockpiles of sulphur increased from 3 million tonnes in 1970 to 25 millions in 1980.

All this is more than enough sulphur for making the sulphuric acid we need, and for other traditional uses of sulphur. Scientists and industrialists began to wonder if sulphur could be used for other things. So they began to explore sulphur's possibilities as a building material. They have found that sulphur can be used to make a kind of concrete. One of the trade names for this sulphur concrete is **Sulphurcrete**. Sulphur can also be used to make flexible surface coatings to protect fabrics.

Questions

1 *Why do oil companies have to recover sulphur from crude oil?*

2 *What kind of problems are caused by acid rain? (You may need to talk to your teacher about this, or consult a book.)*

3 *Why is more and more sulphur becoming available for us to use?*

4 *If you have done some experiments with sulphur, you will know it can exist in different forms. Which form would be most useful for:*

   (a) Making sulphur concrete,
   (b) Making surface coatings for fabrics?

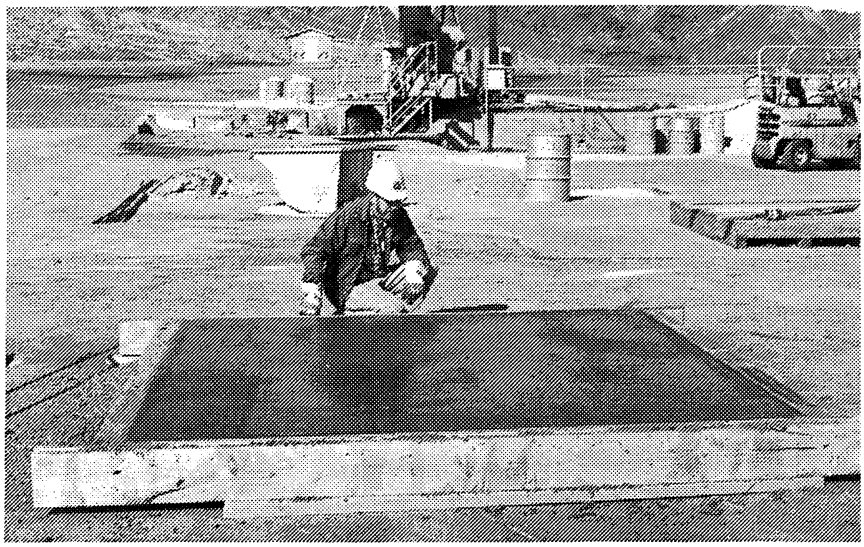


Figure 1 A slab of sulphur concrete

Part 2 Experiment

Making sulphur concrete

In this experiment you will be making a sample of sulphur concrete. In ordinary concrete, particles of sand, gravel and stone, called aggregate, are held together by cement, as shown in Figure 2.

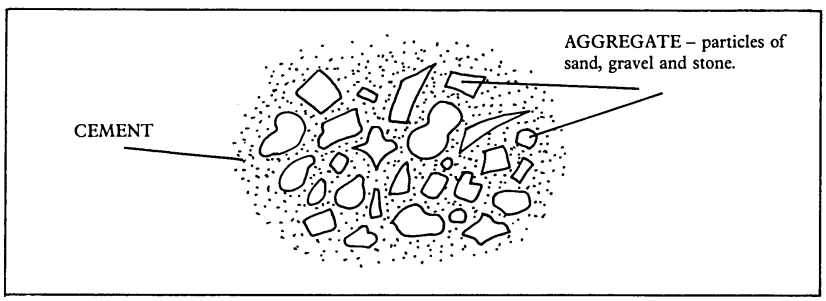


Figure 2 Concrete

In sulphur concrete, the aggregate is held together by sulphur instead of cement. The sulphur must first be melted before it is mixed with the aggregate. The aggregate needs to be warm, so the sulphur does not set too quickly.

What you do

Read the following detailed instructions before you start.

CAUTION – Sulphur sometimes catches fire when it is heated, burning with a blue flame. An unpleasant, choking gas, sulphur dioxide, is given off by burning sulphur. Work in a fume cupboard, and if your sulphur does catch fire, put it out at once by smothering. Wear safety spectacles throughout the practical.

A Half fill a hard-glass test tube with clean sand.

B Fill a small metal container with powdered sulphur. An old crown bottle-cap is ideal, but you must make sure the plastic seal has been removed. Put the container of sulphur onto a gauze resting on a tripod.

C Now heat the sulphur VERY, VERY GENTLY using a small bunsen flame, until the sulphur *just* melts. It should become a runny yellow liquid. Stop heating as soon as this happens.

D Take away the bunsen from under the sulphur and use it gently to warm the sand in the test tube. You will need to work quickly, otherwise the sulphur will have solidified before you finish.

E Carefully pour the warm sand into the molten sulphur. The liquid sulphur will soak into the sand. Go on pouring until all the liquid sulphur is soaked up. You have now made liquid sulphur concrete. Figure 3 summarizes the procedure.

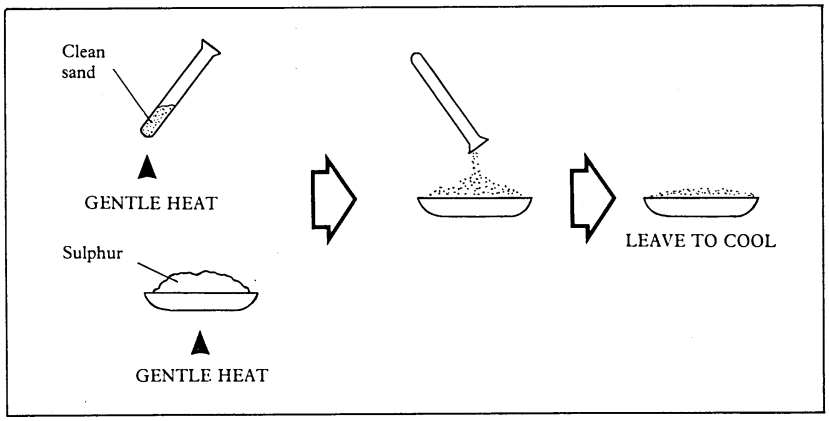


Figure 3 Making sulphur concrete

F Leave the sulphur concrete to solidify and cool.

G When the sulphur concrete is cool, remove it from the container. To do this, you will probably have to bend the container using pliers. The sulphur concrete will break, but this does not matter.

H Examine your sulphur concrete. Compare it with a piece of ordinary concrete.

I Put a piece of sulphur concrete and a piece of ordinary concrete into two separate test tubes. Add a little dilute acid to each. Observe what happens.

J Examine your piece of sulphur concrete after a few days. Has it changed?

Answer questions 5 to 10.

Questions about the experiment

5 *Why was it important to heat the sulphur very gently?*

6 *Why did the sand have to be warmed before adding it to the sulphur?*

7 *How does sulphur concrete compare with ordinary concrete for hardness?*

8 *How does sulphur concrete compare with ordinary concrete for resistance to acid?*

9 *Why is sulphur concrete sometimes used instead of ordinary concrete in chemical factories, particularly where acid is used?*

10 *What changes happened to your sulphur concrete when it was left for a few days?*

Part 3 Sulphur as a building material

Read this, then answer questions 11 to 15.

You have just made sulphur concrete. You will have found that, unlike ordinary concrete, sulphur concrete does not react with acid. For this reason it is used for floors and walls in chemical factories where acid is likely to get spilt. It is also used to make parking kerbs, lamp-post bases, etc.

However, you may have noticed that although your sulphur concrete was hard, it was also brittle. This is because the sulphur crystallizes into a brittle form, similar to the sulphur before you melted it. Chemists have found that certain substances can be added to sulphur to stop it crystallizing. This helps to make the sulphur concrete less brittle.

Sulphur can also be used to make a flexible coating for fabrics. For this purpose, the normal, solid form of sulphur would be far too brittle. But if you have investigated the different forms of sulphur you will probably remember what happens to sulphur when it is heated strongly, then cooled by pouring into cold water. It forms a flexible, rubbery solid called plastic sulphur. Unfortunately, plastic sulphur quickly turns back to its hard, brittle form. But chemists have once again found substances that can be added to the sulphur to keep it in its plastic form. In this form it makes a flexible, acid-resistant coating.

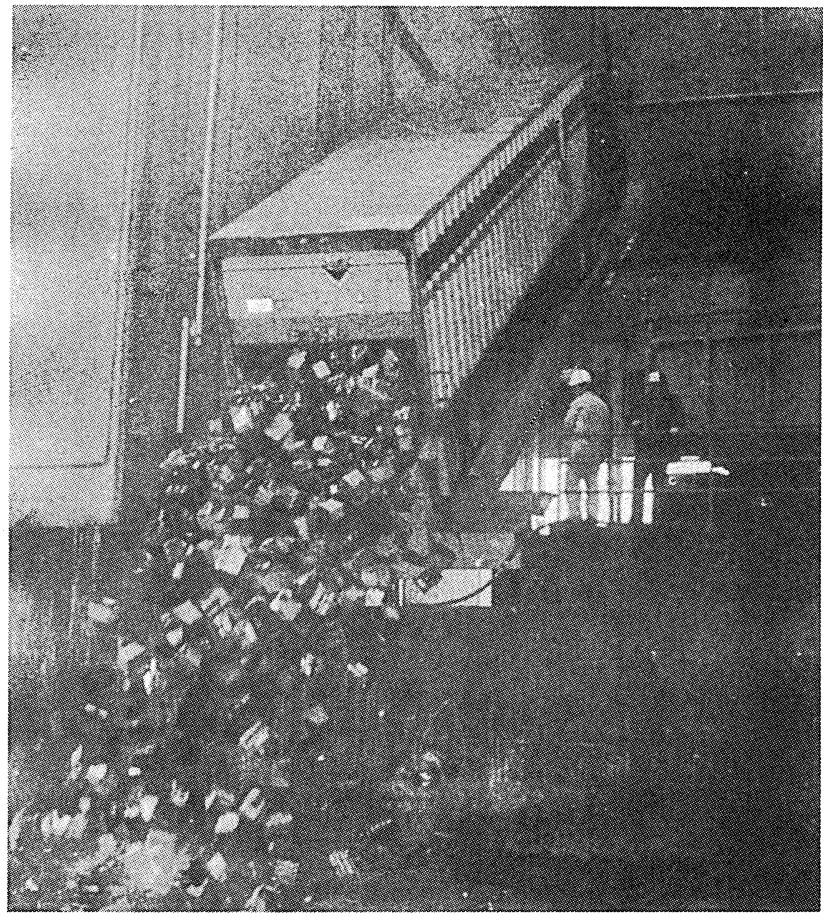


Figure 4 Tipping used car batteries onto a sulphur concrete floor

Questions

11 The sulphur concrete you made was brittle. How have chemists managed to overcome this problem?

12 Why is ordinary plastic sulphur on its own not suitable for coating fabrics? What can be done to overcome this problem?

13 Figure 4 shows used car batteries being tipped onto a concrete floor in order to break open the casing. Why is sulphur concrete particularly useful for making this floor?

14 Sulphur concrete is a useful building material. But sulphur is also an important raw material. It is particularly important for making sulphuric acid. What problems might there be if we use more and more sulphur concrete?

15 Scientists and industrialists are always interested in new materials that may be cheaper and better than traditional ones. What other examples can you think of?