

RS•C

Part 3

Manufacturing sodium carbonate

Material for 14–16 year old students

Manufacturing sodium carbonate

You might be surprised to find that a million tonnes of sodium carbonate is made and sold in the UK each year. This is about 20 kg (20 bags of sugar) for every man, woman and child in the country. However, it is unlikely that you or your family have bought any at all, although a few people might find a small packet of 'washing soda' under the sink. This is sodium carbonate and is still used by a few people to soften water or to help clean the oven or the drains. You will have used sodium carbonate indirectly, though, as 90 per cent of it is used to make glass.

Question

1. Make a list of at least 10 things you have used or bought in the last week which use glass. You can probably think of lots more than 10, so try to make your list as varied as possible.

All the sodium carbonate made in the UK comes from one company – the Brunner Mond company based in Northwich in Cheshire. The company makes sodium carbonate from limestone (calcium carbonate, CaCO_3) and salt (sodium chloride, NaCl) using coke (made from coal) as a fuel. The map in *Figure 1* shows where these raw materials are found.

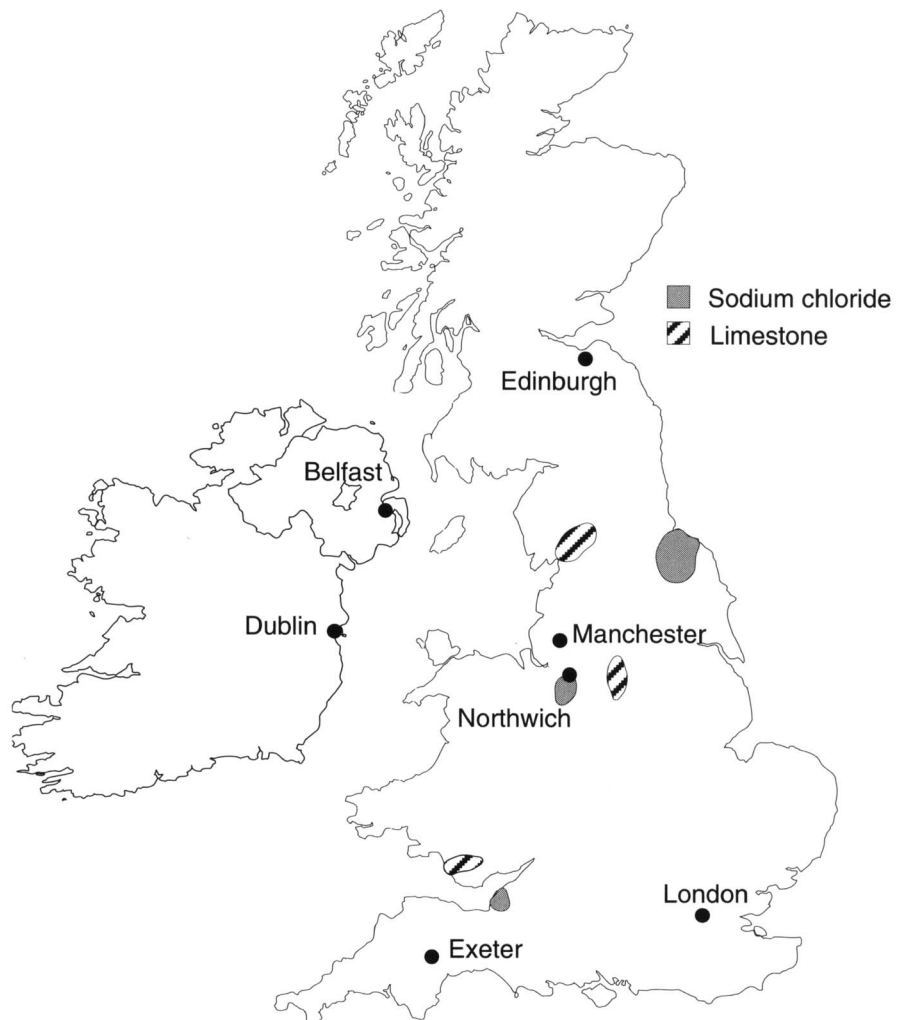


Fig 1 The locations of some mineral deposits in the UK

Figure 2 shows some of the uses of sodium carbonate as well as those of the two raw materials.

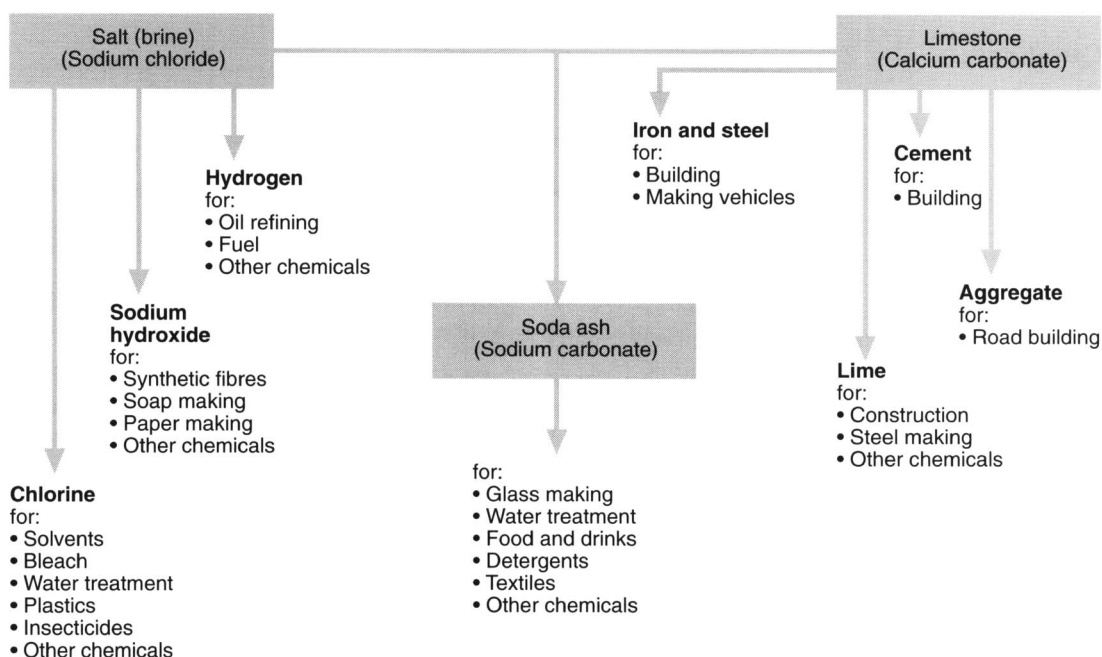


Fig 2 Uses of salt, limestone and sodium carbonate

The manufacture of sodium carbonate is an important use of both salt and limestone.

Salt deposits are found underground, and salt is obtained as brine by 'solution mining' in which water is pumped down a bore hole into the salt beds. It dissolves some of the salt to form brine which is brought to the surface.

Limestone is extracted from quarries.

Questions

2. Look at *Figure 1*. Why do you think that the manufacture of sodium carbonate is based in Northwich in Cheshire?
3. (a) Which ions are present in the compound sodium carbonate, Na_2CO_3 ?
- (b) The two raw materials used for making sodium carbonate are sodium chloride and calcium carbonate. Which ion is supplied by which raw material?
4. Compare the environmental impact of the different methods used for extracting salt and limestone.

Unfortunately sodium chloride and calcium carbonate do not react directly with each other. However, a sequence of reactions can be used to achieve the same overall result. This sequence can be represented by the equations below.

- (a) $\text{calcium carbonate} \xrightarrow{\text{Heat}} \text{calcium oxide} + \text{carbon dioxide}$
- (b) $\text{calcium oxide} + \text{water} \rightarrow \text{calcium hydroxide}$
- (c) $\text{sodium chloride} + \text{ammonia solution} + \text{carbon dioxide} \rightarrow \text{ammonium chloride} + \text{sodium hydrogencarbonate}$
- (d) $\text{calcium hydroxide} + \text{ammonium chloride} \rightarrow \text{calcium chloride} + \text{ammonia} + \text{water}$
- (e) $\text{sodium hydrogencarbonate} \xrightarrow{\text{Heat}} \text{sodium carbonate} + \text{carbon dioxide}$

The raw materials and products are underlined.

Questions

5. Which two reactions are examples of decomposition?
6. Comment on the role of ammonia in the overall process.
7. Name a by-product of the process. A by-product is one which is produced by the process but is not really needed.

Even though the ammonia does not get used up in the overall process, it is necessary to top up the supply from time to time.

The process also uses coke (essentially carbon) which is burned in a kiln along with limestone to decompose the limestone into carbon dioxide and calcium oxide. The carbon dioxide is used in reaction (c) and the calcium oxide is 'slaked' with water to produce the calcium hydroxide used in reaction (d).

Questions

8. Reaction (d) is not a vital part of the production of sodium carbonate as you can see by looking at the reactants and products.
 - (a) Why do you think that the reaction is carried out?
 - (b) Could the calcium hydroxide and ammonium chloride be sold as by-products instead of the calcium chloride? What factors determine whether this is an economically sensible alternative?
9. What is the main purpose of the coke in the furnace with the limestone? (Use the words exothermic and endothermic in your answer.)
10. What additional role is played by the combustion of the coke?