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Briefing: Gypsum: prospects for recycling

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The term gypsum is used to refer to three main compounds of calcium sulphate: anhydrite, hemihydrate and dihydrate; but it is most often used for the dihydrate. The two main industrial uses of these compounds are in cement and in plaster products. Cement producers use a blend of gypsum and anhydrite as a set controller. Plaster is made with hemihydrate. This material is used both for bagged plaster and also to feed the plasterboard production lines. The materials are available from both primary and secondary sources. Waste plasterboard is an increasingly important secondary source but there are a number of problems which limit the proportion of this material that can be used in plasterboard production. Research is therefore in progress to find other uses for it, such as low-strength concrete mixes.

The term 'gypsum' is used loosely to refer to three main compounds of calcium sulphate. With no water molecules the material is called anhydrite (CaSO_4). This naturally occurring mineral, which is found in many countries, has been used, for example, for rural road construction. If a small amount of combined water is present the compound is known as hemihydrate ($\text{CaSO}_4 \cdot 1/2\text{H}_2\text{O}$). When fully reacted with water the dihydrate is formed, and this is the compound that is correctly described as gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). Gypsum is also found as a mineral deposit. Both anhydrite and hemihydrate have several different forms with different properties, but in general, if anhydrite is mixed with water, it will slowly hydrate to gypsum whereas hemihydrate reacts quickly. Gypsum will not react with water, but it is slightly soluble. If the dihydrate (gypsum) is heated (calcined) it may form hemihydrate, or further heating may produce anhydrite.

The two main industrial uses of these compounds are in cement and in plaster products. Cement producers use a blend of gypsum and anhydrite as a set controller. This material is added at the cement clinker grinding stage, and if the ball mill runs too hot and some of the gypsum is calcined to anhydrite, problems will occur. Plaster is typically made with hemihydrate. This material is used both for bagged plaster and also to feed the plasterboard production lines. The boards set in just 4 min as they progress along the line, and they are then strong enough to be picked up and fed into the ovens. Because of increasing industrial demand, and the change to thicker

boards to improve sound insulation, industrial demand is increasing. These two users both require a relatively pure product. Plasterboard (as with all materials introduced into the domestic environment) has to be kept completely free of any potentially harmful substances.

Both gypsum and anhydrite are mined, and in the UK the cement and plaster industries both use some material from this source. There are also very significant sources of synthetic gypsum.

The largest source is now flue gas desulphurisation at power stations. Much of the coal that is burnt for power generation in the UK has a high sulphur content, and the resulting sulphur in the flue gases reacts in the atmosphere to produce acid rain. In response to this, many power stations now treat the gas with lime, which extracts the sulphur and produces gypsum. In the longer term they may adopt the alternative solution of burning low-sulphur coal, which is available from some areas such as parts of Australia, but for the immediate future they are producing very large quantities of high-purity gypsum.

Other industrial sources include phosphogypsum (from the fertiliser industry) and titanogypsum from the titanium dioxide (white pigment) process. The titanium dioxide process produces some clean gypsum, but it also generates larger quantities of contaminated material. Contamination is also a common problem with other sources, such as spent casting cores.

Waste plasterboard is also now a significant source. This board arises from production rejects and also from site cutting waste, which varies from 10% to as high as 25% of the board supplied. This waste board is no longer permitted in mixed landfill above a certain proportion, because the sulphates may react with organics (possibly the paper on the board) to form hydrogen sulphide. A limited number of special cells have been built in landfills for sulphate waste, and there is also a controversial exemption for mixed loads with less than 10% sulphate, which may be encouraging 'dilution' of loads at waste transfer stations.

In theory, waste board can be fed back into the calciner and used to make more board. Several paper-stripping plants have been constructed for this, and they are processing significant quantities, but they face three problems.

- (a) **Contamination.** Site operatives rarely take care to segregate the waste effectively. Also, foil-backed board and some types of water-resistant board cause problems.
- (b) **Quantity.** There is a practical limit to the proportion of recycled board that the process can take. This is due partially to the accumulation of the admixtures that are used to control the process, although theoretically almost 100% recycling could be possible.
- (c) **Location.** In the UK there is unfortunately no effective arrangement for manufacturers to take back board that

they did not produce, so it may have to be carried hundreds of miles to reach a plant run by the appropriate company.

The UK is therefore now in the position where it is a significant importer of gypsum (both natural and synthetic) while also facing a disposal problem. The disposal problem is becoming more severe because of new regulations restricting use as a soil conditioner. The authors' current research is aimed at new applications for contaminated material, such as low-strength concrete mixes.

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