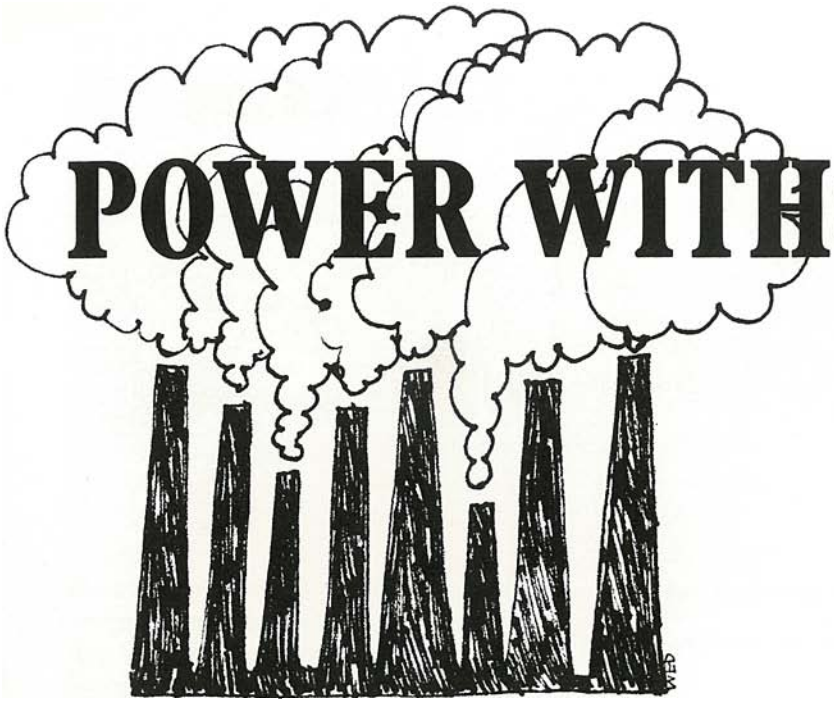


POWER WITHOUT SMOKE

In mainland Australia we generate most of our electricity by burning pulverized coal, so we burn a lot of it—some 33 million tonnes annually in fact. This produces about 3 million tonnes of ash, much of which is in the form of a light-grey dust known as fly-ash.

TEA increased the efficiency of the electrostatic precipitators from 86% to more than 99·5%.

If all this fly-ash were to pass up the power station chimneys, it would emerge as billowing plumes of greyish smoke that would settle on the countryside for miles around. To avoid this, our coal-burning power stations are provided with electrostatic precipitators that remove nearly all of the fly-ash from the smoke before it enters the chimney.

There's nothing new about electrostatic precipitators; industry has used them for years, and usually they work very well. But certain Australian coals have a reputation of being 'difficult'—they produce fly-ashes that slip through without being trapped. Thus, instead of catching more than 99% of the fly-ash, giving an almost invisible smoke, the precipitators may catch 90% or less, giving a definite plume. In fact the past experience of some State electricity authorities has been so bad that they insist on testing precipitators on a pilot scale before the final design for installation in a power station is prepared.

These days the clean air regulations of each State lay down strict limits on the amounts of dust that may be emitted from the tops of smoke stacks, so inefficient precipitators can no longer be tolerated.

About 10 years ago the New South Wales Electricity Commission approached the CSIRO Division of Mineral Chemistry for help in designing precipitators for use with some unfamiliar coals. A collaborative study revealed precipitation difficulties with some of the coals, and a research team from the Division led by Dr Edmund Potter then took up the problem.

The answer that the team came up with was to add very small quantities of triethylamine, known among the researchers as TEA, to the smoke stream before it passed through the precipitators. The very low concentration of 10 parts of TEA per million injected into the smoke stream will increase the precipitators' efficiency enough to guarantee that emissions from power station chimneys conform to the stringent State clean air regulations.

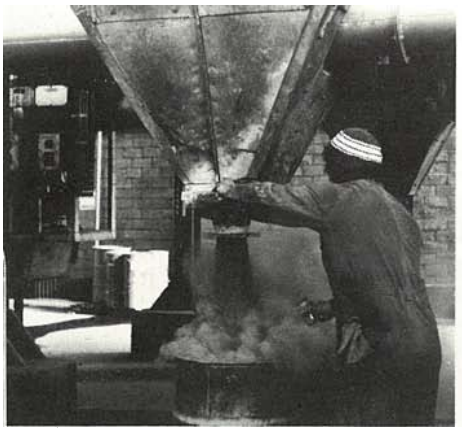
Reducing dust pollution from power station chimneys simply by adding TEA obviously has much to commend it. But the question has arisen as to whether triethylamine itself can cause pollution—even at the very low concentrations used.

Queries about its use have centred on three features—the idea that it may react with nitrous acid in the smoke stream to form a carcinogenic nitrosamine, its smell, and the fear that it may pollute watercourses when it dissolves off fly-ash particles dumped in lagoons.

No nitrosamines

A quick look at the chemistry of TEA will show that, being a tertiary amine, it is very unlikely to react with nitrous acid in the smoke stream to form a nitrosamine. One class of amines—the secondary amines—may, but there is no validated record of tertiary amines such as triethylamine doing so.

To make sure, Dr Potter and his colleagues tried to detect nitrosamine in fly-ash that had come from a smoke stream into which 35 p.p.m. of TEA had been injected. They didn't detect any. In addition, in a laboratory experiment they tried passing a gas mixture that contained no less than 17 000 p.p.m. of TEA as well as nitrous acid through a fresh, uncontaminated bed of fly-ash at 220°C—the temperature at which precipitators often operate. From this concentrated mixture the researchers were able to detect only one part of nitrosamine per million. Thus it seems that only extremely low levels of nitrosamine, if any, could be formed if only



Fly-ash being emptied from an electrostatic precipitator.

A coal-burning power station near Sydney.

10 p.p.m. of TEA were injected.

As to the smell of this additive, Dr Potter has been using it in his test rig at the Division's North Ryde laboratory for more than 2 years—at times with smoke stream concentrations of up to 100 p.p.m. He has never received complaints about TEA's ammonia-like smell. He didn't receive any complaints either when it was used in a power station belonging to Southern Portland Cement Pty Ltd at Berrima in New South Wales. In addition, unlike some amines, TEA does not cling to an operator's skin and clothes, and there have been no complaints on that score.

Anyway, Dr Potter points out, very little of the 10 p.p.m. of TEA normally injected into the smoke stream is likely to emerge from the chimney top, since the gas reacts with sulphur oxides in the smoke to become a solid, odour-free salt that sticks to the fly-ash particles remaining in the precipitators.

He cannot be quite so sure that the triethylamine salt attached to the fly-ash particles doesn't wash off fly-ash dumped in lagoons, especially as the salt dissolves in water. Fly-ash particles from smokes to which 10 p.p.m. of TEA have been added can contain up to 250 p.p.m. of triethylamine salts—that is, 250 grams per tonne.

The problem with lagooning fly-ash is that it contains a number of chemicals that are water-soluble and pollutants anyway. Some other way of disposing of it would be desirable. Some fly-ash can be used for brick-making, and to make cement go further. It fetches about $10 per tonne.

In fact TEA is not the only chemical that makes electrostatic precipitators more efficient. When Dr Potter and his colleagues began their investigations, engineers had known for some years that adding certain gases to the smoke stream increases the precipitators' efficiency. Sulphur trioxide and ammonia were known to do this, and indeed several power stations in New South Wales do add ammonia to their smoke streams. But neither gas is pleasant to handle, and sulphur trioxide does not always give the expected improvement.

Fine dust worst

Early experiments by the CSIRO research team revealed that the efficiency of electrostatic precipitators depended on the size of the dust particles they were trying to catch—the smaller the particles, the less well the precipitators worked. The team therefore looked for an additive that would make the fine ash particles stick to one another or to larger ones. The equipment would then mainly have to deal with larger particles. In this way the researchers succeeded in selecting a number of promising additives.

When tested at the low concentration of 10 p.p.m. on fly-ash derived from a particularly difficult Australian coal, TEA increased the efficiency of the electrostatic precipitators from 86% to more than 99·5%.

Hearing of these figures, the management of Southern Portland Cement suggested that full-scale tests be made on its Berrima power station. This power station burns powdered coal mined from the company's own pit nearby. Southern Portland Cement was having great difficulty with trapping the fly-ash. Tests carried out by Dr Potter and his colleagues confirmed that the precipitators installed there were barely 80% efficient, and so about 20% of the ash in the smoke stream was escaping into the atmosphere.

Dr Potter has never received complaints about TEA's ammonia-like smell.

The Mineral Chemistry team decided to compare the effects on the smoke stack of using ammonia and TEA. To conform with the emission levels set in the New South Wales *Clean Air Act*, the precipitators had to remove 98·5% of the fly-ash. At the relatively high concentration of 80 p.p.m., ammonia increased the precipitators' efficiency to 98·8%—good enough to satisfy the *Act*. But the efficiency reached 99·7% with only 20 p.p.m. TEA. Gradual reductions in the TEA concentration showed that the improvement remained good enough to pass the *Clean Air Act* regulations until the level fell to 9 p.p.m.

The Berrima factory has now ordered its own stocks of the compound, since in the long run it should be more convenient and economic to use than ammonia. The Electricity Commission of New South Wales has also asked for tenders to supply the chemical. Incidentally, triethylamine is not manufactured in Australia, but has to be imported from the major industrial countries where it is used in quantity as an intermediate in plastics manufacture.

More about the topic

Improvements of electrostatic precipitator performance by carrier gas additives and its graphical assessment using an extended Deutsch equation. E. C. Potter and C. A. J. Paulson. *Chemistry and Industry*, 1974, 532–3.