00 50599

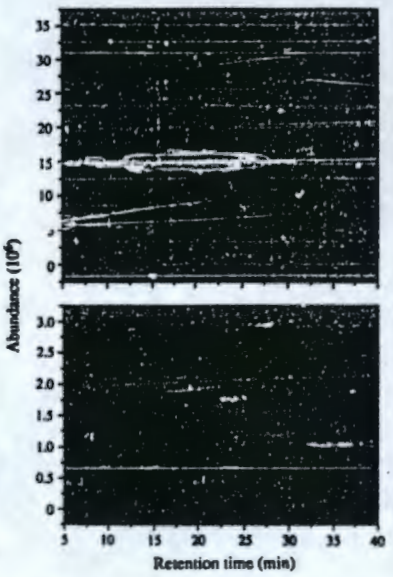
Destruction of toxic materials

SIR — Increased awareness and understanding of the hazards to health and the environment of many synthetically produced chemicals have led to the need for development of a safe means for their effective disposal. Because of their high toxicity and persistence, halogenated organic compounds and other organochlorine pesticides such as DDT, PCBs, aryl halides and dioxins are of particular concern. Current methods of disposal[1] involving high-temperature chemical reactions can be accompanied by unwanted toxic emissions or by-products, which may involve unacceptable risks to the environment. We have developed a low-temperature process[2] involving mechanochemical reactions[3] induced by mechanically milling the toxic material with a suitable reactant in a closed vessel. Such reactants may include reductants which break down the entire molecule or react selectively to remove chlorine. Laboratory measurements of the mechanochemical reaction of DDT, PCB and chlorobenzene with magnesium, calcium and calcium oxide show the destruction of the organochlorines without the formation of toxic by-products.

We milled individual samples of chlorinated organic compounds, including DDT, PCB (Aroclor 1254) and chlorobenzene with Ca, Mg, Fe or CaO as a reactant in a laboratory vibratory mill (SPEX 8000). Each test consisted of milling a total of 5–10 g organochlorine and the reactant using 12-mm diameter steel balls in a sealed steel vial. The figure shows a total ion chromatogram (TIC) from gas chromatography–mass spectroscopy (GC–MS) of compounds present after milling a sample of DDT and Mg for 3 and 6.5 h. Chlorinated break-up products and products of partial dechlorination of DDT were present after 3 h milling (*a* in the figure, retention time t = 10–30 min). Partially dechlorinated oligomer-type materials of DDT (t = 31–35 min) were also present. The presence of chlorinated compounds was not evident from analysis of the TIC from GC–MS of the sample milled for 6.5 h (*b*, t = 10–12 min). We found very small quantities (low p.p.m.) of dechlorinated products, such as diphenylmethane and diphenylethanes (inset in *b*). These compounds were not present in the DDT used for milling, so must have formed during milling.

The levels of DDT and related compounds DDD (DDT minus Cl) and DDE (DDT minus HCl) and the levels of chlorobenzene and PCB determined by dual-column gas chromatography–electron capture detection and expressed as the fraction in p.p.m. of the original organochlorine compounds remaining after being milled for 12 hours, are summarized in the table. For each reactant, the results for the three organochlorines were similar even though both the PCB and chlorobenzene were in liquid form whereas the DDT was solid. Mg, Ca and CaO were all highly effective in dechlorinating the organochlorine reactants. When Fe was used, milling for 12 h resulted in incomplete dechlorination.

The importance of mechanochemical activation is that, with suitable choice of reactants, the reaction can occur at low temperatures in a sealed environment to form safe reaction products requiring only minimal additional processing. Further, the process is based on well-established ball-milling technology and can be scaled to any size. Mobile mills mounted on road or rail vehicles may be used for on-site processing, thus eliminating the environmental hazards associated with the transport of toxic materials. CaO would be the preferred reactant because it is cheap and the reaction products can be disposed of safely.



GC–MS chromatograms of samples of DDT milled with Mg: *a*, after 3 h milling; *b*, after 6.5 h milling. Cross, diphenylmethane; circle, diphenylethane. Measurements were carried out after extraction into *n*-pentane using a HP 5890 II GC–MSD 5790 instrument fitted with a DB-5 column of 30 m length, inside diameter 0.25 mm and film thickness 0.25 μm. The carrier gas was helium at 70 kPa. The temperature programme was 40 °C for 2 min, then 15 °C per min to 310 °C and held for 20 min.

MILLING EXPERIMENTS WITH VARIOUS REACTANTS

	Remaining organochlorine (p.p.m.)		
Reactant	DDT	Chlorobenzene	PCB
Mg	4	<1	260
Ca	<1	50	1,400
Fe	36,000	280	120,000
CaO	4	7	5

Values under 'DDT' also refer to DDD and DDE.

S. A. Rowlands
A. K. Hall
P. G. McCormick
Department of Mechanical and Materials Engineering,
R. Street
Department of Physics, University of Western Australia, Nedlands, WA 6009, Australia
R. J. Hart
G. F. Ebell
Environmental Chemist Laboratory, Chemistry Centre of WA, East Perth, WA 6004, Australia
P. Donecker
CRA Advanced Technical Development, Technology Park, Bentley, WA 6102, Australia

APR 1993 RECEIVED EDMC

1. Murena, F. Famiglietti, V. & Gioia, F. *Ent. Prog.* 12, 231 (1993).
2. Australian Patent Application PL6474 (1992).
3. Heinicke, G. *Tribochemistry* (Hanser, Munich, 1984).

High Jump

SIR — Jha's note (*Nature* 365, 398; 1993) about timing devices in athletic events reminds me that two different philosophies are used in judging competitions. In the first category are running, throwing and long-jumping events, in which times or distances achieved are measured as exactly as possible by existing technology.

The second category comprises high-jumping and pole-vaulting. Here the bar is either cleared or not, and its final height is measured exactly for the record. Although the winning jumper usually clears the bar with distance to spare, he/she receives no credit for that extra distance, other than anecdotally.

We could determine the actual height cleared for the record. We could raise a curtain of laser light along and above the bar shining from one verticle support to the other, and we could measure the height cleared by recording the brief attenuation of the light as the athlete's body or clothing passes through the beam. The bar would remain as a psychological aid to the jumper, and as the traditional means of determining the winner.

But high-jumping is an especially pure, simple and human contest, free of devices aiding the jump or determining the result. Perhaps we should just leave it that way.

James Johnson
Curams Kennels, Westport, Canada KOG 1XO