Zinc Cadmium Sulphide (Fluorescent Particles) Field Trials Conducted by the UK: 1953-1964 (UC)

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4 Hazards

4.1 The Working files of TU1208 contain the very few minutes on toxicology of FP Essentially, there is no evidence that the toxicity of FP was examined in any practical way by CDEE. There is no "T" number for the compound: the absence of such a number tends to indicate that there was no formal toxicity testing at CDEE [13]. There are no records in the archives of the former Medical Division of CDEE about FP toxicity testing. There are no CDEE reports on FP toxicity.

4.2 FP is curious in that there is so little data on its toxicity and more interestingly, no earlier concern about any hazards to the general public from its airborne dissemination. This report is not concerned primarily with any hazard and it is probably sufficient to record a few brief manifestations of toxicity testing together with the references. The following verbatim passages from the 1997 US National Research Council Report, sponsored by the US Army should suffice for this [14]. They end at para 4.2.4.3.

4.2.1 Toxicokinetics and bioavailability of ZnCdS: Availability of cadmium from ZnCdS

4.2.1.1 No studies on the toxicokinetics of ZnCdS were found. ZnCdS is insoluble in water and lipids and poorly soluble in strong acids. A small number of toxicity studies (which do not meet the current standards of toxicity testing) have suggested that it is not absorbed through the skin or gastrointestinal tract (Lawson and Alt 1965; Leighton and others 1965). The subcommittee believes that the lack of solubility of ZnCdS particles together with the limited toxicity studies implies that it will not be absorbed through the skin or gastrointestinal tract and that inhaled particles are not likely to be absorbed from the lung into blood for systemic distribution. Its lack of solubility also suggests that it is highly unlikely that free cadmium ions would become bioavailable to target organs as a result of inhalation of ZnCdS. However, information is not available on whether ZnCdS might break down in the respiratory tract into more-soluble components, which could be easily absorbed into the body.

4.2.2 Toxicity

4.2.2.1 The subcommittee reviewed all available toxicity data on ZnCdS from the Army's files and from the open literature. The toxicity database on ZnCdS is limited and consists of eye irritation and dermal toxicity studies, single dose oral toxicity studies, and observations reported in a few exposed to high concentrations of the dust for 1-2 years. These data are summarised below.

4.2.2.2 Eye irritation from exposure to a phosphor mixture that consisted of 65.4% liquid cosmetic base (composition not specified) and 34.6% (≈35%) ZnCdS (Lawson and Alt 1965; Leighton and others 1965) was examined by instilling 0.1 mL of the test mixture in the eyes of adult rabbits and then observing them at 24, 48 and 72 h. The results of the experiment indicated that ZnCdS has negligible eye-irritation properties (Lawson and Alt 1965).

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4.2.2.3 Dermal toxicity resulting from exposure to ZnCdS was examined by applying the test mixture at 9.4 g/kg of body weight to 4 rabbits for 24 h. The mixture was injected under a rubber sleeve fitted around the clipped trunks of the test animals. No toxic effects were noted, and there was no evidence of dermal irritation during the 3 wk of observation after the treatment (Leighton and others 1965).

4.2.2.4 Lawson (1966) and Lawson and Alt (1965) reported on the medical use of ZnCdS for skin painting as a diagnostic tool for cancer. The compound is a phosphor whose fluorescence increases with increases in temperature. The authors used material that was composed of 59% CdS and 41% ZnS with less than 0.05% silver, less than 0.0005% nickel, and traces of halides to detect the higher temperature of blood in veins that leave a cancerous area. The phosphor was mixed into the same water-soluble cosmetic base used in the Army's toxicity studies and painted on the skin over the area of concern. A warm subcutaneous vein leaving a cancer could be clearly displayed by exposing the painted skin to UV light and observing the fluorescence of the phosphor. The authors stated that the ZnCdS phosphor was "sufficiently insoluble to be physiologically inert."

4.2.2.5 The only oral studies conducted by the Army were single-dose toxicity experiments in which rats and dogs were fed the mixture. None of the animals died at the highest doses tested, which were 10 g/kg of body weight and 20 g/kg of body weight for dogs and rats, respectively. These tests therefore indicated that the LD_{50} of the mixture - the dose that is lethal to 50% of the exposed animals - for dogs and rats was greater than 10 g/kg of body weight and 20 g/kg of body weight, respectively. Because the phosphor mixture used in the LD_{50} study contained 65.4% liquid cosmetic base and about 35% ZnCdS, the highest dose of the mixture tested in dogs and rats contained ZnCdS at 3.5 and 7.0 g/kg of body weight, respectively. To avoid physical injury from the administration of massive doses, higher doses were not administered to the animals. Thus it appears from these data that ZnCdS is not acutely toxic when given orally; that finding is consistent with the insolubility of the compound and its suspected lack of bioavailability.

4.2.2.6 No toxicity experiments of inhaled ZnCdS area available in the literature. Because the ZnCdS particles used in the Army's dispersion studies were so small, the particles could probably be inhaled and deposited in the deep lung. The lack of solubility of the particles suggests that they are not likely to be absorbed from the lung into the blood for systemic distribution. No information is available on the potential toxicity of the particles in the lung. It is also not known whether ZnCdS can be broken down by pulmonary macrophages into more soluble forms of cadmium. The Arkansas Department of Health evaluated the possible adverse effects of ZnCdS aerosol exposure from the Army's tests in White County,

Discussion

10.4 Public knowledge would have led to much disquiet even if the FP field trials had been promulgated as essentially meteorological research, unconnected with BW assessment and defence. During the period of the trials, the Cold War was extant and the needs of defence security were paramount: there was no option beyond secrecy, despite some US openness on the LAC in the early 1960s. The apparent conflict between ethics and openness in the UK on FP field trials and the LAC persisted when MRE continued the LAC-related field trials with live non-pathogenic bacterial simulants from the early 1960s until the 1970s and the closure of MRE in 1979 [2].

10.5 Debate on the ethical aspect is unending. Whether such field trials use could be regarded as ethical or whether they violated the public trust through exposure to chemicals by the government without public knowledge or content, is not further discussed in this report.

10.6 At present, parliamentary and public concern about possible hazards from FP is the major concern. It is quite clear that the US Army Chemical Corps and the UK accepted the view of the meteorological communities in the UK, US and elsewhere, that FP posed no hazard to the exposed public. This was the view originally propounded by Stanford University, who were the progenitors of FP field trials [50]. However, the operational manual, citing the cadmium sulphide element of FP as of greater toxicity than the zinc sulphide element, bases its assumptions on toxicological data on cadmium sulphide from industrial concerns in the cadmium industry. Whilst they advised that it is good practice to store and handle FP as a potentially toxic material, they asserted that there was a safety factor of 1,000-1,000,000 or more between doses which could be encountered by personnel in the neighbourhood of operations and the doses which have been experimentally demonstrated with a nearly equivalent material i.e. cadmium sulphide in the same particle size range, to be "absolutely harmless". FP aerosol experiments "may be run hundreds of times over the same populated area without subjecting any inhabitant to more than one millionth of the proven safe dosage; and the potentially toxic effects of any surface deposition of FP material produced by experimental operations are nil" [50]. All subsequent contemplations of FP hazards have not deviated from this conclusion.

10.7 On the matter of safe storage and handling aspects, it is clear that all those engaged in handling FP in bulk and operating the dissemination devices were well protected with Home Office Mark IV Dust Respirators, white combination overalls, rubber boots, thick neoprene elbow-length gloves and surgeons caps. Used clothing was washed in separate machine located in Range Section. Throughout the trials the CDEE Establishment Medical Officer undertook surveillance of all staff involved in bulk handling and source operation. This has been confirmed from medical records at CBD Sector [51]. This consisted of an annual medical examination, including chest x-ray and examination of blood and urine. At Porton, the concentration of airborne FP was found to fall below the industrial Threshold Limit Value for cadmium, at approximately 1,000 metres from the maximum strength source used in the field: the peak dose from a mobile source operated at ground level under the worst conditions was calculated to be about 1/1000 of the lethal dose for cadmium [48].

Notes and references

9. The subsequent media coverage is too extensive to list here.

10. GILLIGAN ANDREW and EVANS ROB. Britons secretly sprayed in germ warfare tests. Sunday Telegraph, 8 November 1998. The use of FP for this purpose had been apparent in the PRO for some years. The 1998 sensationalisation arose from a letter from the Chief Executive of DERA in response to questions from Matthew Taylor MP, the Liberal Democrat environmental spokesman.

11. The muted discussion on these matters in the report referenced at 2 above may be of interest.

12. DCDRD was the title of the London-based HQ branch which was responsible for CDEE and for its out-station at Nancekuke. The HQ branch in London had many changes of title during its long history from the Great War of 1914-1918 to its cessation in 1979 as the Directorate of Research; Chemical and Biological (DRCB). From 1963, it was also responsible for the Microbiological Research Establishment (MRE) at Porton.

13. The "T" number is a unique identifier for any compound submitted for toxicity testing at CBD and its precursors. Its absence clearly suggests that FP was never formally submitted for such tests.

14. Toxicological assessment of the Army's zinc cadmium sulfide dispersion tests. Sub-committee on zinc cadmium sulfide. Committee on toxicology. Board on environmental studies and toxicology. Commission on Life Sciences. National Research Council. National Academic Press Washington DC (1997) (ISBN 0-309-05783-3). This 358 page report provides detailed information and references.

15. FP from these two US suppliers and the UK supplier was used by CDEE. Latterly, the FP from Derby Luminescents Ltd was used, apparently as a dollar saving step. The costs, from UK and US suppliers have not been identified. Derby Luminescents Ltd were formerly at 11-12 St Swithins Lane, London EC4 and at Millmarsh Lane, Brimsdown, Enfield, Middlesex. The firm no longer exists.

16. http://www.moxtek.com/wwwboard/messages/165.html dated 21 December 1998.

17. Mr Guy Hill, now a director of Phosphor Technology Ltd at Waltham Abbey and a consultant on luminescent materials and applications and Professor Aaron Vecht of the University of Greenwich provided invaluable details, as did Carol Gibbons, Project Manager for phosphor coating at the Centre for Phosphor and Display Materials at Greenwich. Dr I C Sage of DERA Malvern kindly identified these sources. Derby Luminescents Ltd was bought out at some uncertain date. The London office is now a bank and the Enfield factory has disappeared.