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Letter to the Editor

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Poisoning from smoke grenades is not due to phosgene

Recently WANG *et al.* [1] reported on a case of "phosgene poisoning from a smoke grenade" in The European Journal of Respiratory Diseases. Poisoning occurred upon the inhalation of smoke from a pyrotechnic mixture composed of zinc oxide, hexachloroethane and calcium silicide. The grenade was activated in a confined space resulting in high concentrations of the smoke. The description of the symptoms observed in the exposed person are in accordance with other reports on smoke poisoning in man [2, 3]. However, the conclusion given by the authors that the smoke grenade is "another source of phosgene poisoning" is hereby questionned.

During combustion of pyrotechnic mixtures of zinc oxide and hexachloroethane, a hygroscopic aerosol of zinc chloride is formed. This finely dispersed aerosol is the main constituent of the smoke. In addition organic combustion products like amorphous coal, chlorinated hydrocarbons like hexachlorobenzene, hexachlorobutadiene, tetrachloroethylene, noncombusted hexachloroethane and relatively high concentrations of polyaromatic hydrocarbons (PAH) are found in the smoke [4, 5]. In addition to zinc chloride, inorganic combustion products like hydrogen chloride [2, 4] and phosgene [1] have been reported. The presence of hydrogen chloride could not be confirmed upon analysis of smoke with infra-red (IR) or mass spectrometry (CASSEL *et al.*, manuscript in preparation). By using Dräger tubes for hydrogen chloride, we found that the colour reaction obtained was identical for hydrogen chloride and smoke. However, with a membrane filter in front of the Dräger tube, no colour reaction was seen.

According to JARVIS [6], the combustion of a pyrotechnic white smoke composed of zinc oxide and hexachloroethane gives phosgene as an intermediate. The concentration of phosgene in the smoke is generally very low [6,7] and probably of limited importance from a toxicological point of view.

A more plausible explanation of the symptoms described by WANG *et al.* [1] is the presence of zinc chloride in the smoke. Zinc chloride is a known irritant to the skin and mucous membranes [8]. On acute inhalation of zinc chloride in rats the LC50 for a ten min exposure period was around 2,000 $mg{\cdot}m^{-3}$ [9]. The combustion of 1 g of a stoichiometric mixture of zinc oxide and hexachloroethane gives approximately 1 g of zinc chloride. The smallest Swedish smoke grenade of this type contains around 550g of smoke mixture. It can be assumed that the combustion efficiency is about 75%, and consequently around 485g of zinc chloride is formed from this grenade. This amount would give an extremely high concentration if distributed under a poncho, as in the case described by WANG *et al.* [1].

Based on case histories in the literature, STOCUM and HAMILTON [10] compiled data on the relationship between the degree of exposure and effects in exposed persons. Exposure to smoke concentrations of 80–120 $mg{\cdot}m^{-3}$ zinc chloride for two min caused nose, throat and chest irritation, cough and nausea. Concentrations of 190 $mg{\cdot}m^{-3}$ for 9 min caused throat irritation, some lung congestion, usually requiring hospitalization, observation and treatment. At concentrations of 4,100 $mg{\cdot}m^{-3}$ severe respiratory irritation leading to chemical pneumonia, requiring aggressive treatment, was found. At dosages of 50,000 $mg{\cdot}m^{-3}$ or more the authors found the following effects: massive respiratory tract injury, possibly fatal, and death due to shock and pulmonary oedema.

Thus, since the concentration of phosgene in the smoke is low and the concentration of zinc chloride is high, it is most probable that the injuries from the smoke, as described by WANG *et al.* [1] were caused by zinc chloride and not by phosgene. However, in view of the risks imposed by the exposure of unprotected persons to smoke from military smoke grenades, the advice of WANG *et al.* to "avoid activating grenades in poorly ventilated areas", seems highly appropriate.

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