

Chapter 6

Hydrogen bromide

6.1. Background

6.1.1 Basic chemical information

123. Hydrogen bromide (HBr) is a colourless, nonflammable, corrosive gas with a sharp, unpleasant, pungent odour. It is 3.5-times denser than air. Anhydrous hydrogen bromide produces aqueous hydrobromic acid when dissolved in water.

Conversion factors at 25°C and 101 kPa:

$$1 \text{ ppm} = 3.5 \text{ mg/m}^3; 1 \text{ mg/m}^3 = 0.29 \text{ ppm}$$

6.1.2 Sources

124. Releases of hydrogen bromide to air are not estimated by the National Atmospheric Emission Inventory and reporting is only required by the Environment Agency where the release is greater than one tonne per annum or as a specific permit condition. The Environment Agency's Pollution Inventory indicates that approximately 700 tonnes of hydrogen bromide were released to atmosphere in 2002, predominantly from the large coal-burning power stations. Other minor sources include the mineral industries, waste combustion, metals recycling and the displacement reactions of acidic gases with sea salt particles.

6.1.3 Ambient levels

125. Ambient levels of hydrogen bromide are not monitored routinely at any site in the United Kingdom. However, quarterly mean concentrations of particle-associated bromide have been made at three rural sites in the Defra Rural Trace Elements Network. In 2002 quarterly concentrations of particle associated bromide ranged from 2.7×10^{-6} to $11 \times 10^{-6} \text{ mg/m}^3$.

6.2. Health effects

126. The Panel considered animal studies involving exposure to hydrogen bromide and human studies of acute exposures that included both

occupational and one laboratory controlled exposure study as well as chronic exposures.

6.2.1 Animal studies

127. One acute animal study of inhaled hydrogen bromide at a high dose has been published. Stavert *et al.* (1991) exposed groups of male Fischer 344 rats under light anaesthesia to filtered air or 1300 ppm (4550 mg/m³) of hydrogen bromide vapour for 30 minutes. The study compared the effects of hydrogen bromide exposures to equal concentrations (ppm) of hydrogen chloride and hydrogen fluoride. Each treatment had a nose-breathing group and a group intubated to simulate mouth breathing. Twenty-four hours after the exposure, all surviving rats were killed and body and lung lobe weights were measured. Histological sections from the nasal passages, trachea (windpipe) and lung were examined under the microscope.
128. In all the nose-breathing groups, mean body weight was statistically reduced compared to the controls. The reduction seen in the hydrogen bromide-treated group was less than that seen in the groups treated with hydrogen chloride or hydrogen fluoride. In hydrogen bromide-treated rats mean absolute lung weights were similar to controls. Nose breathers exhibited severe damage to the surface tissue in the nose, in some cases extending to the underlying bone. Blood clots were seen in the nasal passages and in the upper airways, but these did not extend into the deeper lung. Fluid and fibrin in the nasal passages often accompanied these lesions. The effects were not observed in the lower regions of the respiratory (breathing) tract. Approximately 8% of nose-breathers died within 24 hours after exposure.
129. In the intubated rats (pseudo-mouth-breathers) exposed to hydrogen bromide, 20% died within 24 hours of exposure. Mean body weight was slightly reduced compared to the controls but the difference was not statistically different. Mean lung weights also were not statistically different compared to controls. Mouth breathers had variable degrees of superficial tissue damage to the upper airways accompanied by fluid in the trachea. The damage did not extend into the deep lung, and it was considered to be less severe than that observed with hydrogen chloride.
130. No subchronic animal studies on hydrogen bromide were found. However, in a 90-day toxicity study rats were fed diets containing from 75–19200 ppm sodium bromide. At the highest dose animals were poorly groomed and showed reduced weight gain: the effect was more prominent in male rats. In all groups, bromide level in the plasma rose to a plateau after 3 weeks. In female rats thyroid weight was increased from 1200 ppm: in males the effect was confined to the group dosed at 19200 ppm, but prostate weight was decreased from 4800 ppm. Microscopic examination of tissues confirmed an effect on the endocrine system. No effects were seen at or below 300 ppm in diet. (van Logten *et al.*, 1974)

6.2.2 Acute effects in humans

131. The only laboratory investigation conducted in humans is an unpublished volunteer study conducted in 1955 and cited by ACGIH (2001), which reported that inhalation of 2 ppm (7 mg/m³) hydrogen bromide vapour for 'several minutes' did not result in eye, nose or throat irritation, although an odour was detected by the volunteers. Inhalation at 3 ppm (10.5 mg/m³) for several minutes resulted in nasal and throat irritation in one out of six volunteers, with nose irritation being observed in three out of six, six out of six and six out of six volunteers at 4, 5 and 6 ppm (14, 17.5 and 21 mg/m³), respectively. The one out of six incidence of throat irritation was unchanged up to 6 ppm (20 mg/m³). No eye irritation was observed up to hydrogen bromide concentrations of 6 ppm (21 mg/m³). The imprecision of this study is a concern, especially the duration of exposure.
132. Garlanda and Basilico, (1993) reported that (presumably accidental) inhalation of approximately 35 ppm (118 mg/m³) hydrogen bromide for a short period was associated with irritation of the throat, with 'more severe exposures' resulting in pulmonary oedema (fluid accumulation in the lung), which was at times accompanied by 'laryngeal spasm'. A few minutes exposure to a hydrogen bromide release estimated to be 1400-2100 ppm (4710-7100 mg/m³) was reported to be lethal.
133. The Health and Safety Commission has set an occupational exposure limit of 3 ppm (10.5 mg/m³) (as a 15-minute time-weighted average) based on unpublished human volunteer data summarised by the ACGIH in their supporting documentation for the threshold limit value (HSE 2002a,b).
134. An accidental exposure, probably to both bromine and hydrogen bromide, occurred in two individuals using a hot tub in which a bromine based disinfectant had been used (Burns and Linden, 1997). Both subjects were non-smokers and had no previously reported respiratory problems. It is not known what concentrations of hydrogen bromide were present. Both subjects had acute upper and lower respiratory and eye symptoms but there was little clinical or radiological evidence of lung abnormality. However, pulmonary (lung) function testing up to 10 months subsequently revealed strongly positive responses to methacholine challenge, consistent with reactive airways dysfunction syndrome (RADS, see Appendix 2).

6.2.3 Subacute effects in humans

135. Alexandrov (1983) reported that chronic occupational exposure (concentration and duration not reported) to hydrogen bromide was associated with inflammation of the upper airways lining, indigestion, reduced red blood cell counts and possible changes to reflexes and sense of smell. Bromide salts have found therapeutic use as anti-convulsants, analgesics and sedatives. Excessive doses (not achievable by inhalation) cause headache, drowsiness and lethargy and, occasionally, skin lesions and psychotic behaviour.

136. The United Kingdom Committee on Toxicity (CoT) considered the dietary intake of bromide in 2003. The Committee reviewed an evaluation by the Joint Evaluation Committee for Food Additives (JECFA) and the Joint Meeting on Pesticide Residues (JMPR), both of which are Subcommittees of the World Health Organisation (WHO) and the Food and Agriculture Organisation (FAO) that established an acceptable daily intake (ADI) in the region of 0-1 mg/kg body weight. CoT considered it inappropriate to recommend a range of intake that included zero, as it is uncertain whether bromine is an essential trace element. The Committee considered the upper bound of 1 mg/kg body weight/day to be unlikely to pose a risk to health. The estimated average dietary intake is equivalent to about 0.06 mg/kg/day and it is unlikely that exposure by inhalation will significantly erode the margin between this value and the ADI.

6.2.4 Carcinogenicity

137. No studies on the carcinogenicity of hydrogen bromide were found. Limited studies with bromides administered orally gave no evidence for carcinogenicity. IARC (1992) has evaluated the carcinogenicity of mists of strong inorganic acids. However hydrogen bromide was not included in this evaluation and the overall evaluation is not relevant for the concentrations considered here.

6.3. Justification for the air quality guideline value

138. The adverse effects of potential concern arising from exposure to low levels of hydrogen bromide are those on the respiratory tract and the eyes, due to its well known irritant and acidic properties.
139. In both anhydrous and aerosol forms, hydrogen bromide is a strong irritant, affecting the conjunctivae (eye) and respiratory mucosa (moist linings of the breathing airways). Because of its high solubility in water, the major irritant effects of acute exposure are usually limited to the upper passages of the respiratory tract.
140. The information available on the sensory effects of hydrogen bromide at low concentrations in humans is sparse and, in the Panel's view, is of insufficient quality to allow a confident definition of exposure levels associated with specific effects. Evidence from animal studies indicates that effects are similar in character, but less severe than those seen after exposure to a similar concentration of hydrogen chloride. This similarity in both chemistry and biological effects allows direct comparison of effect and no effect levels to be used to increase confidence in the value derived.
141. By analogy with hydrogen chloride, with which hydrogen bromide has many similarities, the Panel considered that a concentration of 2 ppm (7 mg/m³) should be regarded as a no observed adverse effect level (NOAEL) for irritant effects on the upper respiratory tract and outer eye. It was noted that this view was based on the only available study of

a small group of volunteers. Nevertheless this concentration is in good accord with the similar effects seen with hydrogen chloride, which increases confidence in the value. To reflect the uncertainty in the derivation of the NOAEL and to take into account the presence of potentially susceptible individuals in the general population, the Panel considered that applying a safety factor of 10 to the 2 ppm (3.5 mg/m³) value would be adequate for exposure in the ambient air. The Panel therefore concluded that 0.2 ppm (0.7 mg/m³) would be an appropriate guidance value for hydrogen bromide that allowed for its irritant effects on the respiratory mucosa.

142. The Panel considered that there were no grounds for regarding hydrogen bromide as a human carcinogen.

6.4. Recommendation

143. **The Panel recommends that a concentration of hydrogen bromide gas or mass equivalent aerosol not exceeding 0.2 ppm (0.7 mg/m³) over a 1-hour averaging period should protect against irritant and inflammatory effects on the skin, eyes and breathing airways. Long-term effects at these low concentrations are considered most unlikely.**

References

Alexandrov, D.D. (1983). Bromine and Compounds. In: *Encyclopaedia of Occupational Health and Safety*, 3rd Ed. Vol. 1, p. 326-329. C. Parmaggianni, Ed. International Labour Office, Geneva, Switzerland. Cited in ACGIH (2001).

ACGIH, (2001). *Documentation of the TLVs, Hydrogen Bromide*. American Conference of Government Industrial Hygienists, Cincinnati, Ohio.

Burns, M.J. and Linden, C.H. (1997). Another hot tub hazard: Reactive airway disease secondary to bromine exposure and hydrobromic acid exposure. *Chest* 111(3): 816-818.

Garlanda, T. and Basilico, S. (1993). *Occupational Exposure Limits - Criteria Document for Hydrogen Bromide*. Office for Official Publications of the European Communities, 2985 Luxembourg, Grand Duchy of Luxembourg, vi, 16.

HSE, (2002a). Occupational exposure limits. EH40/2002. HSE Books, Norwich.

HSE, (2002b). Summary Criteria for Occupational Exposure Limits, EH64/D35: Hydrogen bromide. HSE Books, Norwich.

IARC, (1992). International Agency for Research on Cancer: Monographs on the Evaluation of Carcinogenic Risks to Humans, Vol. 54, Occupational

Exposures to Mists and Vapours from Strong Inorganic Acids; and Other Industrial Chemicals, pp. 189–211. IARC, Lyon, France.

Stavert, D.M., Archuleta, D.C., Behr, M.J. and Lehnert, B.E. (1991). Relative acute toxicities of hydrogen fluoride, hydrogen chloride and hydrogen bromide in nose- and pseudo-mouth-breathing rats. *Toxicol. Appl. Pharmacol.* **81**, 401–406.

van Logten, M., Wolthuis, M., Rauws, A.G., Kroes, R., den Tonkelaar, E.M., Berkvens, H. and van Esch, G.J. (1974). Semichronic toxicity study of sodium bromide in rats. *Toxicology* **2**, 257-267.