



Residential Indoor Air Quality Guideline

Formaldehyde

Physical and Chemical Properties

Low-molecular weight aldehydes, such as formaldehyde, are reactive, highly flammable compounds. At room temperature, formaldehyde is a reactive gas.

Molecular formula	HCHO
Molecular weight	30.03 g/mol
Melting Point	-118 to -92°C
Boiling Point	-21 to -19 °C
Vapor pressure	516 kPa
Conversion: ppb -> µg/m ³	× 1.23

Sources and Concentrations in Indoor Environments

Extensive reviews of formaldehyde emissions sources have been published by the World Health Organization (WHO 1989), and Environment Canada and Health Canada (2001). Sources that influence indoor levels of formaldehyde can be divided into two broad categories: combustion and off-gassing. Combustion sources include cigarettes and other tobacco products, and open fireplaces. Off-gassing sources include wood products such as particle board and other building materials made with adhesives containing formaldehyde as well as some varnishes, paints, carpeting, drapes and curtains.

Results from studies carried out in Canada since the early 1990s consistently indicate that formaldehyde concentrations in

Canadian homes range between 2.5 and 88 µg/m³ with an average between 30 and 40 µg/m³ (Health Canada 2005).

Health Effects

Epidemiological studies on the effects of chronic formaldehyde exposure consistently found respiratory and allergic effects at levels below 123 µg/m³ (Health Canada, 2005). In one study, formaldehyde levels in homes were associated with increased risk of atopy, after ruling out confounding from other indoor air pollutants (Garrett, *et al.*, 1999). In another study, formaldehyde levels were significantly associated with hospitalization for asthma in children aged six months to three years, again after ruling out confounding from other indoor air pollutants. No effects were found in children exposed to 10 to 29 µg/m³ and 30 to 49 µg/m³ formaldehyde, a non-significant increase of risk was observed at 50 to 59 µg/m³ and a significantly increased risk was observed at concentrations exceeding 60 µg/m³ (Rumchev, *et al.*, 2002). An association between low-level exposure to formaldehyde and the development of allergic sensitization and/or asthma is biologically plausible as it is consistent with observations in animals.

Several occupational epidemiologic studies showed an increased risk of nasopharyngeal and sinonasal cancer in workers exposed to high concentrations of formaldehyde (IARC 1995; Environment Canada, Health Canada 2001).

Based on human clinical studies and on animal experiments, the primary effects of acute exposure to formaldehyde are the irritation of the mucosa of the upper respiratory tract and the eyes (Health Canada 2005). The no observable adverse effects level (NOAEL) and lowest observable adverse effects level (LOAEL) for eye irritation are 615 and 1,230 $\mu\text{g}/\text{m}^3$, respectively (Kulle 1993).

Inhalation studies of formaldehyde with animal models have shown histopathological effects such as hyperplasia, squamous metaplasia, inflammation, erosion, ulceration, and disarrangements in the nasal cavity at concentrations of 3.7 mg/m^3 and above (NOAEL 1.2 mg/m^3). These histopathological effects appear to be a function of the formaldehyde concentration in inhaled air rather than of the cumulative dose. In addition, two studies showed that formaldehyde inhalation enhance allergic sensitization to allergens inhaled subsequently (Health Canada 2005).

Carcinogenicity studies consistently found an increased incidence of carcinomas of the nasal cavity at levels of 6.7 mg/m^3 or over; no such tumours were found at lower concentrations (up to 2.4 mg/m^3). Formaldehyde-induced carcinogenicity appears to be a consequence of proliferative regeneration following cytotoxicity (Environment Canada, Health Canada 2001). The risk of cancer associated with formaldehyde levels sufficiently low to prevent irritation and inflammatory responses appears therefore to be negligible.

Assessment Under the Canadian Environmental Protection Act

Formaldehyde was declared “toxic” under the *Canadian Environmental Protection Act*, 1999 as it is “entering the Canadian environment in a quantity or concentration that constitutes or may constitute a danger for the environment on which life depends and a danger in Canada to human life or health” (Environment Canada, Health Canada 2001).

Residential Indoor Air Quality Guidelines for Formaldehydes

A one-hour exposure limit is established at 123 $\mu\text{g}/\text{m}^3$ (100 ppb), which represents one fifth of the no observable adverse effects level and one tenth of the lowest observable adverse effects level found for eye irritation in the Kulle (1993) study. A eight-hour exposure limit is established at 50 $\mu\text{g}/\text{m}^3$ (40 ppb), i.e., a the lower end of the exposure category associated with no significant increase of asthma hospitalization in the Rumchev, *et al.*, (2002) study.

Exposure period	Concentration		Critical effect
	$\mu\text{g}/\text{m}^3$	ppb	
1 hour	123	100	Eye irritation
8 hours	50	40	Respiratory symptoms in children

References

- CIIT. 1999. Formaldehyde: hazard characterization and dose–response assessment for carcinogenicity by the route of inhalation. Rev. ed. Research Triangle Park, NC, USA: Chemical Industry Institute of Toxicology (CIIT).
- Environment Canada, Health Canada 2001. Priority Substance List Assessment Report: Formaldehyde. Ottawa: Minister of Public Works and Government Services.
- Garrett, M.H., Hooper, M.A., Hooper, B.M., Rayment, P.R., and Abramson, M.J. 1999. Increased risk of allergy in children due to formaldehyde exposure in homes. *Allergy* 54: 330–337.
- Health Canada 2005. Proposed residential indoor air quality guideline for formaldehyde. 31 p.
- International Agency for Research on Cancer. 1995. Formaldehyde. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans 62: 217–375.
- Kulle, T.J. 1993. Acute odor and irritation response in healthy nonsmokers with formaldehyde exposure. *Toxicol. Ind. Health* 5: 323–332.
- Rumchev, K.B., Spickett, J.T., Bulsara, M.K., Phillips, M.R., and Stick, S.M. 2002. Domestic exposure to formaldehyde significantly increases the risk of asthma in young children. *Eur. Respir. J.* 20: 403–406.
- WHO. 1989. Formaldehyde. Environmental Health Criteria 89. Geneva: World Health Organization, International Programme on Chemical Safety.

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