

NIST Technical Note 1439

International Study of the Sublethal Effects of Fire Smoke on Survivability and Health (SEFS): Phase I Final Report

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Table 46. Major Transportable Toxic Gases from Combustion

(Sublethal effects occurring: A, below 10^{-5} volume fraction (10 ppm by volume); B, 10^{-5} to 10^{-4} volume fraction (tens of ppm by volume); C, at 10^{-4} to 10^{-3} volume fraction (hundreds of ppm by volume); D, at 10^{-3} to 10^{-2} volume fraction (thousands of ppm by volume).⁹⁸)

Toxic Gas	Potential Sources	Sublethal Effects
Acrolein ($\text{CH}_2=\text{CHCHO}$)	Cellulosic materials, e.g., wood, cotton, paper; polystyrenes, ABS	A
Toluene diisocyanate (TDI)	Flexible polyurethane foams	A
Formaldehyde (HCHO)	POM, polypropylenes	B
Hydrogen cyanide (HCN)	Nitrogen-containing materials, e.g., wool, silk, PAN, ABS, acrylic fibers, nylons, urea/formaldehyde, melamine, polyurethanes, polyacrylamide	C
Nitrogen dioxide (NO_2)	Nitrogen-containing materials	B
Hydrogen chloride (HCl)	PVC and chlorinated additives	B, D
Hydrogen fluoride (HF)	PTFE, other fluorinated compounds and additives	B
Hydrogen bromide (HBr)	Brominated compounds and additives	B,D
Sulfur dioxide (SO_2)	Sulfur-containing materials, e.g., wool, vulcanized rubbers, poly(phenylene sulfide)	B
Hydrogen sulfide (H_2S)	Sulfur-containing materials	C
Ammonia (NH_3)	Nitrogen-containing materials	C
Styrene (C_8H_8)	Polystyrenes, ABS	C
Toluene (C_7H_8)	Polystyrenes, PVC, polyurethane foams	D
Benzene (C_6H_6)	Polystyrenes, PVC, polyesters, nylons	C

Despite the awareness of the importance of aerosols in affecting smoke toxicity, there is relatively little quantitative information regarding the transport on particles of sufficient mass of noxious molecules to cause toxicological effects. The following summarizes the available information, the best of which is for HCl, with some on HCN and other toxicants

Hydrogen chloride. The transport of HCl has been studied largely because it is a major pyrolysis and combustion product of polyvinylchloride (PVC), a polymer in widespread use. Chlorine is also present in a number of flame retardant additives. Further, other halogens (bromine and fluorine) are present in a number of commercial products, whose combustion generates the analogous halogen acids, HBr and HF. Their transport should behave much like HCl. Thus HCl is a surrogate for any toxic combustion products with high polarity and high solubility in water.