Table 2. Chemical Composition of Wood Smoke

Species[1]	g/kg wood[2]	Physical State[3]	Reference
Carbon Monoxide	80-370	V	4,5
Methane	14-25	V	5
VOCs (C_2-C_7)	7-27	V	5
Aldehydes	0.6-5.4	V	4,6
Formaldehyde	0.1-0.7	V	4,6
Acrolein	0.02-0.1	V	6
Propionaldehyde	0.1-0.3	V	4,6
Butryaldehyde	0.01-1.7	V	4,6
Acetaldehyde	0.03-0.6	V	4,6
Furfural	0.2-1.6	V	7,8
Substituted Furans	0.15-1.7	V	7,8
Benzene	0.6-4.0	V	5
Alkyl Benzenes	1-6	V	9
Toluene	0.15-1.0	V	9
Acetic Acid	1.8-2.4	V	7
Formic Acid	0.06-0.08	V	7
Nitrogen Oxides (NO,NO_2)	0.2-0.9	V	4,5
Sulfur Dioxide	0.16-0.24	V	4
Methyl chloride	0.01-0.04		10
Napthalene	0.24-1.6	V	9
Substituted Napthalenes	0.3-2.1	V/P	9
Oxygenated Monoaromatics	1 - 7	V/P	9
Guaiacol (and derivatives)	0.4-1.6	V/P	11
Phenol (and derivatives)	0.2-0.8	V/P	11
Syringol (and derivatives)	0.7-2.7	V/P	11
Catechol (and derivatives)	0.2-0.8	V/P	11
Total Particle Mass	7-30	P	5
Particulate Organic Carbon	2-20	P	12
Oxygenated PAHs	0.15-1	V/P	9
PAHs			
Fluorene	$4x10^{-5}$ - $1.7x10^{-2}$	V/P	13
Phenanthrene	$2x10^{-5}$ - $3.4x10^{-2}$	V/P	13
Anthracene	$5x10^{-5}$ - $2.1x10^{-2}$	V/P	13

Species[1]	g/kg wood[2]	Physical State[3]	Reference
Methylanthracenes	$7x10^{-5}$ - $8x10^{-3}$	V/P	13
Fluoranthene	$7x10^{-4}$ - $4.2x10^{-2}$	V/P	13
Pyrene	$8x10^{-4}$ - $3.1x10^{-2}$	V/P	13
Benzo(a)anthracene	$4x10^{-4}$ - $2x10^{-3}$	V/P	13
Chrysene	$5x10^{-4}$ - $1x10^{-2}$	V/P	13
Benzofluoranthenes	$6x10^{-4}$ - $5x10^{-3}$	V/P	13
Benzo(e)pyrene	$2x10^{-4}$ - $4x10^{-3}$	V/P	13
Benzo(a)pyrene	$3x10^{-4}$ - $5x10^{-3}$	V/P	13
Perylene	$5x10^{-5}$ - $3x10^{-3}$	V/P	13
Ideno(1,2,3-cd)pyrene	$2x10^{-4}$ - $1.3x10^{-2}$	V/P	13
Benz(ghi)perylene	$3x10^{-5}$ - $1.1x10^{-2}$	V/P	13
Coronene	$8x10^{-4}$ - $3x10^{-3}$	V/P	13
Dibenzo(a,h)pyrene	$3x10^{-4}$ - $1x10^{-3}$	V/P	13
Retene	$7x10^{-3}$ - $3x10^{-2}$	V/P	14
Dibenz(a,h)anthracene	$2x10^{-5}$ - $2x10^{-3}$	V/P	13
Trace Elements			
Na	$3x10^{-3}$ - $1.8x10^{-2}$	P	15
Mg	$2x10^{-4}$ - $3x10^{-3}$	P	15
Al	$1x10^{-4}$ - $2.4x10^{-2}$	P	15
Si	$3x10^{-4}$ - $3.1x10^{-2}$	P	15
S	$1x10^{-3}$ - $2.9x10^{-2}$	P	15
Cl	$7x10^{-4}$ - $2.1x10^{-1}$	P	15
K	$3x10^{-3}$ - $8.6x10^{-2}$	P	15
Ca	$9x10^{-4}$ - $1.8x10^{-2}$	P	15
Ti	$4x10^{-5}$ - $3x10^{-3}$	P	15
V	$2x10^{-5}$ - $4x10^{-3}$	P	15
Cr	$2x10^{-5}$ - $3x10^{-3}$	P	15
Mn	$7x10^{-5}$ - $4x10^{-3}$	P	15
Fe	$3x10^{-4}$ - $5x10^{-3}$	P	15
Ni	$1x10^{-6}$ - $1x10^{-3}$	P	15
Cu	$2x10^{-4}$ - $9x10^{-4}$	P	15
Zn	$7x10^{-4}$ - $8x10^{-3}$	P	15
Br	$7x10^{-5}$ - $9x10^{-4}$	P	15
Pb	$1x10^{-4}$ - $3x10^{-3}$	P	15

Species[1]	g/kg wood[2]	Physical State[3]	Reference
Particulate Elemental Carbon	0.3 - 5	P	16
Normal alkanes (C_{24}-C_{30})	$1x10^{-3}$ - $6x10^{-3}$	P	17
Cyclic di-and triterpenoids			
Dehydroabietic acid	0.01 - 0.05	P	18
Isopimaric acid	0.02 - 0.10	P	18
Lupenone	$2x10^{-3}$ - $8x10^{-3}$	P	18
Friedelin	$4x10^{-6}$ - $2x10^{-5}$	P	18
Chlorinated dioxins	$1x10^{-5}$ - $4x10^{-5}$	P	19
Particulate Acidity	$7x10^{-3}$ - $7x10^{-2}$	P	20

1 Some species are grouped into general classes as indicated by italics

2 To estimate the weight percentage in the exhaust, divide the g/kg value by 80. This assumes that there are 7.3 kg combustion air per kg of wood. Major species not listed here include carbon dioxide and water vapor (about 12 and 7 weight percent respectively under the assumed conditions).

3 At ambient conditions; V = vapor, P = particulate, and V/P = vapor and/or particulate (i.e., semi-volatile).

4 DeAngelis (1980)

5 OMNI (1988)

6 Lipari (1984), values for fireplaces

7 Edye et al (1991). smoldering conditions; other substituted furans include 2-furanmethanol, 2 acetylfuran, 5-methyl-2furaldehyde, and benzofuran

8 Value estimated for pine from Edye et al (1991) from reported yield relative to guaiacol, from guaiacol values of Hawthorne (1989) and assuming particulate organic carbon is 50% of total particle mass

9 Steiber et al (1992), values computed assuming a range of 3-20 g of total extractable, speciated mass per kg wood

10 Khalil (1983)

11 Hawthorne (1989), values for syringol for hardwood fuel; see also Hawthorne (1988)

12 Core (1989), DeAngelis (1980), Kalman and Larson (1987)

13 From one or more of the following studies: Cooke (1981), Truesdale (1984), Alfheim et al (1984), Zeedijk (1986), Core (1989), Kalman and Larson (1987); assuming a range of 7 to 30 grams of particulate mass per kg wood when values were reported in grams per gram of particulate mass. Similar assumptions apply to references 14,15 and references 17-19

14 Core (1989), Kalman and Larson (1987)

15 Watson (1979), Core (1989), Kalman and Larson (1987)

16 Rau (1989), Core (1989)

17 Core (1989)

18 Standley and Simoneit (1990); Dehydroabietic acid values for pine smoke, lupenone and isopimaric acid values for alder smoke, and friedelin values for oak soot.

19 Nestrick and Lamparski (1982), from particulate condensed on flue pipes; includes TCDDs, HCDDs, H_7CDDs and OCDDS

20 Burnet et al (1986); one gram of acid = one equivalent of acid needed to reach a pH of 5.6 in extract solution