Wood Dust*

Known to be a human carcinogen
First Listed in the *Tenth Report on Carcinogens* (2002)

Carcinogenicity

Wood dust is *known to be a human carcinogen* based on sufficient evidence of carcinogenicity from studies in humans. An association between wood dust exposure and cancer of the nasal cavity has been observed in many case reports, cohort studies, and case-control studies that specifically addressed nasal cancer. Strong and consistent associations with cancer of the nasal cavities and paranasal sinuses were observed both in studies of people whose occupations are associated with wood dust exposure and in studies that directly estimated wood dust exposure. Risks were highest for adenocarcinoma, particularly among European populations. Studies of U.S. populations showed similar significant positive associations. A pooled analysis of 12 case-control studies showed that the estimated relative risk of adenocarcinoma was very high (45.5) among men with the greatest exposure and that the risk increased with duration of exposure (Demers *et al.* 1995). The association between wood dust exposure and elevated nasal cancer risk in a large number of independent studies and with many different occupations in many countries strongly supports the conclusion that the increased risk is caused by wood dust rather than by simultaneous exposure(s) to other substances, such as formaldehyde or wood preservatives. Other types of nasal cancer (squamous-cell carcinoma of the nasal cavity) and cancer at other sites, including cancer of the nasopharynx and larynx and Hodgkin's disease, have been associated with exposure to wood dust in several epidemiologic studies. However, these findings were positive in some, but not all, studies, and the overall epidemiologic evidence is not strong enough or consistent enough to allow firm conclusions about the role of wood dust exposure in the development of cancer at these other sites (IARC 1995, NTP 2000).

There is inadequate evidence for the carcinogenicity of wood dust from studies in experimental animals. No tumors attributable to beech wood dust exposure were found in inhalation studies in female Sprague-Dawley rats, female Wistar rats, or male Syrian golden hamsters or in intraperitoneal injection studies in female Wistar rats. Similarly, inhalation exposure to wood dust did not significantly affect the incidence of tumors induced by simultaneous exposure to other compounds, including formaldehyde in female Sprague-Dawley rats, sidestream cigarette smoke in female Wistar rats, or *N*-nitrosodiethylamine in male Syrian golden hamsters. However, each of these studies suffers from various limitations, such as small numbers of animals or dose groups, short study duration, or inadequate data reporting (IARC 1995). Dermal exposure to a methanol extract of beech wood dust resulted in a significant dose-related increase in the incidence of skin tumors (squamous-cell carcinoma and papilloma) and mammary tumors (adenocarcinoma, adenoacanthoma, and mixed tumors) in female NMRI mice (IARC 1995).

Additional Information Relevant to Carcinogenicity

Studies using polar organic solvent extracts of some hardwood dusts have reported weak positive results for reverse mutations in *Salmonella typhimurium.* In addition, two chemicals found in wood, Δ^3 carene and quercetin, were found to be mutagenic in *Salmonella. In vitro* and *in vivo* tests in mammals, using polar organic solvent extracts of some wood dusts (beech and oak) have shown positive results for DNA damage, micronucleus induction, and chromosomal aberrations (primarily chromatid breaks). A higher rate of DNA damage (primarily single-strand breaks and DNA repair) and micronucleus induction has been observed in peripheral blood lymphocytes from people who are occupationally exposed to wood dust (IARC 1995, NTP 2000).

The roles of specific chemicals found in wood dust (either naturally in the wood or added to it in processing) in inducing cancer are not clear. The particulate nature of wood dust also may contribute to wood dust-associated carcinogenesis, because dust generated by woodworking typically consists of a high proportion of particles that are deposited in the nasal cavity. Some studies of people with long-term exposure to wood dust have found decreased mucociliary clearance and enhanced inflammatory reactions in the nasal cavity. Also, cellular changes (metaplasia and dysplasia) observed in the nasal mucosa of woodworkers and of laboratory animals may be precancerous (IARC 1995, NTP 2000).

Properties

Wood is an important worldwide renewable natural resource. Forests extend over approximately one-third of the earth's total landmass (about 3.4 million km^2). There are an estimated 12,000 species of trees, each producing a characteristic type of wood; therefore, the species of trees harvested vary considerably among different countries and even among different parts of a single country. However, even in countries with high domestic production of wood, some wood may be imported for specific uses, such as furniture production (IARC 1995).

Most of the 12,000 tree species are broad-leaved deciduous trees, or hardwoods, principally angiosperms. Only approximately 800 species are pines, firs, and other coniferous trees, or softwoods, principally gymnosperms. The terms "hardwood" and "softwood" refer to the species, and not necessarily the hardness of the wood. Although hardwoods generally are denser than softwoods, the density varies greatly within each group, and the hardness of the two groups overlaps somewhat. The composition of softwood tissue is simpler than that of hardwood, consisting of mainly one type of cells, tracheids. In hardwoods, there is more detailed differentiation between stabilizing, conducting, and storage tissue. Although most trees harvested worldwide are hardwoods (58% of volume), much of the hardwood is used for fuel. For industrial purposes, softwood is the major wood used (69%), although this varies from region to region (IARC 1995).

Wood dust is a complex mixture generated when timber is processed, such as when it is chipped, sawed, turned, drilled, or sanded. Its chemical composition depends on the species of tree and consists mainly of cellulose, polyoses, and lignin, with a large and variable number of substances with lower relative molecular mass. Cellulose is the major component of both softwood and hardwood. Polyoses (hemicelluloses), which consist of five neutral sugar units, are present in larger amounts in hardwood than in softwood. The lignin content of softwood is higher than that of hardwood. The lower-molecular-mass substances significantly affect the properties of wood; these include substances extracted with nonpolar organic solvents (fatty acids, resin acids, waxes, alcohols, terpenes, sterols, steryl esters, and glycerols), substances extracted with polar organic solvents (tannins, flavonoids, quinones, and lignans), and water-soluble substances (carbohydrates, alkaloids, proteins, and inorganic material).

Wood dust also is characterized by its moisture content, with dry wood referring to wood with a moisture content of less than approximately 15% and moist wood referring to wood with a greater moisture content. Woodworking operations using dry wood generate more total dust and a greater amount of inhalable dust particles than those using moist wood (IARC 1995).

Use

Wood dust is usually produced in woodworking industries as a byproduct of manufacturing wood products and is not usually

produced for specific uses. However, one commercial use for wood dust is in wood composts (Weber *et al.* 1993). "Industrial roundwood" refers to categories of wood not used for fuel, which include sawn wood (54%), pulpwood (21%), poles and pit props (14%), and wood used for other purposes, such as particle board and fiberboard (11%) (IARC 1995).

Production

Wood dust is created when machines or tools are used to cut or shape wood materials. Industries in which large amounts of wood dust are produced include sawmills, dimension mills, furniture industries, cabinetmaking, and carpentry (IARC 1995).

Total estimated production values for wood used in industry in the United States for 1990 were 311.9 million cubic meters of softwood and 115 million cubic meters of hardwood (Demers *et al.* 1997).

Exposure

Exposure to wood dust occurs when individuals use machinery or tools to cut or shape wood. Breathing in the dust causes it to deposit in the nose, throat, and other airways. The amount of dust deposited within the airways depends on the size, shape, and density of the dust particles and the strength (turbulence and velocity) of the airflow. Particles with a diameter larger than 5 µm ("inspirable" particles) are deposited almost completely in the nose, while particles 0.5 µm to 5 µm in diameter ("respirable" particles) are deposited in the lower airways. Wood dust usually is measured as airborne dust concentrations, by particle size distribution, by type of wood, and by other characteristics of wood (IARC 1981, 1995).

Total airborne dust concentrations are described as mass per unit volume (usually milligrams per cubic meter). Wood dust generally is collected by a standard gravimetric method that involves using a sampling pump to collect a known volume of air through a special membrane filter contained in a plastic cassette. Some sampling studies reported that the particle size distribution varied according to the woodworking operation, with sanding producing smaller particles than sawing, but others found no consistent differences (IARC 1995). The majority of the wood dust mass was reported to be contributed by particles larger than 10 µm in aerodynamic diameter; however, between 61% and 65% of the particles by count measured between 1 and 5 µm in diameter (IARC 1995).

Exposure to wood dust also occurs through handling of compost containing wood dust. Wood compost materials consist of successive layers of chopped leaves, bark, and wood stored outdoors during spring where high rainfall is expected. Visible clouds of fine particulates are easily generated when the compost materials are agitated. Background concentrations of 0.32 mg/m^3 of respirable dust have been reported from samplers upwind from the compost pile. Routine exposures of 0.74 mg/m^3 of inspirable dust (> 5 µm) and 0.42 mg/m^3 of respirable dust (0.5 to 5 µm) were determined with samplers at the breathing zone level during loading and unloading of compost. The highest exposures were collected directly from the visible clouds generated by compost agitation and contained 149 mg/m^3 of inspirable and 83 mg/m^3 of respirable dust (Weber *et al.* 1993).

The National Occupational Exposure Survey (NOES), conducted by the National Institute for Occupational Safety and Health (NIOSH) from 1981 to 1983, estimated that approximately 600,000 workers were exposed to wood dust in the United States (IARC 1995, Noertjojo *et al.* 1996, RTECS 2003).

Jobs with high exposure to wood dust included sanders in the transportation equipment industry (unadjusted geometric mean = 17.5 mg/m^3), press operators in the wood products industry (12.3 mg/m^3), lathe operators in the furniture industry (7.46 mg/m^3), and sanders in the wood cabinet industry (5.83 mg/m^3). High exposures occurred in the chemical, petroleum, rubber, and plastics products industries, in which exposures occured in sanding, pattern making, and mill and saw operations. The lowest exposures occurred in industrial pattern-making facilities, paper and paperboard mills, schools and institutional training facilities, and veneer and plywood mills (Teschke *et al.* 1999).

Teschke *et al.* (1999) analyzed 1,632 measurements of personal time-weighted-average airborne wood dust concentrations in 609 establishments on 634 inspection visits that were reported to the Occupational Safety and Health Administration (OSHA) Integrated Management Information System between 1979 and 1997. Exposures ranged from less than 0.03 to 604 mg/m^3, with an arithmetic mean of 7.93 mg/m^3 and a geometric mean of 1.86 mg/m^3. Exposure levels have decreased significantly over time (the unadjusted geometric mean was 4.59 mg/m^3 in 1979 and 0.14 mg/m^3 in 1997).

Use of hand-held electric sanders has been identified as a particularly dusty process that will lead to dust exposure. Wood dust concentrations vary with type of dust extraction, amount of wood removed, and type of sander (Thorpe and Brown 1994). For electric belt sanders used to sand dowels, total dust concentrations ranged from 0.22 mg/m^3 with external dust extraction to 3.74 mg/m^3 without, and concentrations of respirable dust (0.5 to 5 µm) ranged from 0.003 to 0.936 mg/m^3 under the same conditions. Rotary sanders tested with flat wood samples produced total dust concentrations ranging from 0.002 (with extraction) to 0.699 mg/m^3 (without extraction) and concentrations of respirable dust from 0.001 (with extraction) to 0.088 mg/m^3 (without extraction). Comparable decreases in dust concentrations were observed for electrical orbital sanders used with dust extraction.

Regulations

OSHA

Permissible Exposure Limit (PEL) = 15 mg/m^3 (total); 5 mg/m^3 (respirable) (PEL based on the standard for *Particulates Not Otherwise Regulated*)

Guidelines

ACGIH

Threshold Limit Value - Time-Weighted Average Limit (TLV-TWA) = 1 mg/m^3 (certain hard woods such as beech and oak); 5 mg/m^3 (softwood)

Threshold Limit Value - Short Term Exposure Limit (TLV-STEL) = 10 mg/m^3 (softwood)

NIOSH

Recommended Exposure Limit (REL) = 1 mg/m^3

Listed as a potential occupational carcinogen

*There is no separate CAS registry number assigned to wood dust.

REFERENCES

Demers, P. A., P. Boffetta, M. Kogevinas, A. Blair, B. A. Miller, C. F. Robinson, *et al.* 1995. Pooled reanalysis of cancer mortality among five cohorts of workers in wood-related industries. Scand J Work Environ Health 21(3): 179-90.

Demers, P. A., K. Teschke and S. M. Kennedy. 1997. What to do about softwood? A review of respiratory effects and recommendations regarding exposure limits. Am J Ind Med 31(4): 385-98.

IARC. 1981. Wood, Leather and Some Associated Industries. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Humans, vol. 25. Lyon, France: International Agency for Research on Cancer.

IARC. 1995. Wood Dust. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Humans, vol. 62. Lyon, France: International Agency for Research on Cancer. 35-215 pp.

Noertjojo, H. K., H. Dimich-Ward, S. Peelen, M. Dittrick, S. M. Kennedy and M. Chan-Yeung. 1996. Western red cedar dust exposure and lung function: a dose-response relationship. Am J Respir Crit Care Med 154(4 Pt 1): 968-73.

NTP. 2000. Report on Carcinogens Background Document for Wood Dust. National Toxicology Program. http://ntp-server.niehs.nih.gov/newhomeroc/roc10/WD.pdf.

RTECS. 2003. Registry of Toxic Effects of Chemical Substances. Wood Dust. National Institute for Occupational Safety and Health.

Teschke, K., S. A. Marion, T. L. Vaughan, M. S. Morgan and J. Camp. 1999. Exposures to wood dust in U.S. industries and occupations, 1979 to 1997. Am J Ind Med 35(6): 581-9.

Thorpe, A. and R. C. Brown. 1994. Measurements of the effectiveness of dust extraction systems of hand sanders used on wood. Ann Occup Hyg 38(3): 279-302.

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Wood dust is a complex mixture generated when timber is processed, such as when it is chipped, sawed, turned, drilled, or sanded. Its chemical composition depends on the species of tree and consists mainly of cellulose, polyoses, and lignin, with a large and variable number of substances with lower relative molecular mass. Cellulose is the major component of both softwood and hardwood. Polyoses (hemicelluloses), which consist of five neutral sugar units, are present in larger amounts in hardwood than in softwood. The lignin content of softwood is higher than that of hardwood. The lower-molecular-mass substances significantly affect the properties of wood; these include substances extracted with nonpolar organic solvents (fatty acids, resin acids, waxes, alcohols, terpenes, sterols, steryl esters, and glycerols), substances extracted with polar organic solvents (tannins, flavonoids, quinones, and lignans), and water-soluble substances (carbohydrates, alkaloids, proteins, and inorganic material).

Wood dust also is characterized by its moisture content, with dry wood referring to wood with a moisture content of less than approximately 15% and moist wood referring to wood with a greater moisture content. Woodworking operations using dry wood generate more total dust and a greater amount of inhalable dust particles than those using moist wood (IARC 1995).

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Wood dust is usually produced in woodworking industries as a byproduct of manufacturing wood products and is not usually

produced for specific uses. However, one commercial use for wood dust is in wood composts (Weber *et al.* 1993). "Industrial roundwood" refers to categories of wood not used for fuel, which include sawn wood (54%), pulpwood (21%), poles and pit props (14%), and wood used for other purposes, such as particle board and fiberboard (11%) (IARC 1995).

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Wood dust is created when machines or tools are used to cut or shape wood materials. Industries in which large amounts of wood dust are produced include sawmills, dimension mills, furniture industries, cabinetmaking, and carpentry (IARC 1995).

Total estimated production values for wood used in industry in the United States for 1990 were 311.9 million cubic meters of softwood and 115 million cubic meters of hardwood (Demers *et al.* 1997).

Exposure

Exposure to wood dust occurs when individuals use machinery or tools to cut or shape wood. Breathing in the dust causes it to deposit in the nose, throat, and other airways. The amount of dust deposited within the airways depends on the size, shape, and density of the dust particles and the strength (turbulence and velocity) of the airflow. Particles with a diameter larger than 5 µm ("inspirable" particles) are deposited almost completely in the nose, while particles 0.5 µm to 5 µm in diameter ("respirable" particles) are deposited in the lower airways. Wood dust usually is measured as airborne dust concentrations, by particle size distribution, by type of wood, and by other characteristics of wood (IARC 1981, 1995).

Total airborne dust concentrations are described as mass per unit volume (usually milligrams per cubic meter). Wood dust generally is collected by a standard gravimetric method that involves using a sampling pump to collect a known volume of air through a special membrane filter contained in a plastic cassette. Some sampling studies reported that the particle size distribution varied according to the woodworking operation, with sanding producing smaller particles than sawing, but others found no consistent differences (IARC 1995). The majority of the wood dust mass was reported to be contributed by particles larger than 10 µm in aerodynamic diameter; however, between 61% and 65% of the particles by count measured between 1 and 5 µm in diameter (IARC 1995).

Exposure to wood dust also occurs through handling of compost containing wood dust. Wood compost materials consist of successive layers of chopped leaves, bark, and wood stored outdoors during spring where high rainfall is expected. Visible clouds of fine particulates are easily generated when the compost materials are agitated. Background concentrations of 0.32 mg/m^3 of respirable dust have been reported from samplers upwind from the compost pile. Routine exposures of 0.74 mg/m^3 of inspirable dust (> 5 µm) and 0.42 mg/m^3 of respirable dust (0.5 to 5 µm) were determined with samplers at the breathing zone level during loading and unloading of compost. The highest exposures were collected directly from the visible clouds generated by compost agitation and contained 149 mg/m^3 of inspirable and 83 mg/m^3 of respirable dust (Weber *et al.* 1993).

The National Occupational Exposure Survey (NOES), conducted by the National Institute for Occupational Safety and Health (NIOSH) from 1981 to 1983, estimated that approximately 600,000 workers were exposed to wood dust in the United States (IARC 1995, Noertjojo *et al.* 1996, RTECS 2003).

Jobs with high exposure to wood dust included sanders in the transportation equipment industry (unadjusted geometric mean = 17.5 mg/m^3), press operators in the wood products industry (12.3 mg/m^3), lathe operators in the furniture industry (7.46 mg/m^3), and sanders in the wood cabinet industry (5.83 mg/m^3). High exposures occurred in the chemical, petroleum, rubber, and plastics products industries, in which exposures occured in sanding, pattern making, and mill and saw operations. The lowest exposures occurred in industrial pattern-making facilities, paper and paperboard mills, schools and institutional training facilities, and veneer and plywood mills (Teschke *et al.* 1999).

Teschke *et al.* (1999) analyzed 1,632 measurements of personal time-weighted-average airborne wood dust concentrations in 609 establishments on 634 inspection visits that were reported to the Occupational Safety and Health Administration (OSHA) Integrated Management Information System between 1979 and 1997. Exposures ranged from less than 0.03 to 604 mg/m^3, with an arithmetic mean of 7.93 mg/m^3 and a geometric mean of 1.86 mg/m^3. Exposure levels have decreased significantly over time (the unadjusted geometric mean was 4.59 mg/m^3 in 1979 and 0.14 mg/m^3 in 1997).

Use of hand-held electric sanders has been identified as a particularly dusty process that will lead to dust exposure. Wood dust concentrations vary with type of dust extraction, amount of wood removed, and type of sander (Thorpe and Brown 1994). For electric belt sanders used to sand dowels, total dust concentrations ranged from 0.22 mg/m^3 with external dust extraction to 3.74 mg/m^3 without, and concentrations of respirable dust (0.5 to 5 µm) ranged from 0.003 to 0.936 mg/m^3 under the same conditions. Rotary sanders tested with flat wood samples produced total dust concentrations ranging from 0.002 (with extraction) to 0.699 mg/m^3 (without extraction) and concentrations of respirable dust from 0.001 (with extraction) to 0.088 mg/m^3 (without extraction). Comparable decreases in dust concentrations were observed for electrical orbital sanders used with dust extraction.

Regulations

OSHA

Permissible Exposure Limit (PEL) = 15 mg/m^3 (total); 5 mg/m^3 (respirable) (PEL based on the standard for *Particulates Not Otherwise Regulated*)

Guidelines

ACGIH

Threshold Limit Value - Time-Weighted Average Limit (TLV-TWA) = 1 mg/m^3 (certain hard woods such as beech and oak); 5 mg/m^3 (softwood)

Threshold Limit Value - Short Term Exposure Limit (TLV-STEL) = 10 mg/m^3 (softwood)

NIOSH

Recommended Exposure Limit (REL) = 1 mg/m^3

Listed as a potential occupational carcinogen

*There is no separate CAS registry number assigned to wood dust.

REFERENCES

Demers, P. A., P. Boffetta, M. Kogevinas, A. Blair, B. A. Miller, C. F. Robinson, *et al.* 1995. Pooled reanalysis of cancer mortality among five cohorts of workers in wood-related industries. Scand J Work Environ Health 21(3): 179-90.

Demers, P. A., K. Teschke and S. M. Kennedy. 1997. What to do about softwood? A review of respiratory effects and recommendations regarding exposure limits. Am J Ind Med 31(4): 385-98.

IARC. 1981. Wood, Leather and Some Associated Industries. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Humans, vol. 25. Lyon, France: International Agency for Research on Cancer.

IARC. 1995. Wood Dust. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Humans, vol. 62. Lyon, France: International Agency for Research on Cancer. 35-215 pp.

Noertjojo, H. K., H. Dimich-Ward, S. Peelen, M. Dittrick, S. M. Kennedy and M. Chan-Yeung. 1996. Western red cedar dust exposure and lung function: a dose-response relationship. Am J Respir Crit Care Med 154(4 Pt 1): 968-73.

NTP. 2000. Report on Carcinogens Background Document for Wood Dust. National Toxicology Program. http://ntp-server.niehs.nih.gov/newhomeroc/roc10/WD.pdf.

RTECS. 2003. Registry of Toxic Effects of Chemical Substances. Wood Dust. National Institute for Occupational Safety and Health.

Teschke, K., S. A. Marion, T. L. Vaughan, M. S. Morgan and J. Camp. 1999. Exposures to wood dust in U.S. industries and occupations, 1979 to 1997. Am J Ind Med 35(6): 581-9.

Thorpe, A. and R. C. Brown. 1994. Measurements of the effectiveness of dust extraction systems of hand sanders used on wood. Ann Occup Hyg 38(3): 279-302.

Weber, S., G. Kullman, E. Petsonk, W. G. Jones, S. Olenchock, W. Sorenson, *et al.* 1993. Organic dust exposures from compost handling: case presentation and respiratory exposure assessment. Am J Ind Med 24(4): 365-74.

Wood Dust*

Known to be a human carcinogen
First Listed in the *Tenth Report on Carcinogens* (2002)

Carcinogenicity

Wood dust is *known to be a human carcinogen* based on sufficient evidence of carcinogenicity from studies in humans. An association between wood dust exposure and cancer of the nasal cavity has been observed in many case reports, cohort studies, and case-control studies that specifically addressed nasal cancer. Strong and consistent associations with cancer of the nasal cavities and paranasal sinuses were observed both in studies of people whose occupations are associated with wood dust exposure and in studies that directly estimated wood dust exposure. Risks were highest for adenocarcinoma, particularly among European populations. Studies of U.S. populations showed similar significant positive associations. A pooled analysis of 12 case-control studies showed that the estimated relative risk of adenocarcinoma was very high (45.5) among men with the greatest exposure and that the risk increased with duration of exposure (Demers *et al.* 1995). The association between wood dust exposure and elevated nasal cancer risk in a large number of independent studies and with many different occupations in many countries strongly supports the conclusion that the increased risk is caused by wood dust rather than by simultaneous exposure(s) to other substances, such as formaldehyde or wood preservatives. Other types of nasal cancer (squamous-cell carcinoma of the nasal cavity) and cancer at other sites, including cancer of the nasopharynx and larynx and Hodgkin's disease, have been associated with exposure to wood dust in several epidemiologic studies. However, these findings were positive in some, but not all, studies, and the overall epidemiologic evidence is not strong enough or consistent enough to allow firm conclusions about the role of wood dust exposure in the development of cancer at these other sites (IARC 1995, NTP 2000).

There is inadequate evidence for the carcinogenicity of wood dust from studies in experimental animals. No tumors attributable to beech wood dust exposure were found in inhalation studies in female Sprague-Dawley rats, female Wistar rats, or male Syrian golden hamsters or in intraperitoneal injection studies in female Wistar rats. Similarly, inhalation exposure to wood dust did not significantly affect the incidence of tumors induced by simultaneous exposure to other compounds, including formaldehyde in female Sprague-Dawley rats, sidestream cigarette smoke in female Wistar rats, or *N*-nitrosodiethylamine in male Syrian golden hamsters. However, each of these studies suffers from various limitations, such as small numbers of animals or dose groups, short study duration, or inadequate data reporting (IARC 1995). Dermal exposure to a methanol extract of beech wood dust resulted in a significant dose-related increase in the incidence of skin tumors (squamous-cell carcinoma and papilloma) and mammary tumors (adenocarcinoma, adenoacanthoma, and mixed tumors) in female NMRI mice (IARC 1995).

Additional Information Relevant to Carcinogenicity

Studies using polar organic solvent extracts of some hardwood dusts have reported weak positive results for reverse mutations in *Salmonella typhimurium.* In addition, two chemicals found in wood, Δ^3 carene and quercetin, were found to be mutagenic in *Salmonella. In vitro* and *in vivo* tests in mammals, using polar organic solvent extracts of some wood dusts (beech and oak) have shown positive results for DNA damage, micronucleus induction, and chromosomal aberrations (primarily chromatid breaks). A higher rate of DNA damage (primarily single-strand breaks and DNA repair) and micronucleus induction has been observed in peripheral blood lymphocytes from people who are occupationally exposed to wood dust (IARC 1995, NTP 2000).

The roles of specific chemicals found in wood dust (either naturally in the wood or added to it in processing) in inducing cancer are not clear. The particulate nature of wood dust also may contribute to wood dust-associated carcinogenesis, because dust generated by woodworking typically consists of a high proportion of particles that are deposited in the nasal cavity. Some studies of people with long-term exposure to wood dust have found decreased mucociliary clearance and enhanced inflammatory reactions in the nasal cavity. Also, cellular changes (metaplasia and dysplasia) observed in the nasal mucosa of woodworkers and of laboratory animals may be precancerous (IARC 1995, NTP 2000).

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IARC. 1981. Wood, Leather and Some Associated Industries. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Humans, vol. 25. Lyon, France: International Agency for Research on Cancer.

IARC. 1995. Wood Dust. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Humans, vol. 62. Lyon, France: International Agency for Research on Cancer. 35-215 pp.

Noertjojo, H. K., H. Dimich-Ward, S. Peelen, M. Dittrick, S. M. Kennedy and M. Chan-Yeung. 1996. Western red cedar dust exposure and lung function: a dose-response relationship. Am J Respir Crit Care Med 154(4 Pt 1): 968-73.

NTP. 2000. Report on Carcinogens Background Document for Wood Dust. National Toxicology Program. http://ntp-server.niehs.nih.gov/newhomeroc/roc10/WD.pdf.

RTECS. 2003. Registry of Toxic Effects of Chemical Substances. Wood Dust. National Institute for Occupational Safety and Health.

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