GENERAL REMARKS

This forty-seventh volume of the *IARC Monographs* comprises six monographs on organic solvents, one on a solvent stabilizer, three on resin monomers and modifiers, two on pigments and one on occupational exposures in paint manufacture and painting.

Of the solvents, petroleum solvents, toluene and xylene are used primarily in paints. Cyclohexanone is used primarily as an intermediate in the production of nylon, although it may be used in some paint products. Dimethylformamide is a polymer and resin solvent, and morpholine is used mainly as an intermediate in the production of rubber chemicals and as a corrosion inhibitor. 1,2-Epoxybutane is used as a solvent stabilizer, particularly in trichloroethylene. Of the resin monomers, bis(2,3-epoxycyclopentyl)ether was used as a resin modifier. Glycidyl ethers have been used similarly; bisphenol A diglycidyl ether is a basic component of many epoxy paints, which polymerizes when the uncured resin is mixed with a curing agent. Phenol was a common resin monomer used in paints and lacquers when phenolformaldehyde resins were in wide use; such resins are still used to glue plywood and other wood products, but other resins have replaced them for the most part in modern paint products. Antimony trioxide is used mainly in fire retardants; both antimony trioxide and antimony trisulfide are used as paint pigments. Titanium dioxide is the most common white pigment used in paints.

The monograph on occupational exposures in paint manufacture and painting covers four broad categories of industry: manufacture of paints and related products; construction painting; painting and related operations in the furniture industry; and painting in the metal industry, including painting of cars and other vehicles. 'Painting' includes lacquering, varnishing and paint removal; preparation is also involved in painting activities. The few studies on radium dial painting were excluded because this activity is not usually considered as one of the painting trades. The carcinogenic risks of paint manufacture and of painting have not been evaluated previously; however, chemical agents to which employees working in painting trades may be exposed have been, and the evaluations of these compounds are presented in Table 1.

Only limited information is available about the extent of exposure to the agents covered by the present volume. The numbers of potentially exposed workers cited in the individual monographs are estimations based on two field studies conducted by the National Institute for Occupational Safety and Health (1974, 1983) in the USA. These estimates depend on the methods used in the two surveys and cannot be extrapolated to provide worldwide figures.

The monograph on petroleum solvents covers marketable hydrocarbon mixtures derived from petroleum that are used mainly as solvents. It supplements three previous

Table 1. Agents encountered in the painting trades that have been evaluated for carcinogenicity in *IARC Monographs* Volumes 1–47

Agent[a]	Degree of evidence for carcinogenicity[b]		Overall evaluation[b]	IARC Vol. (year)
	Human	Animal		
Acrylonitrile	L	S	2A	19 (1979)
Antimony trioxide	I	S	2B	47 (1989)
Antimony trisulfide	I	L	3	47 (1989)
Arsenic and arsenic compounds	S	L	1[c]	23 (1980)
Asbestos	S	S	1	14 (1977)
Attapulgite	I	L	3	42 (1987)
Benzene	S	S	1	29 (1982)
Benzoyl peroxide	I	I	3	36 (1985)
Bisphenol A diglycidyl ether	ND	L	3	47 (1989)
Cadmium and cadmium compounds	L	S	2A	11 (1976)
Carbon blacks	I	I	3	33 (1984)
Carbon-black extracts		S	2B	
Carbon tetrachloride	I	S	2B	20 (1979)
Chlorophenols	L		2B	41 (1981)
Pentachlorophenol		I		20 (1979)
Chromium, hexavalent compounds	S	S	1[c]	23 (1980)
Coal-tars	S	S	1	35 (1983)
Cyclohexanone	ND	I	3	47 (1989)
ortho-Dichlorobenzene	I	I	3	29 (1982)
1,2-Dichloroethane	ND	S	2B	20 (1979)
Dichloromethane	I	S	2B	41 (1981)
Di(2-ethylhexyl)phthalate	ND	S	2B	29 (1982)
Dimethylformamide	L	I	2B	47 (1989)
Epichlorohydrin	I	S	2A	11 (1976)
1,2-Epoxybutane	ND	L	3	47 (1987)
Ethyl acrylate	ND	S	2B	39 (1986)
Formaldehyde	L	S	2A	29 (1982)
Gasoline	I		2B	45 (1989)
Unleaded automotive gasoline		L		
Kerosene, straight-run and hydrotreated		L		45 (1989)
Lead and lead compounds (inorganic)	I	S	2B	23 (1980)
Melamine	ND	I	3	39 (1986)
4,4′-Methylenedianiline	ND	S	2B	39 (1986)
Methyl methacrylate	ND	I	3	19 (1979)
Nickel and nickel compounds	S	S	1[c]	11 (1976)
2-Nitropropane	ND	S	2B	29 (1982)
Petroleum solvents	I		3	47 (1989)
High-boilding aromatic solvents		I		
Special boiling-range solvents		ND		
White spirits		ND		

Table 1 (contd)

Agent[a]	Degree of evidence for carcinogenicity[b]		Overall evaluation[b]	IARC Vol. (year)
	Human	Animal		
meta-Phenylenediamine	ND	I	3	16 (1978)
Polychlorinated biphenyls	L	S	2A	18 (1978)
Polycyclic aromatic hydrocarbons	ND	I/L/S	3/2B/2A	32 (1983)
Polyvinyl acetate	ND	I	3	19 (1979)
Silica, crystalline	L	S	2A	42 (1987)
Styrene	I	L	2B	19 (1979)
Styrene–butadiene copolymers	ND	ND	3	19 (1979)
Styrene oxide	ND	S	2A	19 (1979)
Talc				42 (1987)
Not containing asbestiform fibres	I	I	3	
Containing asbestiform fibres	S	I	1	
Titanium dioxide	I	L	3	47 (1989)
Toluene	I	I	3	47 (1989)
Toluene diisocyanates	ND	S	2B	39 (1986)
1,1,1-Trichloroethane	ND	I	3	20 (1979)
Trichloroethylene	I	L	3	20 (1979)
Vinyl acetate	ND	I	3	39 (1986)
Xylene	I	I	3	47 (1989)

[a]Based on information provided in the monograph on paint manufacture and painting

[b]Based on *IARC Monographs* Suppl. 7 (IARC, 1987) and Volumes 45–47 (IARC, 1989a,b,c); ND, no adequate data; I, inadequate evidence; L, limited evidence; S, sufficient evidence. For definitions of the degrees of evidence and overall evaluations, see Preamble, pp. 27–30.

[c]The evaluation applies to the group of chemicals as a whole and not necessarily to all individual chemicals within the group.

IARC Monographs on petroleum products, which covered petroleum refining and petroleum fuels (IARC, 1989a), bitumens (IARC, 1985a) and mineral oils (IARC, 1984). The monograph on petroleum solvents excludes substances (e.g., toluene, xylenes, benzene and *n*-hexane) that are not generally classified as hydrocarbon mixtures, and it does not include hydrocarbon mixtures such as gasoline, jet fuel and kerosene, which were evaluated in 1988 (IARC, 1989a) and are used primarily as fuels and not as solvents.

The nomenclature and classification of petroleum solvents are not well defined and are not standardized throughout the world. The grouping adopted in this volume is common in Europe and is based on their boiling ranges and solvent strengths. However, the same product may be referred to by many names, and the same name may be used to refer to two very different products. Section 1 of the monograph on petroleum solvents lists commonly used names and synonyms and provides basic physicochemical data that may be used in interpreting the results of studies in other sections. In the sections on experimental and human studies of petroleum solvents, the name of the solvent given by the authors has been used.

Glycidyl ethers are used mainly as components and reactive modifiers of epoxy resins. Those considered in this volume were chosen on the basis that there is at least one study on carcinogenicity available. Diglycidyl resorcinol ether was evaluated previously (IARC, 1985b). Glycidyl ethers that are produced in high or moderate quantities and for which data on genetic or related effects were available were also considered. Bisphenol A diglycidyl ether is an epoxy compound that can be polymerized to a thermosetting resin and can therefore be considered an uncured epoxy resin. Concentrations of bisphenol A diglycidyl ether in epoxy products vary widely.

There was, in general, a paucity of studies of carcinogenicity in experimental animals for some of the most commonly used solvents, which are some of the most widely used chemicals worldwide. This problem is highlighted in the case of petroleum solvents: not a single publication on white spirits was available. A further difficulty was encountered in that the materials used in many investigations may have been commercial substances of variable composition.

Interpretation of epidemiological studies of carcinogenicity and of other toxic and genetic effects for solvents is complicated by the fact that many occupational groups (e.g., painters and lacquerers) are exposed not only to many solvents but also to other agents, as in many other occupations. When the exposure of a population was estimated quantitatively for a specific solvent, or when the agent was stated to be the main or one of the major solvents to which the study population was exposed, the study was included in the monograph on that agent. For sections on epidemiological studies of carcinogenicity in humans, studies were also allocated to different monographs solely on the basis of whether the substance was named as an exposure in the paper, regardless of the method of identifying the exposure or analysing the data. Some studies (e.g., on painters) were used in more than one monograph, and the same study often appears in many sections, giving the relevant outcomes of the same individuals but associated with different exposures. These are identified in the text. The studies now summarized in the monographs on some petroleum solvents, toluene and xylene are those in which the specific agents being considered are mentioned. They represent, however, selected studies in which details are given that suggest that exposure to more than one solvent is usual and that it would be difficult to separate out the effects of any single agent. Exposures that are specified in epidemiological studies of cancer have generally been estimated by an industrial hygienist on the basis of presumed exposures given in work histories or as mentioned by the subjects; the latter gives rise to serious problems of recall bias.

The studies of cancers and other effects in the children of exposed parents present particular problems, since risk may be due to exposures of the mother or father occurring before, during or after the pregnancy. Such timing is usually poorly identified and varies between studies, making comparison difficult.

The majority of the epidemiological studies included in the last monograph are on 'painters' described as such. Details of the length and extent of exposure and of the specific type of work done were rarely given or analysed separately. Data from cross-sectional studies of large numbers of deaths were used because painting is well identified as a trade; however, it should be noted that the occupation as stated on a death certificate is not necessarily

comparable to the census data that are used to derive expected numbers. In many case–control studies of specific cancer sites, painting was one of a list of occupational exposures considered; all studies in which findings in painters were mentioned have been included here, but there is no way of knowing how many other studies enquired about painting but did not present the results. It should also be noted that reports of 'exposure to paint' may include nonprofessional use of paints.

References

IARC (1984) *IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans*, Vol. 33, *Polynuclear Aromatic Compounds, Part 2, Carbon Blacks, Mineral Oils and Some Nitroarene Compounds*, Lyon, pp. 87–168

IARC (1985a) *IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans*, Vol. 35, *Polynuclear Aromatic Compounds, Part 4, Bitumens, Coal–tar and Derived Products, Shale–oils and Soots*, Lyon, pp. 39–81

IARC (1985b) *IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans*, Vol. 36, *Allyl Compounds, Aldehydes, Epoxides and Peroxides*, Lyon, pp. 181–188

IARC (1987) *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans*, Suppl. 7, *Overall Evaluations of Carcinogenicity: An Updating of* IARC Monographs *Volumes 1 to 42*, Lyon

IARC (1989a) *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans*, Vol. 45, *Occupational Exposures in Petroleum Refining; Crude Oil and Major Petroleum Fuels*, Lyon

IARC (1989b) *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans*, Vol. 46, *Diesel and Gasoline Engine Exhausts and Some Nitroarenes*, Lyon

IARC (1989c) *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans*, Vol. 47, *Some Organic Solvents, Resin Monomers and Related Compounds, Pigments and Occupational Exposures in Paint Manufacture and Painting*, Lyon

National Institute for Occupational Safety and Health (1974) *National Occupational Hazard Survey 1972–1974*, Cincinnati, OH

National Institute for Occupational Safety and Health (1983) *National Occupational Exposure Survey 1981–1983*, Cincinnati, OH