

## RESULTS AND CONCLUSIONS

The assessments of degrees of evidence for carcinogenicity to humans and in experimental animals and for activity in short-term tests, as well as the summary evaluations of carcinogenic risk to humans are given in Table 1.

*Group 1:* The Working Group concluded that the following 7 industrial processes and occupational exposures and 23 chemicals and groups of chemicals are causally associated with cancer in humans\*.

Industrial processes and occupational exposures:

- Auramine manufacture
- Boot and shoe manufacture and repair  
(certain occupations)
- Furniture manufacture
- Isopropyl alcohol manufacture  
(strong-acid process)
- Nickel refining
- Rubber industry (certain occupations)
- Underground haematite mining  
(with exposure to radon)

---

\* This list does not include known human carcinogens such as tobacco smoke, betel quid and alcoholic beverages, since they have not yet been covered in the *Monographs* programme.

## Chemicals and groups of chemicals:

4-Aminobiphenyl  
Analgesic mixtures containing phenacetin<sup>a</sup>  
Arsenic and arsenic compounds<sup>a</sup>  
Asbestos  
Azathioprine  
Benzene  
Benzidine  
*N,N*-Bis(2-chloroethyl)-2-naphthylamine (Chlornaphazine)  
Bis(chloromethyl)ether and technical-grade chloromethyl methyl ether  
1,4-Butanediol dimethanesulphonate (Myleran)  
Certain combined chemotherapy for lymphomas<sup>a</sup> (including MOPP<sup>b</sup>)  
Chlorambucil  
Chromium and certain chromium compounds<sup>a</sup>  
Conjugated oestrogens<sup>a</sup>  
Cyclophosphamide  
Diethylstilboestrol  
Melphalan  
Methoxsalen with ultra-violet A therapy (PUVA)  
Mustard gas  
2-Naphthylamine  
Soots, tars and oils<sup>a,c</sup>  
Tresulphan  
Vinyl chloride

*Group 2:* The following 61 chemicals, groups of chemicals or industrial processes are *probably* carcinogenic to humans

*Group 2A*

Acrylonitrile  
Aflatoxins  
Benzo[*a*]pyrene  
Beryllium and beryllium compounds<sup>a</sup>  
Combined oral contraceptives<sup>a</sup>  
Diethyl sulphate  
Dimethyl sulphate  
Manufacture of magenta<sup>a</sup>  
Nickel and certain nickel compounds  
Nitrogen mustard  
Oxymetholone  
Phenacetin  
Procarbazine  
*ortho*-Toluidine

<sup>a</sup> The compound(s) responsible for the carcinogenic effect in humans cannot be specified.

<sup>b</sup> Procarbazine, nitrogen mustard, vincristine and prednisone

<sup>c</sup> Mineral oils may vary in composition, particularly in relation to their content of carcinogenic polycyclic aromatic hydrocarbons.

*Group 2B*

Actinomycin D  
Adriamycin  
Amitrole  
Auramine (technical grade)  
Benzotrichloride  
Bischloroethyl nitrosourea (BCNU)  
Cadmium and cadmium compounds  
Carbon tetrachloride  
Chloramphenicol  
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU)  
Chloroform  
Chlorophenols (occupational exposure to)<sup>a</sup>  
Cisplatin  
Dacarbazine  
DDT  
3,3'-Dichlorobenzidine  
Dienoestrol  
3,3'-Dimethoxybenzidine (*ortho*-Dianisidine)  
Dimethylcarbamoyl chloride  
1,4-Dioxane  
Direct Black 38 (technical grade)  
Direct Blue 6 (technical grade)  
Direct Brown 95 (technical grade)  
Epichlorohydrin  
Ethinyloestradiol  
Ethylene dibromide  
Ethylene oxide  
Ethylene thiourea  
Formaldehyde (gas)  
Hydrazine  
Mestranol  
Metronidazole  
Norethisterone  
Oestradiol-17 $\beta$   
Oestrone  
Phenazopyridine  
Phenytoin  
Phenoxyacetic acid herbicides (occupational exposure to)<sup>a</sup>  
Polychlorinated biphenyls  
Progesterone  
Propylthiouracil  
Sequential oral contraceptives<sup>a</sup>  
Tetrachlorodibenzo-*para*-dioxin (TCDD)  
2,4,6-Trichlorophenol  
Tris(aziridinyl)-*para*-benzoquinone (Triaziquone)  
Tris(1-aziridinyl)phosphine sulphide (Thiotepa)  
Uracil mustard

*Group 3*: The remaining 64 chemicals, groups of chemicals, industrial processes and occupational exposures could not be classified as to their carcinogenicity to humans.

<sup>a</sup> The compound(s) responsible for the probable carcinogenic effect in humans cannot be specified.

## RESULTS AND CONCLUSIONS

17

Table 1. Summary evaluations of carcinogenic risk to humans from chemicals, industrial processes and industries\* based on evidence for carcinogenicity to humans and to animals and for activity in short-term tests†

Chemical, process or industry	Evidence for carcinogenicity in humans	Evidence for carcinogenicity in animals	Evidence for activity in short-term tests	Summary evaluation of carcinogenic risk to humans
Acrylonitrile	limited	sufficient	sufficient	2A
Actinomycin D	inadequate	limited	sufficient	2B
Adriamycin	inadequate	sufficient	sufficient	2B
Aflatoxins	limited	sufficient	sufficient	2A
Aldrin	inadequate	limited	inadequate	3
4-Aminobiphenyl	sufficient	sufficient	sufficient	1
Amitrole	inadequate	sufficient	inadequate	2B
Anaesthetics, volatile	inadequate	inadequate	inadequate	3
Analgesic mixtures containing phenacetin	sufficient	limited	no data	1
Phenacetin	limited	sufficient	limited	2A
Aniline	inadequate	limited	inadequate	3
Arsenic and certain arsenic compounds	sufficient	inadequate	limited	1
Asbestos	sufficient	sufficient	inadequate	1
Auramine (technical grade)	limited	limited	sufficient	2B
Manufacture of auramine	sufficient	-	-	1
Azathioprine	sufficient	limited	sufficient	1
Benzene	sufficient	limited	limited	1
Benzidine	sufficient	sufficient	sufficient	1
Benzidine-based dyes				
Direct Black 38 (technical grade)	inadequate	sufficient	inadequate	2B
Direct Blue 6 (technical grade)	inadequate	sufficient	no data	2B
Direct Brown 95 (technical grade)	inadequate	limited	no data	2B
Beryllium and beryllium compounds	limited	sufficient	inadequate	2A
<i>N,N</i> -Bis(2-chloroethyl)-2-naphthylamine (Chlornaphazine)	sufficient	limited	limited	1
Bischloroethyl nitrosourea (BCNU)	inadequate	sufficient	sufficient	2B
Bis(chloromethyl)ether and technical-grade chloromethylmethyl ether	sufficient	sufficient	limited	1

\* In *IARC Monographs* 1-29, for which data in humans were available† This table does not include known human carcinogens such as tobacco smoke, betel quid and alcohol beverages, since they have not yet been considered in the *IARC Monographs*.

Chemical, process or industry	Evidence for carcinogenicity in humans	Evidence for carcinogenicity in animals	Evidence for activity in short-term tests	Summary evaluation of carcinogenic risk to humans
Bleomycins	inadequate	inadequate	sufficient	3
1,4-Butanediol dimethanesulphonate (Myleran)	sufficient	limited	sufficient	1
Cadmium and cadmium compounds	limited	sufficient	inadequate	2B
Carbon tetrachloride	inadequate	sufficient	inadequate	2B
Certain combined chemotherapy for lymphomas (including MOPP)	sufficient	-	inadequate	1
Chlorambucil	sufficient	sufficient	sufficient	1
Chloramphenicol	limited	inadequate	inadequate	2B
Chlordane/Heptachlor	inadequate	limited	inadequate	3
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU)	inadequate	sufficient	sufficient	2B
Chlorinated toluenes (production of):				
Benzyl chloride	inadequate	limited	sufficient	3
Benzoyl chloride	inadequate	inadequate	inadequate	3
Benzal chloride	inadequate	limited	limited	3
Benzotrichloride	inadequate	sufficient	limited	2B
Chloroform	inadequate	sufficient	inadequate	2B
Chlorophenols (occupational exposure to)	limited	-	-	2B
Chloroprene	inadequate	inadequate	sufficient	3
Chromium and certain chromium compounds	sufficient	sufficient	sufficient (Cr VI) inadequate (Cr III)	1
Cisplatin	inadequate	limited	sufficient	2B
Clofibrate	inadequate	limited	inadequate	3
Clomiphene	inadequate	inadequate	no data	3
Cyclamates	inadequate	limited	inadequate	3
Cyclophosphamide	sufficient	sufficient	sufficient	1
2,4-D and esters (See also Phenoxyacetic acid herbicides, occupational exposure to)	inadequate	inadequate	inadequate	3
Dacarbazine	inadequate	sufficient	limited	2B
Dapsone	inadequate	limited	inadequate	3
DDT	inadequate	sufficient	inadequate	2B
<i>ortho</i> -Dichlorobenzene and <i>para</i> -Dichlorobenzene	inadequate	inadequate	inadequate	3

## RESULTS AND CONCLUSIONS

19

Chemical, process or industry	Evidence for carcinogenicity in humans	Evidence for carcinogenicity in animals	Evidence for activity in short-term tests	Summary evaluation of carcinogenic risk to humans
3,3'-Dichlorobenzidine	inadequate	sufficient	sufficient	2B
Dichloromethane	inadequate	inadequate	limited	3
Dieldrin	inadequate	limited	inadequate	3
Diethyl sulphate	limited	sufficient	sufficient	2A
3,3'-Dimethoxybenzidine ( <i>ortho</i> -Dianisidine)	inadequate	sufficient	limited	2B
Dimethylcarbamoyl chloride	inadequate	sufficient	sufficient	2B
Dimethyl sulphate	inadequate	sufficient	sufficient	2A
1,4-Dioxane	inadequate	sufficient	inadequate	2B
Epichlorohydrin	inadequate	sufficient	sufficient	2B
Ethylene dibromide	inadequate	sufficient	sufficient	2B
Ethylene oxide	inadequate	limited	sufficient	2B
Ethylene thiourea	inadequate	sufficient	limited	2B
5-Fluorouracil	inadequate	inadequate	limited	3
Formaldehyde (gas)	inadequate	sufficient	sufficient	2B
Hexachlorocyclohexane	inadequate	limited	inadequate	3
Hydralazine	inadequate	limited	sufficient	3
Hydrazine	inadequate	sufficient	sufficient	2B
Industries				
Boot and shoe manufacture and repair (certain occupations)	sufficient	-	-	1
Carpentry and joinery (certain exposures)	inadequate	-	-	3
Furniture manufacture	sufficient	-	-	1
Leather goods manufacture	inadequate	-	-	3
Leather tanning	inadequate	-	-	3
Lumber and sawmill industry	inadequate	-	-	3
Pulp and paper manufacture (certain exposures)	inadequate	-	-	3
Rubber industry (certain occupations)	sufficient	-	-	1
Iron dextran complex	inadequate	sufficient	inadequate	3
Isonicotinic acid hydrazide	inadequate	limited	limited	3
Lead and lead compounds	inadequate	sufficient (for some salts)	inadequate	3
Manufacture of isopropyl alcohol (strong-acid process)	sufficient	-	-	1
Isopropyl oils	inadequate	inadequate	no data	3
Manufacture of magenta	limited	-	-	2A
Magenta (technical grade)	inadequate	inadequate	inadequate	3
Melphalan	sufficient	sufficient	sufficient	1
6-Mercaptopurine	inadequate	inadequate	sufficient	3

Chemical, process or industry	Evidence for carcinogenicity in humans	Evidence for carcinogenicity in animals	Evidence for activity in short-term tests	Summary evaluation of carcinogenic risk to humans
Methotrexate	inadequate	inadequate	sufficient	3
Methoxsalen with ultraviolet A therapy (PUVA)	sufficient	sufficient	sufficient	1
Metronidazole	inadequate	sufficient	limited	2B
Mustard gas	sufficient	limited	sufficient	1
1-Naphthylamine	inadequate	inadequate	sufficient	3
2-Naphthylamine	sufficient	sufficient	sufficient	1
Nickel refining	sufficient	-	-	1
Nickel and certain nickel compounds	limited	sufficient	inadequate	2A
Nitrogen mustard (See also Certain combined chemotherapy for lymphomas)	inadequate	sufficient	sufficient	2A
Oestrogens and progestins				
Combined oral contraceptives	limited*	-	inadequate	2A
Sequential oral contraceptives	limited	-	-	2B
Other oestrogen-progestin combinations	inadequate	-	-	3
Conjugated oestrogens	sufficient	inadequate	inadequate	1
Oestrogens				
Dienoestrol	limited	inadequate	inadequate	2B
Diethylstilboestrol	sufficient	sufficient	inadequate	1
Ethinylloestradiol	inadequate	sufficient	inadequate	2B
Mestranol	inadequate	sufficient	inadequate	2B
Oestradiol-17 $\beta$	inadequate	sufficient	inadequate	2B
Oestrone	inadequate	sufficient	inadequate	2B
Progestins:				
Chlormadinone acetate	inadequate	limited	inadequate	3
Dimethisterone	inadequate	inadequate	inadequate	3
Ethinodiol diacetate	inadequate	limited	inadequate	3
17 $\alpha$ -Hydroxyprogesterone caproate	inadequate	inadequate	no data	3
Lynoestrenol	inadequate	inadequate	inadequate	3
Medroxyprogesterone acetate	inadequate	limited	inadequate	3
Megestrol acetate	inadequate	limited	inadequate	3
Norethisterone	inadequate	sufficient	inadequate	2B
Norethynodrel	inadequate	limited	inadequate	3
Norgestrel	inadequate	inadequate	no data	3
Progesterone	inadequate	sufficient	inadequate	2B

\* Sufficient for liver adenomas.

## RESULTS AND CONCLUSIONS

21

Chemical, process or industry	Evidence for carcinogenicity in humans	Evidence for carcinogenicity in animals	Evidence for activity in short-term tests	Summary evaluation of carcinogenic risk to humans
Oxymetholone	limited	no data	no data	2A
Pentachlorophenol (See also Chlorophenols, occupational exposure to)	inadequate	inadequate	inadequate	3
Phenazopyridine	inadequate	sufficient	no data	2B
Phenelzine	inadequate	limited	inadequate	3
Phenobarbital	inadequate	limited	inadequate	3
Phenoxyacetic acid herbicides (occupational exposure to)	limited	-	-	2B
Phenylbutazone	inadequate	no data	inadequate	3
<i>N</i> -Phenyl-2-naphthylamine	inadequate	inadequate	inadequate	3
Phenytoin	limited	limited	inadequate	2B
Polychlorinated biphenyls	inadequate	sufficient	inadequate	2B
Prednisone (See also Certain combined chemotherapy for lymphomas)	inadequate	inadequate	inadequate	3
Procarbazine (See also Certain combined chemotherapy for lymphomas)	inadequate	sufficient	sufficient	2A
Propylthiouracil	inadequate	sufficient	no data	2B
Reserpine	inadequate	limited	inadequate	3
Saccharin	inadequate	limited	inadequate	3
Soots, tars and oils	sufficient	sufficient	-	1
Benzo[ <i>a</i> ]pyrene	inadequate	sufficient	sufficient	2A
Spirolactone	inadequate	limited	no data	3
Styrene	inadequate	limited	sufficient	3
Styrene oxide	inadequate	limited	sufficient	3
Sulfafurazole	inadequate	inadequate	inadequate	3
Sulfamethoxazole	inadequate	limited	inadequate	3
2,4,5-T and esters (See also Phenoxyacetic acid herbicides, occupational exposure to)	inadequate	inadequate	inadequate	3
Tetrachlorodibenzo- <i>para</i> -dioxin (TCDD)	inadequate	sufficient	inadequate	2B
Tetrachloroethylene	inadequate	limited	inadequate	3
<i>ortho</i> -Toluidine	inadequate	sufficient	sufficient	2A
Treosulphan	sufficient	no data	inadequate	1
Trichloroethylene	inadequate	limited	inadequate	3
2,4,5-Trichlorophenol (See also Chlorophenols, occupational exposure to)	inadequate	inadequate	no data	3
2,4,6-Trichlorophenol (See also Chlorophenols, occupational exposure to)	inadequate	sufficient	no data	2B



Chemical, process or industry	Evidence for carcinogenicity in humans	Evidence for carcinogenicity in animals	Evidence for activity in short-term tests	Summary evaluation of carcinogenic risk to humans
Tris(aziridiny)- <i>para</i> -benzoquone (Triaziquone)	inadequate	limited	sufficient	2B
Tris(1-aziridinyl)phosphine sulphide (Thiotepa)	inadequate	sufficient	sufficient	2B
Underground haematite mining (with exposure to radon)	sufficient	-	-	1
Haematite	inadequate	inadequate	inadequate	3
Uracil mustard	inadequate	sufficient	sufficient	2B
Vinblastine	inadequate	inadequate	inadequate	3
Vincristine (See also Certain combined chemotherapy for lymphomas)	inadequate	inadequate	inadequate	3
Vinyl chloride	sufficient	sufficient	sufficient	1
Vinylidene chloride	inadequate	limited	sufficient	3