



WORLD HEALTH ORGANIZATION  
INTERNATIONAL AGENCY FOR RESEARCH ON CANCER

IARC Monographs on the Evaluation of Carcinogenic Risks to Humans

## Volume 3

# Certain Polycyclic Aromatic Hydrocarbons and Heterocyclic Compounds

### Summary of Data Reported and Evaluation

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#### Polycyclic Aromatic Hydrocarbons

Benz(*a*)anthracene  
Benzo(*b*)fluoranthene  
Benzo(*j*)fluoranthene  
Benzo(*a*)pyrene  
Benzo(*e*)pyrene  
Chrysene  
Dibenz(*a,h*)anthracene  
Dibenzo(*h,rst*)pentaphene  
Dibenzo(*a,e*)pyrene  
Dibenzo(*a,h*)pyrene  
Dibenzo(*a,i*)pyrene  
Dibenzo(*a,l*)pyrene  
Indeno(1,2,3-*cd*)pyrene

#### Heterocyclic Compounds

Benz(*c*)acridine  
Dibenz(*a,h*)acridine  
Dibenz(*a,j*)acridine  
7*H*-Dibenzo(*c,g*)carbazole

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# BENZ(a)ANTHRACENE

VOL.: 3 (1973) (p. 45)

## 5. Summary of Data Reported and Evaluation

### 5.1 Animal carcinogenicity data

Benz(a)anthracene given by several routes of administration has proved to be carcinogenic in the mouse. It produced hepatomas and lung adenomas following repeated oral administration to young mice. In a parallel experiment with 3-methylcholanthrene, the carcinogenic effect upon the liver and lung was similar for the two compounds at the same dose level. In the same experiment, benz(a)anthracene did not produce tumours of the gastrointestinal tract, whereas 3-methylcholanthrene induced them consistently.

Benz(a)anthracene is a complete carcinogen for the mouse skin. The fact that the tumour yield was higher when using a dodecane solution than with toluene is related to the co-carcinogenic effect of dodecane. Benzo(a)pyrene given at a lower dose level produced more skin tumours with a shorter latency period than did benz(a)anthracene. Benz(a)anthracene is also an initiator of skin carcinogenesis in mice.

Benz(a)anthracene produced tumours in mice following s.c. injections. Fifty µg benz(a)anthracene was the lowest dose tested, and it was effective in newborn and in adult animals. It produced bladder tumours in mice following implantation.

It has not been adequately tested in other species.

### 5.2 Human carcinogenicity data

No case reports or epidemiological studies on the significance of benz(a)anthracene exposure to man are available. However, coal-tar and other materials which are known to be carcinogenic to man may contain benz(a)anthracene. The substance has also been detected in other environmental situations. The possible contribution of polycyclic aromatic hydrocarbons from some environmental sources to the overall carcinogenic risk to man is discussed in the General Remarks.

**Subsequent evaluations:** [Vol. 32 \(1983\)](#); [Suppl. 7 \(1987\)](#) (p. 58: **Group 2A**)

For definition of Groups, see [Preamble Evaluation](#).

# BENZO(*b*)FLUORANTHENE

VOL.: 3 (1973) (p. 69)

## 5. Summary of Data Reported and Evaluation

### 5.1 Animal carcinogenicity data

Benzo(*b*)fluoranthene has produced skin tumours in mice following repeated skin paintings. The lowest carcinogenic dose for the mouse skin was at least ten times higher than that of benzo(*a*)pyrene. Benzo(*b*)fluoranthene is also an initiator of skin carcinogenesis in mice and produces local sarcomas after s.c. injections. It has not been tested by other routes in the mouse or in other species.

### 5.2 Human carcinogenicity data

No case reports or epidemiological studies on the significance of benzo(*b*)fluoranthene exposure to man are available. However, coal-tar and other materials which are known to be carcinogenic to man may contain benzo(*b*)fluoranthene. The substance has also been detected in other environmental situations. The possible contribution of polycyclic aromatic hydrocarbons from some environmental sources to the overall carcinogenic risk to man is discussed in the General Remarks.

**Subsequent evaluations:** [Vol. 32 \(1983\)](#); Suppl. 7 (1987) (p. 58: **Group 2B**)

For definition of Groups, see [Preamble Evaluation](#).

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Last updated: 16 March 1998

# BENZO(j)FLUORANTHENE

VOL.: 3 (1973) (p. 82)

## 5. Summary of Data Reported and Evaluation

### 5.1 Animal carcinogenicity data

Benzo(j)fluoranthene has only been tested in mice by repeated skin painting, in which a high incidence of skin carcinomas was obtained. It has not been tested by other routes in the mouse or in other species.

### 5.2 Human carcinogenicity data

No case reports or epidemiological studies on the significance of benzo(j)fluoranthene exposure to man are available. However, coal-tar and other materials which are known to be carcinogenic to man may contain benzo(j)fluoranthene. The substance has also been detected in other environmental situations. The possible contribution of polycyclic aromatic hydrocarbons from some environmental sources to the overall carcinogenic risk to man is discussed in the General Remarks.

**Subsequent evaluations:** [Vol. 32 \(1983\)](#); Suppl. 7 (1987) (p. 58: **Group 2B**)

For definition of Groups, see [Preamble Evaluation](#).

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# BENZO(a)PYRENE

VOL.: 3 (1973) (p. 91)

## 5. Summary of Data Reported and Evaluation

### 5.1 Animal carcinogenicity data

Benzo(a)pyrene has produced tumours in all of the nine species for which data are reported following different administrations including oral, skin and intratracheal routes. It has both a local and a systemic carcinogenic effect. In sub-human primates, there is convincing evidence of the ability of benzo(a)pyrene to produce local sarcomas following repeated subcutaneous injections and lung carcinomas following intratracheal instillation. It is also an initiator of skin carcinogenesis in mice, and it is carcinogenic in single-dose experiments and following prenatal exposure.

In skin carcinogenesis studies in mice benzo(a)pyrene was consistently found to produce more tumours in a shorter period of time than did other polycyclic aromatic hydrocarbons, with the possible exception of dibenzo(a,h)anthracene (see other monographs published in this volume). In a dose-response study involving subcutaneous injection in mice, the minimal dose at which carcinogenicity was detected was higher for benzo(a)pyrene than for dibenzo(a,h)anthracene and for 3-methylcholanthrene. However, the latent periods were shorter for benzo(a)pyrene than for dibenzo(a,h)anthracene. In studies using intratracheal administration, benzo(a)pyrene appeared to be less effective than 7H-dibenzo(c,g)carbazole in the hamster.

### 5.2 Human carcinogenicity data

No epidemiological studies on the significance of benzo(a)pyrene exposure to man are available, and the studies reported in section 3.3 are insufficient to prove that B(a)P is carcinogenic for man. However, coal-tar and other materials which are known to be carcinogenic to man may contain benzo(a)pyrene. The substance has also been detected in other environmental situations. The possible contribution of polycyclic aromatic hydrocarbons from some environmental sources to the overall carcinogenic risk to man is discussed in the General Remarks. Similarities of metabolism of benzo(a)pyrene in human and mouse cells cultured *in vitro* have been reported. The relevance of this finding for evaluating the risk for man cannot yet be assessed.

**Subsequent evaluations:** [Vol. 32 \(1983\)](#); Suppl. 7 (1987) (p. 58: **Group 2A**)

For definition of Groups, see [Preamble Evaluation](#).

# BENZO(e)PYRENE

VOL.: 3 (1973) (p. 137)

## 5. Summary of Data Reported and Evaluation

### 5.1 Animal carcinogenicity data

The data are confined to two skin painting experiments in mice in which benzo(e)pyrene evoked a weaker response than either benzo(a)pyrene or dibenz(a,h)anthracene. Benzo(e)pyrene does not appear to be an initiator of skin carcinogenesis in mice. It has not been tested by other routes in the mouse or in other species.

### 5.2 Human carcinogenicity data

No case reports or epidemiological studies on the significance of benzo(e)pyrene exposure to man are available. However, coal-tar and other materials which are known to be carcinogenic to man may contain benzo(e)pyrene. The substance has also been detected in other environmental situations. The possible contribution of polycyclic aromatic hydrocarbons from some environmental sources to the overall carcinogenic risk to man is discussed in the General Remarks.

**Subsequent evaluations:** [Vol. 32 \(1983\)](#); Suppl. 7 (1987) (p. 58: **Group 3**)

For definition of Groups, see [Preamble Evaluation](#).

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# CHRYSENE

VOL.: 3 (1973) (p. 159)

## 5. Summary of Data Reported and Evaluation

### 5.1 Animal carcinogenicity data

Chrysene has produced skin tumours in mice following repeated paintings in the only study in which a concentration as high as 1% in acetone was used. It is also an initiator of skin carcinogenesis in mice, whereas a single painting with 1 mg chrysene with no further treatment did not induce tumours.

High doses (2-20 mg) given by s.c. injection to mice produced a low incidence of tumours with a long induction time.

It has not been adequately tested by other routes or in other species.

### 5.2 Human carcinogenicity data

No case reports or epidemiological studies on the significance of chrysene exposure to man are available. However, coal-tar and other materials which are known to be carcinogenic to man may contain chrysene. The substance has also been detected in other environmental situations. The possible contribution of polycyclic aromatic hydrocarbons from some environmental sources to the overall carcinogenic risk to man is discussed in the General Remarks.

**Subsequent evaluations:** [Vol. 32 \(1983\)](#); Suppl. 7 (1987) (p. 60: **Group 3**)

For definition of Groups, see [Preamble Evaluation](#).

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# DIBENZ(*a,h*)ANTHRACENE

VOL.: 3 (1973) (p. 178)

## 5. Summary of Data Reported and Evaluation

### 5.1 Animal carcinogenicity data

Dibenz(*a,h*)anthracene has produced tumours by different routes of administration in mice, rats, guinea pigs, frogs, pigeons and chickens. It has both local and systemic carcinogenic effects.

On oral administration, it produced tumours of the forestomach in the mouse; intratracheal administration to rats produced lung tumours.

In repeated skin painting experiments in mice, dibenz(*a,h*)anthracene and benzo(*a*)pyrene appeared to be equally effective. In a dose-response study on s.c. carcinogenicity with dibenz(*a,h*)anthracene, benzo(*a*)pyrene and 3-methylcholanthrene, dibenz(*a,h*)anthracene was shown to be effective at a lower dose than that effective for benzo(*a*)pyrene or for 3-methylcholanthrene; its latent period, however, was longer. Dibenz(*a,h*)anthracene induced local sarcomas and increased the incidence of lung adenomas following a single s.c. injection in newborn mice at dose levels which were ineffective with 3-methylcholanthrene.

It has not been adequately tested in other species.

### 5.2 Human carcinogenicity data

No case reports or epidemiological studies on the significance of dibenz(*a,h*)anthracene exposure to man are available. However, coal-tar and other materials which are known to be carcinogenic to man may contain dibenz(*a,h*)anthracene. The substance has also been detected in other environmental situations. The possible contribution of polycyclic aromatic hydrocarbons from some environmental sources to the overall carcinogenic risk to man is discussed in the General Remarks.

**Subsequent evaluation:** [Vol. 32 \(1983\)](#); Suppl. 7 (1987) (p. 61: **Group 2A**)

For definition of Groups, see [Preamble Evaluation](#).

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# DIBENZO(*h,rst*)PENTAPHENE

**VOL.:** 3 (1973) (p. 197)

**CAS No.:** 194-47-2

## 5. Summary of Data Reported and Evaluation

### 5.1 Animal carcinogenicity data

In the only experiment reported, subcutaneous injection in mice induced sarcomas. It has not been tested by other routes in the mouse or in other species.

### 5.2 Human carcinogenicity data

No case reports or epidemiological studies on the significance of dibenzo(*h,rst*)pentaphene exposure to man are available. Only one study reports its occurrence in urban air.

**Subsequent evaluation:** Suppl. 7 (1987) (p. 62: **Group 3**)

For definition of Groups, see [Preamble Evaluation](#).

### Synonyms for Dibenzo(*h,rst*)pentaphene

- Tribenzo(*a,e,i*)pyrene
- (1,2,4,5,7,8)-Tribenzopyrene
- (1,2,4,5,8,9)-Tribenzopyrene

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# DIBENZO(a,e)PYRENE

VOL.: 3 (1973) (p. 201)

## 5. Summary of Data Reported and Evaluation

### 5.1 Animal carcinogenicity data

Dibenzo(a,e)pyrene has produced tumours in mice following skin paintings and s.c. injection. In skin painting experiments, dibenzo(a,e)pyrene was less active than benzo(a)pyrene. It has not been tested by other routes in the mouse or in other species.

### 5.2 Human carcinogenicity data

No case reports or epidemiological studies on the significance of dibenzo(a,e)pyrene exposure to man are available. The only reported occurrence of this substance was in the exhaust of internal combustion engines.

**Subsequent evaluations:** [Vol. 32 \(1983\)](#); Suppl. 7 (1987) (p. 62: **Group 2B**)

For definition of Groups, see [Preamble Evaluation](#).

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# DIBENZO(*a,h*)PYRENE

VOL.: 3 (1973) (p. 207)

## 5. Summary of Data Reported and Evaluation

### 5.1 Animal carcinogenicity data

Carcinogenic effects of dibenzo(*a,h*)pyrene were demonstrated following repeated skin painting in mice and injections in mice and rats. In the skin painting experiment, it was less active than benzo(*a*)pyrene. It has not been tested by other routes or in other species.

### 5.2 Human carcinogenicity data

No case reports or epidemiological studies on the significance of dibenzo(*a,h*)pyrene exposure to man are available. However, coal-tar and other materials which are known to be carcinogenic to man may contain dibenzo(*a,h*)pyrene. The substance has also been detected in other environmental situations. The possible contribution of polycyclic aromatic hydrocarbons from some environmental sources to the overall carcinogenic risk to man is discussed in the General Remarks.

**Subsequent evaluations:** [Vol. 32 \(1983\)](#); Suppl. 7 (1987) (p. 62: **Group 2B**)

For definition of Groups, see [Preamble Evaluation](#).

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# DIBENZO(a,i)PYRENE

VOL.: 3 (1973) (p. 215)

## 5. Summary of Data Reported and Evaluation

### 5.1 Animal carcinogenicity data

Subcutaneous injections of dibenzo(a,i)pyrene resulted in the rapid appearance of local sarcomas in the hamster and the mouse. The smallest single dose which produced sarcomas in mice was 50 µg. Repeated skin application in mice was also effective, but dibenzo(a,i)pyrene was less active than benzo(a)pyrene. It has not been tested by other routes or in other species.

### 5.2 Human carcinogenicity data

No case reports or epidemiological studies on the significance of dibenzo(a,i)pyrene exposure to man are available. However, coal-tar and other materials which are known to be carcinogenic to man may contain dibenzo(a,i)pyrene. The substance has also been detected in other environmental situations. The possible contribution of polycyclic aromatic hydrocarbons from some environmental sources to the overall carcinogenic risk to man is discussed in the General Remarks.

**Subsequent evaluations:** [Vol. 32 \(1983\)](#); Suppl. 7 (1987) (p. 62: **Group 2B**)

For definition of Groups, see [Preamble Evaluation](#).

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# DIBENZO(a,l)PYRENE

VOL.: 3 (1973) (p. 224)

## 5. Summary of Data Reported and Evaluation

### 5.1 Animal carcinogenicity data

Because of an error in identification, early experiments supposedly made with dibenzo(a,l)pyrene did not in fact deal with this compound. In the only study actually carried out with dibenzo(a,l)pyrene, sarcomas were induced in all animals following subcutaneous administration to mice. It has not been tested by other routes in mice or in other species.

### 5.2 Human carcinogenicity data

No case reports or epidemiological studies on the significance of dibenzo(a,l)pyrene exposure to man are available. It is likely that it occurs in the environment, but the data available cannot be interpreted because of the identification problem mentioned above.

**Subsequent evaluations:** [Vol. 32 \(1983\)](#); Suppl. 7 (1987) (p. 62: **Group 2B**)

For definition of Groups, see [Preamble Evaluation](#).

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# INDENO(1,2,3-*cd*)PYRENE

VOL.: 3 (1973) (p. 229)

## 5. Summary of Data Reported and Evaluation

### 5.1 Animal carcinogenicity data

Indeno(1,2,3-*cd*)pyrene is a complete carcinogen and an initiator for skin carcinogenesis in the mouse. It produces local sarcomas in the same species after subcutaneous injection. It seems to be of lower potency as a skin carcinogen than benzo(*a*)pyrene. It has not been tested by other routes in the mouse or in other species.

### 5.2 Human carcinogenicity data

No case reports or epidemiological studies on the significance of indeno(1,2,3-*cd*)pyrene exposure to man are available. However, coal-tar and other materials which are known to be carcinogenic to man may contain indeno(1,2,3-*cd*)pyrene. The substance has also been detected in other environmental situations. The possible contribution of polycyclic aromatic hydrocarbons from some environmental sources to the overall carcinogenic risk to man is discussed in the General Remarks.

**Subsequent evaluations:** [Vol. 32 \(1983\)](#); Suppl. 7 (1987) (p. 64: **Group 2B**)

For definition of Groups, see [Preamble Evaluation](#).

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# BENZ(c)ACRIDINE

VOL.: 3 (1973) (p. 241)

## 5. Summary of Data Reported and Evaluation

### 5.1 Animal carcinogenicity data

Benz(c)acridine produced skin tumours in mice treated topically and bladder tumours in rats following local paraffin wax pellet implantation. It has not been tested in other species or by other routes.

### 5.2 Human carcinogenicity data

No case reports or epidemiological studies on the significance of benz(c)acridine exposure to man are available. However, coal-tar and other materials which are known to be carcinogenic to man may contain benz(c)acridine. The substance has also been detected in other environmental situations. The possible contribution of heterocyclic compounds from some environmental sources to the overall carcinogenic risk to man is discussed in the General Remarks.

**Subsequent evaluation:** [Vol. 32 \(1983\)](#); Suppl. 7 (1987) (p. 58: **Group 3**)

For definition of Groups, see [Preamble Evaluation](#).

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# DIBENZ(*a,h*)ACRIDINE

VOL.: 3 (1973) (p. 247)

## 5. Summary of Data Reported and Evaluation

### 5.1 Animal carcinogenicity data

In mice, painting with dibenz(*a,h*)acridine induces skin tumours. Subcutaneous administration to mice induced local sarcomas and increased the incidence of lung tumours. It has not been tested adequately by other routes in the mouse and not at all in other species.

### 5.2 Human carcinogenicity data

No case reports or epidemiological studies on the significance of dibenz(*a,h*)acridine exposure to man are available. However, coal-tar and other materials which are known to be carcinogenic to man may contain dibenz(*a,h*)acridine. The substance has also been detected in other environmental situations. The possible contributions of heterocyclic compounds from some environmental sources to the overall carcinogenic risk to man is discussed in the General Remarks.

**Subsequent evaluations:** [Vol. 32 \(1983\)](#); Suppl. 7 (1987) (p. 61: **Group 2B**)

For definition of Groups, see [Preamble Evaluation](#).

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Last updated: 16 March 1998

# DIBENZ(*a,j*)ACRIDINE

VOL.: 3 (1973) (p. 254)

## 5. Summary of Data Reported and Evaluation

### 5.1 Animal carcinogenicity data

Dibenz(*a,j*)acridine induced skin tumours in mice following topical application and produced local sarcomas at the highest dose tested following subcutaneous administration. It increased the incidence of lung tumours after s.c. administration. Negative results were obtained by the oral route in mouse, but the test was inadequate because of the small number of animals. It has not been tested in other species.

### 5.2 Human carcinogenicity data

No case reports or epidemiological studies on the significance of dibenz(*a,j*)acridine exposure to man are available. However, coal-tar and other materials which are known to be carcinogenic to man may contain dibenz(*a,j*)acridine. The substance has also been detected in other environmental situations. The possible contribution of heterocyclic compounds from some environmental sources to the overall carcinogenic risk to man is discussed in the General Remarks.

**Subsequent evaluations:** [Vol. 32 \(1983\)](#); Suppl. 7 (1987) (p. 61: **Group 2B**)

For definition of Groups, see [Preamble Evaluation](#).

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# 7H-DIBENZO(c,g)CARBAZOLE

VOL.: 3 (1973) (p. 260)

## 5. Summary of Data Reported and Evaluation

### 5.1 Animal carcinogenicity data

7H-Dibenzo(c,g)carbazole is carcinogenic in the mouse, rat, hamster and possibly in the dog. It has both a local and systemic carcinogenic effect. Following oral administration in the mouse, forestomach tumours and hepatomas occurred; intratracheal administration to hamsters produced tumours of the respiratory tract. In comparison with benzo(a)pyrene, 7H-dibenzo(c,g)carbazole appears to be a stronger respiratory tract carcinogen for the hamster.

### 5.2 Human carcinogenicity data

No case reports or epidemiological studies on the significance of 7H-dibenzo(c,g)carbazole exposure to man are available. The substance has been detected in cigarette tar. The possible contribution of heterocyclic compounds from some environmental sources to the overall carcinogenic risk to man is discussed in the General Remarks.

**Subsequent evaluations:** [Vol. 32 \(1983\)](#); Suppl. 7 (1987) (p. 61: **Group 2B**)

For definition of Groups, see [Preamble Evaluation](#).

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