SHALE-OILS (Group 1)

A. Evidence for carcinogenicity to humans (*sufficient*)

The association between shale-oils and skin cancers, particularly of the scrotum, was demonstrated by analyses of 65 cases of skin cancer, including 31 of the scrotum, from the Scottish shale-oil industry. In the UK, over 2000 cases of skin cancer ('mule-spinners' cancer') were recorded among cotton-textile workers and others exposed to lubricating oils (many of which are believed to have been shale-derived). The occupational etiology of these cases is supported by occupational mortality statistics for the UK and by an occupational comparison with fatal cases of penile cancer. In contrast, one study showed very few scrotal cancers among US cotton-textile workers employed in mills where shale-derived lubricants were not used. A cohort study of shale-oil workers in western USA showed statistically significant excesses of all cancers and of colon cancer, although data on duration and time since first exposure were not available. A cohort study of shale-oil workers in Estonia showed a significant excess of skin cancer but not of cancers at other sites[1]. A follow-up of 6064 men who had worked in the Scottish oil-shale industry between 1950 and 1962 showed a significant excess of skin cancer[2]. A case-control study of lung cancer in the shale area showed no association with work in the shale industry[2].

Two basal- and two squamous-cell carcinomas were found among 325 workers employed at an oil-shale demonstration facility during 1948-1969 in Utah, USA. The incidence was about that expected[3].

B. Evidence for carcinogenicity to animals (*sufficient*)

Inhalation of either raw oil shale or spent oil shale produced lung tumours in rats. Application of an extract of spent oil shale produced skin tumours in mice[1].

Skin application of crude oils from both low- and high-temperature retorting induced skin tumours in mice and rabbits; the high-temperature retorted oils had greater carcinogenic activity. A low-temperature crude oil produced lung tumours in mice after intratracheal instillation[1].

Various fractions of shale-oils were carcinogenic when applied to the skin of mice and rabbits[1].

Shale-oil distillates, residues, blends and commercial products of the oil-shale industry were tested in mice by skin application, producing skin tumours. Distillation fractions from less highly refined shale-oils were more carcinogenic than the more highly refined products[1].

C. Other relevant data

No data were available on the genetic and related effects of shale-oils in humans.

All shale-derived materials assayed in tests for genetic and related effects came from sources in the USA and were therefore all produced by low-temperature processes[4].

Chromosomal aberrations were induced in bone-marrow cells of rats following administration by gavage of a suspension of raw oil-shale. In-vitro tests of extracts of raw oil-shale in cultured rodent cells, yeast and bacteria gave negative results[4].

Preparations of spent oil-shale yielded negative results in an assay for chromosomal aberrations *in vivo* and in mutation assays with eukaryotic cells *in vitro*; contradictory results were obtained in bacterial mutation assays[4].

Preparations of shale-derived crude oils from various sources and retort processes gave both positive and negative results in assays for chromosomal effects in rodents *in vivo*. Two crude shale-oil preparations induced sister chromatid exchanges in cultured human lymphocytes; three others did not induce mitotic gene conversion in yeast. Shale-derived crude oils were mutagenic to cultured rodent cells, yeast and bacteria following metabolic or photoinduced activation[4].

As compared with the corresponding crude shale-oils, preparations of hydrotreated oils showed less activity or gave negative results in various short-term tests[4].

Oil-shale retort process-waters induced chromosomal aberrations, but not sister chromatid exchanges, in cells of mice treated *in vivo*, chromosomal aberrations in cultured rodent cells and mutation and DNA damage in cultured rodent cells and bacteria following metabolic activation or photoactivation[4].

Extracts of oil-shale ash were not mutagenic to fungi but were mutagenic to bacteria in the absence of a metabolic system[4].

References

[1]*IARC Monographs, 35*, 161-217, 243-247, 1985

[2]Miller, B.G., Cowie, H.A., Middleton, W.G. & Seaton, A. (1986) Epidemiologic studies of Scottish oil shale workers. III. Causes of death. *Am. J. ind. Med., 9*, 433-446

[3]Rom, W.N., Krueger, G., Zone, J., Attfield, M.D., Costello, J., Burkart, J. & Turner, E.R. (1985) Morbidity survey of US oil shale workers employed during 1948-1969. *Arch. environ. Health, 40*, 58-62

[4]*IARC Monographs, Suppl. 6*, 494, 1987