

SOOTS*

First Listed in the *First Annual Report on Carcinogens*

CARCINOGENICITY

Soots are *known to be human carcinogens* based on sufficient evidence of carcinogenicity in humans (IARC 1987). Evidence for an increased skin cancer risk, particularly of the scrotum, is demonstrated by numerous case reports, dating back over 200 years, among chimney sweeps. More recent cohort studies of mortality among chimney sweeps have shown a significantly increased risk of lung cancer. Supporting evidence for an association with lung cancer was provided by two earlier epidemiological studies. The potentially confounding and interactive effects of smoking could not be evaluated; however, cigarette smoking is not believed to have seriously biased these estimates. In addition to lung cancer, statistically significant excess mortality from esophageal cancer, primary liver cancer, and leukemia was found among chimney sweeps in one study (IARC 1987).

There is adequate evidence for the carcinogenicity of soot extracts, but inadequate evidence for the carcinogenicity of soots, in experimental animals (IARC 1985, 1987). In two studies in mice, when administered topically, a coal-derived soot extract induced skin carcinomas and papillomas in both male and female mice. Coal-derived soot was tested in two experiments in mice by whole-body exposure, but the studies were inadequate for evaluation. A wood-soot extract applied to the skin of mice was inadequately tested. In limited studies, subcutaneous implants of wood soot in female rats produced a few local sarcomas; similar implants in the scrotal sac of rats did not. An extract of fuel oil soot was inadequately tested by application to the skin of mice. Extracts of soot from the combustion of oil shale produced skin papillomas and carcinomas in mice after dermal application and lung carcinomas in rats after intratracheal instillation. Extracts of soot from the combustion of a heating oil produced from shale oil produced skin papillomas and carcinomas in mice in two experiments when applied to the skin (IARC 1987). Soots are known to contain a number of known carcinogens and potentially carcinogenic chemicals including arsenic, cadmium, chromium, nickel, benz[*a*]anthracene, benzo[*a*]pyrene, dibenz[*a,h*]anthracene, and indeno[1,2,3-*cd*]pyrene.

PROPERTIES

Soots are black particulates and are formed as unwanted by-products of combustion of organic materials such as coal, wood, fuel oil, waste oil, paper, plastics, and household refuse; therefore, the chemical composition and properties of soot are highly variable and depend on the type of starting material and the combustion conditions. These include the relative amount of carbon, type of particulate carbon, size and shape of the particle, and the types of organic and inorganic compounds adsorbed to the particle. In general, soots have a total carbon content of <60% and a high content of inorganic material and/or soluble organic fraction. The soluble organic fraction of soot may be extracted with organic solvents and consists of polycyclic aromatic compounds and their derivatives. Inorganic matter may include oxides, salts, metals, sulfur and nitrogen compounds, water, and other adsorbed liquids and gases. (IARC 1985, Watson and Valberg 2001).

* No separate CAS registry number is assigned to soots.

Soots are classified into four morphologically distinct forms: (1) aciniform carbon, (2) particulate carbonaceous xerogel, (3) carbon cenospheres, and (4) coke and char fragments. Aciniform carbons are aggregates of rounded particles fused together in random configurations and may resemble grape clusters. Although particulate emissions from fireplaces are composed largely of aciniform carbon, this type is uncommon in chimney soot. Xerogel particles form when organic materials deposited on aciniform carbon are heated causing the particulate aggregates to cement together. This type is common in chimney soot (IARC 1985).

Carbon cenospheres are formed when liquid drops undergo carbonization with little change in shape. They are hard, shiny, porous or hollow spheres and are particularly associated with combustion of heavy fuel-oil sprays. Coke and char fragments are common in chimney soots from domestic wood- or coal-burning fireplaces. They are fragments of carbonized wood or coal and range in size from μm to mm (IARC 1985).

USE

Soots are unwanted by-products and have limited uses; however, they have been used in the recovery of trace metals in the metallurgical industry and in horticulture. Weathered soot has been used as a fertilizer to provide small amounts of nitrogen and essential trace metals to plants. Further, the physical nature of soot deters slugs and its black color absorbs heat (IARC 1985).

PRODUCTION

Soots are not produced commercially. They are produced as unwanted by-products of the incomplete combustion or pyrolysis of carbon-containing materials (IARC 1985).

EXPOSURE

The primary routes of potential human exposure to soots are inhalation, ingestion, and dermal contact. There is potential occupational exposure to soot for chimney sweeps, heating-unit service personnel, brick masons and helpers, building demolition personnel, insulators, firefighters, metallurgical workers, horticulturists, and anyone who works where organic materials are burned. The general population is potentially exposed to soots from fireplaces, furnaces, engine exhaust, and particulate emissions from any combustion sources (IARC 1985).

REGULATIONS

EPA has prescribed guidelines for the thermal processing of solid wastes containing soot. Under the Resource Conservation and Recovery Act (RCRA), wastes containing soot are subject to reporting and record-keeping requirements under the hazardous waste disposal rule.

OSHA regulates soots as chemical hazards in laboratories under the Hazard Communication Standard. Regulations are summarized in Volume II, Table 162.

REFERENCES

IARC. International Agency for Research on Cancer. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Polynuclear Aromatic 4. Bitumens, Coal Tars and Derived Products, Shale Oils and Soots. Vol. 35. 271 pp. Lyon, France: IARC, 1985.

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