APPLICATION OF MUTAGENICITY TESTS FOR DETECTION AND SOURCE
ASSESSMENT OF GENOTOXIC AGENTS IN THE RUBBER WORK ATMOSPHERE

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INTRODUCTION

In 1954, the increased risks of developing urinary bladder tumors were established among rubber workers (Case and Hosker, 1954). Later, other cancer forms were reported to appear in excess among workers in this industry (Peters et al., 1976; Monson and Fine, 1978; Hakama and Kilpikari, in press). The earlier use of beta-naphthylamine as an antioxidant was probably the single cause of the bladder tumors. Dust has been suggested as the most probable cause of stomach cancer among workers in the weighing and mixing departments (Maisey, 1981). Exposure to hazardous substances in fumes generated during the vulcanization of rubber leads to an elevated risk of developing lung disease (Peters et al., 1976; Maisey, 1981). This exposure may also explain the enhanced lung cancer frequencies found among workers in the curing department (Fox et al., 1974).

The amounts and complexity of chemicals used and generated in the rubber manufacturing processes make a risk identification very difficult. A new approach to the problem of identifying noxious substances in polluted working environments uses short-term bioassays for mutagenicity and teratogenicity in combination with human monitoring and epidemiological programs. This work, undertaken as a Swedish-Finnish collaborative study between Wallenberg Laboratory, the University of Stockholm and the

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Institute of Occupational Health, Helsinki, can be divided into three major areas: (1) short-term bioassays -- Ames test, Drosophila (recessive lethals), hamster cells (HGPRT-point mutations), micronucleus test, and chicken embryo teratogenicity; (2) human monitoring -- urine (Ames test and tioether concentration) and blood (SCE in lymphocytes and chromosomal aberrations); and (3) epidemiology -- spontaneous abortions, malformations, and cancer.

Falck et al. (1980) have observed increased mutagenic activity in the urine of rubber workers as compared to a control group of office clerks. A number of substances used as rubber additives have been shown to be genotoxic in short-term bioassays (Hedenstedt et al., 1979; Hedenstedt et al., 1981; Donner, 1981). Mutagenic substances have been found especially among accelerators of the dithiocarbamatic type and among antioxidants. Many of these chemicals have melting points that admit vaporization at mixing and curing temperatures (approximately 100 to 220°C). Other additives, like soot and aromatic oils, may pose a risk by emitting polynuclear aromatic hydrocarbons. Volatilized rubber polymers seem to play an important role in the mutagenicity detected in the fumes (Hedenstedt et al., in press).

The present investigation using the Ames test was undertaken to determine to what extent additives and rubber materials in a number of different polymer types contribute to the total mutagenicity. The mutagenicity tests were conducted on condensed curing fumes generated in a laboratory. The chemical complexity of the condensates reported by others (Fraser and Rappaport, 1976; Willoughby and Lawson, 1979) was confirmed by gas chromatography (GC). Chemical separation of one chloroprene rubber condensate was performed in order of increasing polarity, and the fractions were tested for mutagenicity.

MATERIALS AND METHODS

Collection and Preparation of Samples

Industrial samples. Vulcanization fumes were filter collected from chloroprene rubber (CR) cured in a continuous process by heating to 220°C in a salt bath containing NaN03. Fumes were collected on glass-fiber filters outside the closed process using a high-volume sampler. The filters were continuously extracted with acetone for 18 h. The extracts were then concentrated by evaporation.