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The Finnish–Swedish project on genotoxic hazards in the rubber industry

Conclusions and recommendations

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The joint Finnish–Swedish project on genotoxic hazards in the rubber industry was carried out in 1979–1982 at three levels. First individual chemicals used in the rubber industry were tested. Then tests were made of complex mixtures of chemicals encountered at the worksites. Finally epidemiologic investigations were carried out and workers exposed to rubber chemicals were monitored. A final report on the project has already been published (1).

Extensive mutagenicity testing of a large number of individual chemicals was performed, particularly with *Salmonella*, but to some extent also with mammalian tests in vivo and in vitro, and with *Drosophila*. From this data it can be concluded that mutagenic compounds occur in essentially all groups of chemical additives – vulcanization chemicals, accelerators, antioxidants, retarders, carbon black, and highly aromatic oils. It should, however, be pointed out that among the additives there are also many nonmutagenic chem-

icals which may be used as replacements in case some mutagenic compounds are considered hazardous from a genotoxic point of view.

Particular attention has been paid to one group of chemicals, ie, thiurams and dithiocarbamates. The reason for this is twofold. These chemicals are extensively used in the rubber industry and the experimental results indicated a strong mutagenic effect. The data furthermore pointed to an exceptional mechanism of action on the genetic material and to the possibility of co-mutagenic and carcinogenic effects. The *Salmonella* assays revealed a strong positive correlation between the mutagenicity of these compounds and oxygen tension. The data suggest that they act in an indirect way by inhibiting enzymes involved in the protection against radicals, such as superoxide dismutase, catalase, and glutathione peroxidase. To what extent this mechanism may, in practice, imply a co-mutagenic and cocarcinogenic interaction with radical-forming chemicals must be determined in further investigations.

Experimental data on teratogenic effects on chicken embryos were also collected for 80 individual rubber chemicals. In this system a particularly strong effect was observed for thiurams and dithiocarbamates.

In a simulation of the actual exposure at the worksites, the mutagenicity of vul-

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canization gases was studied by means of vulcanizing different rubber samples in the laboratory. All the samples, except for those of natural rubber and possibly acrylonitrile rubber, exhibited a mutagenic effect. The pattern of response with respect to the effect on different strains and the metabolic activation and deactivation pattern in *Salmonella* assays often served as an indication of the individual compounds responsible for the mutagenicity.

Some particulate samples from vulcanization gases collected in the rubber plants also revealed high mutagenic activity.

The preceding comments relate to results on experimental organisms at two levels – individual chemicals and complex mixtures. The project also comprised a third level, ie, investigations concerning the workers in the rubber industries. These results can, to some extent, act as a verification of the exposure situation indicated by the experimental results already outlined. Measurement of urine mutagenicity by means of *Salmonella* tests can give a conception of the exposure to mutagenic chemicals in different workplaces in the plants, even if the chemicals involved in this exposure are not known. It is of interest that particularly high mutagenicity was observed in the urine samples of the personnel engaged in the mixing department, but also the workers in the vulcanization department had clearly increased mutagenicity. Some results indicate that the problems may be solved with comparatively easy means in some cases. Thus the personnel working with continuous vulcanization in the salt baths exhibited high urine mutagenicity at a site where there was a leakage of gas and insufficient ventilation, while at comparable process sites without leakage and with efficient ventilation the urine mutagenicity was low. Unexpectedly a particularly high urine mutagenicity was observed for the cleaning personnel, ie, people not included in actual production. Probably this category of people is easily forgotten, but the data indicate that cleaning personnel are in need of protection against chemical dust to the same extent as the workers responsible for the direct handling of the chemicals.

The results of the analyses of urine mutagenicity also verified the importance of tobacco smoking to the mutagenicity in

urine, and to the risk for synergistic effects between smoking and exposure to mutagenic chemicals in the work environment in rubber plants.

A more direct influence of the chemical work environment could be observed by means of screening for chromosome changes in exposed workers. In the weighing and mixing departments an increased frequency of chromosome changes, particularly of sister chromatid exchanges, was found. In other departments also a few individuals exhibited high frequencies of sister chromatid exchanges. Although there are no data indicating a health hazard from such chromosome changes at the individual level, the results showed that the work environment in the rubber plants has an effect on genetic material. It may be added that, also with respect to chromosome changes, there was a clear increase among smokers.

In epidemiologic investigations of the frequency of spontaneous abortions among rubber workers in general, no significant increase was found among those employed during pregnancy, but there were indications of an increased incidence of spontaneous abortions in the shoe department.

It can be concluded from the results of this project, as well as from other data, that a great number of mutagenic and potentially carcinogenic compounds are used in the rubber industry and also that significant exposures to such chemicals do occur among the workers. These phenomena are indicated by the results of monitoring the workers for urine mutagenicity and chromosome effects. The experimental data do not lend themselves to any risk evaluation, but it is possible to discern some industrial processes which may involve a genotoxic hazard.

Thus there is an imminent risk for exposure to a spectrum of mutagenic chemicals during the processes of weighing and mixing. The high urine mutagenicity among the workers in the weighing-mixing department clearly points to the occurrence of such an exposure. Furthermore the increase of chromosome aberrations and sister chromatid exchanges among these workers shows that the exposure is connected with genetic effects, although the actual consequences of these measured effects may not be alarming in

themselves. In addition both mutagenicity data from the vulcanization of most rubber types and the monitoring of workers in the vulcanization department point to the fact that these processes may involve a health risk.

Although it is not possible at this stage to make any evaluation of these genotoxic risks, certain recommendations seem appropriate. During the weighing and mixing of rubber chemicals, direct contact with the chemicals should be avoided. Several protective measures can be used for this purpose – automation of the processes, application of master batches or pellets, improvement in ventilation, and the use of gloves and other protective clothing.

For at least certain vulcanization procedures a sealing of the process without significant leakage is called for, and in other cases improved ventilation should be considered. The efficiency of fairly simple improvements along such lines is indicated by results from the urine mutagenicity investigations.

The monitoring data pointed to an unexpected risk group in the rubber in-

dustry, ie, the cleaning personnel. They must obviously be subjected to mutagenic dust, and protective measures ought to be considered for them.

This investigation joins a number of others indicating a synergistic effect between tobacco smoking and various mutagens. The occupational health hazard from mutagenic chemicals is very often significantly enhanced by tobacco smoking, and more widely spread information of this fact is indeed justified.

Finally it should be pointed out that in some cases an exchange of mutagenic chemicals with biologically less aggressive ones may be possible. It seems of particular importance to investigate the possibility to replace tetramethylthiuram disulfide and ziram with other chemicals.

References

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