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Health Hazards in the Production and Processing of Some Fibers, Resins, and Plastics in Bulgaria

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Results of the toxicological studies of working conditions, general and professional morbidity, and complex examinations carried out on workers engaged in the production of polyamides, polyacrylonitrile fibers, polyester fibers and poly(vinyl chloride) resin, urea-formaldehyde glue, glass fibre materials and polyurethane resins are given. An extremely high occupational hazard for workers in the production of poly(vinyl chloride) resin and porous materials from polyurethane resins and urea-formaldehyde glue has been established. Cases of vinyl chloride disease, poisoning from formaldehyde, isocyanates, and styrene were noted. Prophylactic measures were taken in Bulgaria to lessen the occupational hazard in the productions as set forth included limitation of the work day to 6 hr, free food, additional bonus and leave, and annual physical examinations of workers.

The production and processing of artificial fibers, resins, and plastics considerably increased during the last 10 years in Bulgaria. The utilization and production of new chemicals and the new work conditions required an immediate estimation of the health hazard to which workers are exposed, in order to organize technical and medical preventive health standards and procedures.

In the present communication we give the results of toxicological studies already performed in some industries (*1–14*).

Polyamide Fibers

Polyamide fibers have been produced by modern technology during the last 5 years. The level of biphenyl, caprolactam, and noise and the microclimate determine the work conditions in the chemical part of the plant. The biphenyl concentrations exceed the maximum allowable concentration (MAC) (100 mg/m^3) being 1 to 1.5 times the MAC in winter and 3.5 times the MAC in summer. The caprolactam concentrations during all seasons are less than the MAC (3.0 mg/m^3). However, there is a synergistic effect of two toxic substances, and their total concentration, according to the equation of Averyanov, surpasses the MAC by a factor of 1 to 3.62 times. The industrial microclimate is overheating during the summer season. The noise is of broad-band character, average and with high frequency, surpassing the norms by 9 to 13 dB. Vibrations less than the north. The spinning department is windowless, with noise level of 90–100 dB.

The analysis of the total morbidity shows an increase in colds, gastrointestinal, and skin diseases and complications during pregnancy.

Clinical laboratory studies established that neurological symptoms are recorded for ca. 30% of the workers where a degree of correlation is observed between the length of service and the impairment of the nervous system. The gynacological examinations show changes in the menstrual cycle, with a dependence between the length of service and the prolongation of the interval with increasing length of service in 37.2% of the female workers. There is a decrease in hormone levels and amenorrhea in 17.5% of the women workers. The rate of complications of pregnancy is high: 42% in comparison with the 17% in controls. Most affected are the chemical laboratory assistants.

There are insignificant disturbances in other organs and systems: gastrointestinal syndrome,

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12.5%; liver syndrome and cardiovascular, 5%; skin disease, 18%.

Taking into consideration that the workers are subjected to concentrations of dinyl exceeding the standard, we decided to determine phenol in urine, proceeding from the fact that the dinyl is composed of two phenol rings. The phenol in the urine was under the standard (20 mg/l.) in only four of 30 workers, while with the rest it averaged 64 mg/l. (maximum 340 mg/l., and minimum 25 mg/l.).

The changes in the nervous system and gynacological status in workers are slight and could be accepted as a result of the effect of the factors of the working environment: high ambient temperature with simultaneous effects of caprolactam, dinyl, and high-pitched noise.

Polyacrylonitrile Fibers

In the production of polyacrylonitrile fibers the basic chemical toxic material is the acrylonitrile. The MAC is 0.5 mg/m^3 in the air, but during the summer the acrylonitrile concentrations reach 4–7.2 mg/m^3, although during the winter they are within the limits of the standard. The samples show, however, that during some working operations, such as taking aliquots for analysis, loading with inhibitors, or cleaning of filters, the acrylonitrile concentrations reach to 36–130 times above the norm, which is a real hazard with respect to acute poisonings.

Methyl methacrylate concentrations reach six times the MAC during summer and are about the norm during winter.

Concentrations of dimethylformamide, no matter what the season, are about the norm, but in some cases increase to three times the MAC (10 mg/m^3). The "modelling and finished processing" shop is very often the site of intolerable overheating in the summer (32–38°C with 48–79% RH at EET 27–30.7). Chronometric observations established that 90% of the operators and those working with machines are exposed daily to the effect of the abovementioned chemical substances.

Clinic laboratory examinations proved the presence of neurasthenic syndrome in 41.5% of the workers. There were no deviations from the normal liver function, hemopoiesis, and arterial pressure. Toxic and allergic dermatitis were established due to the three chemical substances.

Rhodanites are metabolites of acrylonitrile. We determined them before and after work in workers, both smokers and nonsmokers. No deviation in comparison with the control group was established.

The changes recorded in the health of those working with polyacrylonitrile fibers may be a result of the effect of chemicals on the nervous system and skin. However, they are slightly expressed because of the low length of service (3–5 yr).

Polyester Fibers

In the production of polyester fibers the basic chemical toxic agents to be found in the air of the working environment are dinyl and methanol. Both, however, were within normal limits during both the winter and summer seasons. A study of phenol in the urine shows an increase in 54% of the workers (more than 20 mgl.). The methanol in the urine in this 54% of the workers is above 1.6 mg/l., and formaldehyde is above 10 mg/l. in 80%. These data show that besides the inhalatory resorption there is a strong resorption of dinyl and methanol.

The observations carried out on the health status of the workers showed no changes which could be correlated with occupational hazards. This is due mainly to the facts that the length of service is low (2 yr), and that the concentrations of methanol and dinyl lie within standard limits. In 20% of the workers, however, certain neurological changes were recorded.

Poly(vinyl) Chloride Resin

The production of poly(vinyl chloride) resin is carried out under controlled conditions; therefore the concentrations of vinyl chloride are in the limits of the Bulgarian MAC (30 mg/m^3). In spite of this, changes in the health status characteristic of vinyl chloride disease (dystonia, acroosteoporosa, certain changes in the electroencephalograph and EKG, increase of γ-glutamine transpeptidase and changes in protein fractions) were recorded in about 5% of the workers with length of service above 5 yr. The changes in the electrocardiogram of workers between 20 and 40 years old are characterized by disturbed chamber repolarization, changes of the auricular rhythm ventricular extra systoles, and data suggestive of myocardial

ischemia. The electroencephalogram shows considerable changes, including acute alpha waves, activity to 35%, and in some individuals and isolated groups delta waves also. These changes point to an increase of the subcortical excitatory processes. Cases of hepatomegaly, splenomegaly, thrombocytopenia, and angiosarcoma have been established. The presence of vinyl chloride disease at such low concentrations of vinyl chloride induced us to start experiments in order to establish a new MAC (*8, 9, 14*).

Processing of Plastics

The processing of plastics also poses some hygiene toxicological problem, the first of which was the production of urea–formaldehyde glue and its use for joining wood surfaces in making furniture. Workers working with glue containing 10% free formaldehyde were found to have changes characteristical for its allergic effect: urticaria, allergic dermatitis and eczema, spastic bronchitis, and allergic asthma. Lung edema was recorded in one of the workers which led to exitus. Considerable quantities of formaldehyde were found in the urine and blood. Kitchen furniture made with such glue continued to give off formaldehyde for a period of several months; therefore, foodstuffs put on them, especially meat and milk products were inedible. As a result the production of such glue was prohibited, and glue with only 1% free formaldehyde was allowed to be used. This decreased the reported cases of allergy (*5–7*).

The production of glass fiber materials is characterized by high concentrations of styrene in the air of the working environment which reach 60 times the norm (5 mg/m^3). These concentrations, depending on the season are the lowest in winter and the highest in summer. The basic reason for the high concentrations are large sizes of the pieces manufactured where no effective exhaust ventilation could be built. Therefore, the mandelic acid in urine is increased from 7 to 10 times. Moreover, there is certain dependence between the presence of styrene in the air and the mandelic acid in urine, as well as a dependence of the mandelic acid with the length of the worker's service. It is of interest that at very high concentrations of styrene in the air, reaching 400 times the MAC, styrene, as well as mandelic acid was found in the urine. Styrene affects the nervous system also: in 30% of the workers dystonia and neurasthenia, etc., are observed. Certain effects on the liver function are established with changes in the liver sample protein fraction and transaminase activity (*10, 12*)

In the first years of production of porous materials from polyurethane resins a number of cases of acute poisoning from isocyanates were recorded, in which violent irritation and spastic bronchitis, bronchial asthma with constriction and cyanosis were noted. There were cases of dermatitis and eczema. In 42% of the workers neurosis was established. Toxic hepatitis was recorded in 10 men consuming various quantities of alcohol. Isocyanates were determined in blood and urine, levels being 0.002–0.120 mg-% in blood and 0.005–0.77 mg-% in urine. A correlation between the level of isocyanates and signs of poisoning was not established. After taking a number of occupational hygiene measures, the concentrations of isocyanates now are in the limits of the norm; during summer they increase to twice the MAC. No acute poisoning was reported, but a chronic effect of isocyanates is observed. The highest number of cases are diseases of the respiratory tract and the nervous system: chronic pharyngitis, laryngitis and spastic bronchitis, neurosis, neurasthenia, and neurovegetative dystonia (*11*).

Conclusion

Generalizing the above mentioned results we can draw a conclusion that there is only a slight health hazard in the production of polyamides, polyacrylonitrile, and polyester fibers. The highest health hazard is in the production of poly(vinyl chloride) resins and in receiving glass-fiber materials, porous materials from polyurethane and ureau formaldehydre glue (*1–5, 15*).

In order to decrease the health hazard during work with resin fibers and plastics prophylactic measures were taken in Bulgaria as follows: (a) systematic control on the hygienic conditions in industry and annual examinations of workers by specialists (toxicologists, neurologists, dermatologists, and internists) concurrent with clinical studies.

(b) organization of sanitary-technical undertakings; building of local and general exchange ventilation, improvement of insulation, etc.;

(c) scientific research on a large scale with detailed studies of workers and experiments on animals;

(d) proposals for new work legislation, including a 6-hr day for those engaged in the production of poly(vinyl chloride) resin, urea and phenol–formaldehyde resin and glue, and also in the production of glass-fiber materials and porous materials, free food and an additional bonus for those working in the production of poly(vinyl chloride) resin, restriction of the length of service to 10 yr for those working in the production of poly(vinyl chloride) resin, with obligatory transfer to other work at the same salary at the end of the term, and changes in the organization of the plant to lessen hazards in the production of glass fiber materials, porous materials, and glue.

At the present, experiments for the determination of a new MAC for vinyl chloride are being carried out. Additional studies are performed on the toxicity of 1,1-dichloroethane and dinyl. Special attention is being given to the effect of these substances on microsomal enzymes, cytochromes b and P-450. The elimination of acrylonitrile and its metabolites with exhaled air and urine is being followed. Studies are being carried out on the long-term, embryotoxic, and teratogenic effects of vinyl chloride, acrylonitrile, and dichloroethane.

We consider the investigations on the toxic effect of synthetic resins, fibers and plastics are lagging in comparison with that on pesticides. We propose the organization of a coordination center or committee in order to study the effect of plastics not only on workers but also on the population. Particular attention should be paid to the pollution of the environment by plastics.

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