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Control of Hazardous Substances at Small Workplaces

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Abstract: Lots of chemicals are produced in chemical industry and used everywhere as convenient and indispensable materials in daily life and industry. Moreover, many new chemicals are needed to produce competitive new goods such as new medicines, new dyestuffs, new agricultural chemicals and others. Main chemicals used in industry have reached to more than 50,000 kinds. And many workers are exposed to chemicals and injured all over the world. To protect the workers in small workplaces against hazardous chemicals is one of the most important tasks of occupational health. n-Hexane, lead and 1-bromopropane poisoning are shown as examples for health hazards and preventive measures in small workplaces. Preventive measure such as TLV or OEL, Material Safety Data sheets, health check-up, comprehensive cooperation among employers, workers, researchers, industrial physicians and administrative officers, and information on toxicity are discussed.

Key words: Chemicals, Health hazards, n-Hexane, Lead, 1-Bromopropane, Preventive measures, Small workplace

Introduction

In these days, computer is surprisingly developed and it is called computerized era. However, it could be also called chemicalized era, because lots of chemicals are also produced in chemical industry and used everywhere as convenient and indispensable materials in daily life and industry. For example, main chemicals used in industry have reached to more than 50,000 kinds[1]. And about 3 billion tons of petroleum in the world and about 300 million ton in Japan are annually consumed. And many workers are exposed to chemicals and injured by them all over the world[2]. To protect the workers in small workplaces against hazardous chemicals is one of the most important tasks of occupational health. Large amount of chemicals is produced in large enterprises and poured into small workplaces, and the workers in the small workplaces are not well protected against them.

Recent Trend of Small-Scale Enterprises

The number of workers in the manufacturing industry tends to decrease in the developed countries and that in the service industry is increasing. In contrast, the number of workers in the manufacturing industry is increasing in the developing countries. However, the numbers of full-time workers in the manufacturing industry are keeping high level even in the developed countries. The manufacturing industry is playing a very important role even in the developed countries. The figure shows the number of full-time workers in manufacturing industry by county (Fig. 1).

The percentage of small enterprises with less than 30 full-time workers is 91%, and the percentage of the full-time workers in small enterprises is 27% in Japan.

Introduction of New Chemicals and their Toxicity

The more and more sophisticated skills and new materials are introduced in manufacturing industry to be competitive enough in the world economy. Many new chemicals are needed to produce competitive new goods to fulfill the demand of the consumers. Introducing new chemicals has developed new medicines, new dyestuffs, new agricultural chemicals, new clothes and other new stuffs. And many new chemicals are used without enough knowledge of toxicity. About 500 new chemicals are annually introduced in industry in Japan. The figure 2 shows the cumulative numbers of newly registered chemicals in Japan since 1979 (Fig. 2).

The number of new chemicals amounted to 11,271 in 2003. Mutagenicity of new chemicals must be tested before they are put on the market by the law in Japan. The results of the mutagenicity test show that about 4% of the tested chemicals

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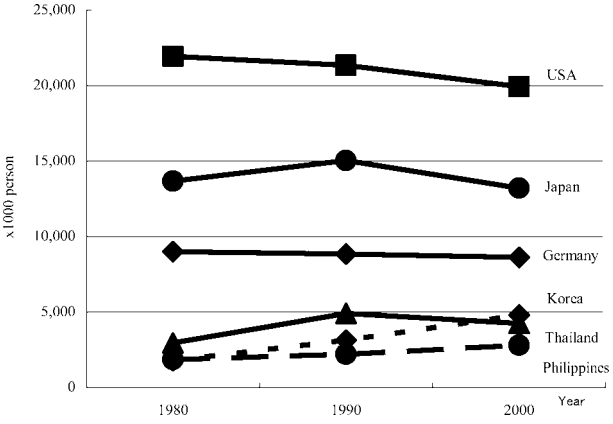

Fig. 1. The number of workers in manufacturing industry by country.

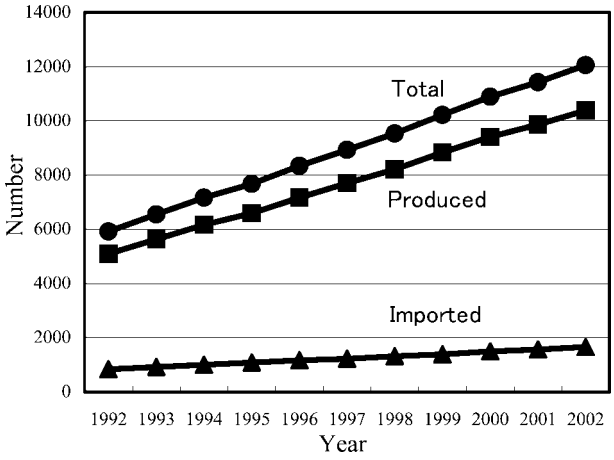

Fig. 2. Cumulative numbers of new chemicals in Japan since 1979.

Table 1. Mode of polyneuropathy by exposure concentration of n-hexane

Mode of polyneuropathy	Number of patients	Exposure conc. of n-hexane Average (Min-Max)
Sensory polyneuropathy	53	120 (94–140) ppm
Sensori-motor polyneuropathy	32	340 (330–350) ppm
Sensori-motor polyneuropathy with muscle atrophy	8	578 (95–1250) ppm

are strongly mutagenic, and about 9% are weakly mutagenic. Mutagenicity is important to screen carcinogenicity and reproductive toxicity. However, each chemical substance has many kinds of toxicity. And it is not until it is used in workplaces that unexpected toxicity of new chemicals might be sometimes found in the workers. It has been very difficult to predict toxicity of new chemicals although it is eagerly expected to exactly predict it by using highly advanced sciences including molecular biology.

Some Lessons from the Cases in Small Workplaces

n-Hexane polyneuropathy

The four cases of serious polyneuropathy were found in the small polyethylene laminating factories in Nagoya, Japan and reported as the first cases of n-hexane polyneuropathy in the world in 1964[3]. n-Hexane is one of the main constituents of petroleum and is revealed to have specific neurotoxicity by many studies. The outbreak of n-hexane polyneuropathy in the small vinyl sandal manufacturers occurred in 1966–67 in Japan. We investigated about 1,000 workers in vinyl sandal manufacturers and found 93 patients suffering from polyneuropathy. The Table 1 shows the exposure concentrations by mode of polyneuropthy in vinyl sandal manufacturers (Table 1)[4].

The results showed that more than 100 ppm exposure of n-hexane could cause clinical polyneuropathy. After that, subclinical neuropathy was revealed by electrophysiological examinations in the workers exposed to less than 50 ppm[5]. From the result of the survey and animal experiments Occupational Exposure Limit (OEL) was lowered in Japan from 500 ppm to 100 ppm, then 40 ppm. In these days OEL of n-hexane is 40 ppm in Japan[6] and TLV of n-hexane is 50 ppm in ACGIH[7]. The outbreak of n-hexane polyneuropathy showed that the homework using hazardous chemicals was very dangerous to the workers' health, and Industrial Homework Law was enacted to protect the workers against hazardous works in industrial homework in Japan in 1970. The cases of n-hexane polyneuropathy showed that large petrochemical industry started producing large amount of n-hexane in the 1960s and supplying n-hexane as a solvent in place of benzene without enough knowledge about its toxicity and caused outbreaks of n-hexane poisoning at that time. The case of n-hexane polyneuropathy shows that it is very dangerous to workers if new chemicals are introduced particularly into small workplaces with poor protective measures.

Lead poisoning in traditional Shippo-yaki (cloisonné) industry

A patient suffering from classic paralysis of extensors in hands was found in a traditional Shippo-yaki factory in 1989[8].

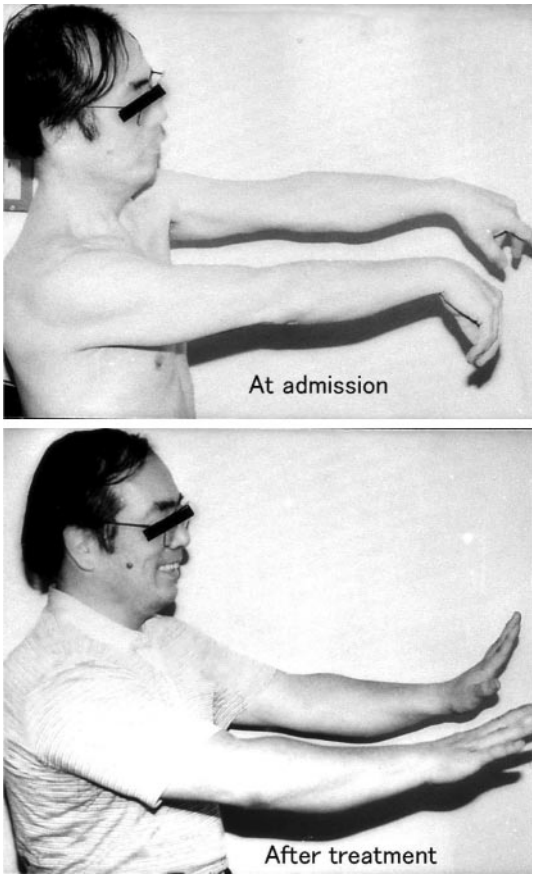

Fig. 3. The patient of lead poisoning at admission (upper) and after treatment for one and a half years (lower).

The pictures show 49 yr old male patient suffering paralysis in hands at admission to the hospital (upper) and after treatment for one and a half years (lower) (Fig. 3).

He has produced Shippo-yaki using lead oxide, silica, and others for 30 yr. The muscle strength of his hands gradually weakened as the products in his workplace increased, and he became difficult to mix raw materials. He was admitted to the hospital in December 1989.

The table shows the results of health check-up in the workers in his small workplace (Table 2). The results show very high lead concentration in blood of the patient and his family, and two craftsmen.

The concentrations of lead were much higher than occupational exposure limit (OEL) in Japan. A mixing machine was introduced in his workplace and he used it outside the door wearing a dustproof mask. And his health disorders were improved as shown in the lower picture (Fig. 3) and he could resume his work after about one year. His father was found to be suffering from similar symptoms to his son's one. His father had been diagnosed as ALS by mistake and wrongly treated for about 30 yr but severe muscle atrophy in hands and lower extremities were neither improved nor deteriorated. He was correctly diagnosed and treated as lead poisoning at the investigation, but his symptoms and signs were not improved at all. He lamented that if he had been correctly diagnosed and properly treated at an early stage of his lead poisoning, he might have recovered like his son. Other three patients suffering from paralysis of extensors in hands were found in the other Shippo-yaki factories. Some preventive measures and education on occupational health were conducted with the support of Industrial Research Institute in Aichi Prefecture and town office in Shippo-cho. Shippo-cho established the Shippo-yaki Art Village in October 1st, 2004, where the workers could get raw materials in safer way and inherit traditional technology. The cases showed that early correct diagnosis was very important to treat the health disorders due to poisoning and prevent poisoning by improving working conditions. It is shown that a close cooperation among the trade association, regional governments, regional institute of technology and occupational health specialists could play an important role to improve working conditions and prevent poisoning.

Bromopropanes poisoning

2-Bromopropane caused serious reproductive disorders in an electronic company in Korea in 1995. Some animal

Table 2. Health check-up of Shippo-yaki workers

Person (Age)	Pb in blood (μg/dl)	ALA in urine (mg/l)	RBC ($\times 10^4$/mm^3)	Hb (g/dl)
Patient (49)	104	62.4	416	12.8
Wife (46)	44.5	27.8	488	14.9
Father (71)	54.2	5.9	515	15.2
Mother (71)	52.7	8	418	12.8
Craftsman A (61)	31	4.4	532	16.1
Craftsman B (57)	43.9	5.1	554	16.8
Normal range	<20	<5		

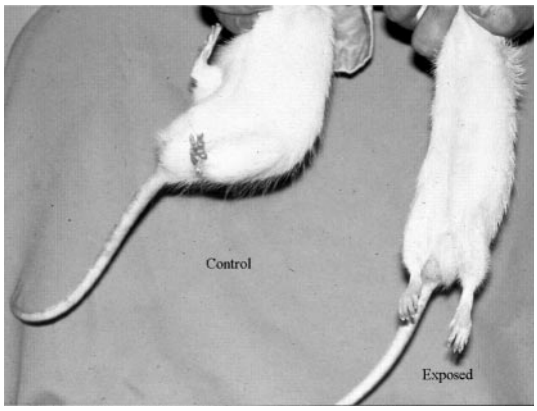

Fig. 4. Rat exposed to 1-bromopropane showed paralysis of lower extremities (right).

experiments revealed its severe reproductive toxicity[9]. The quick actions of the producers and providers of 2-bromopropane, and Ministry of Health, Labor and Welfare prevented serious poisoning of 2-bromopropane in Japan. The cases and animal experiments indicated that reproductive toxicity of industrial chemicals is very important. In place of 2-bromopropane, 1-bromopropane is becoming widely used in the world.

We revealed the severe neurotoxicity of 1-bromopropane in animal experiments (Fig. 4), and cautioned the producers and providers of 2-bromopropane to carefully supply it to workplaces[10]. However some foreign makers started producing and providing 1-bromopropane by claiming that 1-bromopropane was much less toxic than 2-bromopropane in terms of reproductive toxicity and mutagenicity according to their experiments. We gave information to the producers and providers of 1-bromopropane on the results of our animal experiments and surveys of the workers, and advised that 1-bromopropane might be very neurotoxic and should be carefully used in workplaces. The first case of 1-bromopropane poisoning in USA was reported by Sclar G. in 1999[11] and three cases that occurred in USA were also reported by Ichihara G. in 2002[12]. We surveyed the workers exposed to 1-bromopropane in a chemical factory in China and neurological impairments were found in the workers[13]. Six cases with serious disorders in the central nervous system and peripheral nerves were reported by Majersik JJ, *et al*. in the conference of the American Neurological Association in October 5th, 2004. All patients were working as foam cushion gluers and exposed to high concentrations of 1-bromopropane. All of them complained of subacute onset of lower extremities pain or paresthesia and 5 of the 6 complained of difficulty in walking. Eighteen months after leaving the work, the two most severely affected patients regained minimal function but still required assistance in walking. Three patients continued to experience chronic neuropathic pain. One patient had subtle cognitive changes. Air samples taken at the workplace one day after gluing operations ceased revealed the mean concentration of 1-bromopropane to be 130 ppm (range 91–176 ppm). The patients were supposed to have been exposed to higher concentrations of 1-bromopropane while gluing. Severe neurotoxicity of 1-bromopropane was revealed by animal experiments at first and then found in the exposed workers. It is important to predict potential risk of new chemicals and prevent its poisoning in the future. We had a close cooperation with the makers and providers in exchanging information on toxicity of 1-bromopropane and could advise them to carefully provide it, particularly to small workplaces in order to prevent its poisoning. Fortunately, no serious poisoning due to 1-bromopropane occured in Japan thanks to good cooperation among makers, providers and occupational specialists.

Protective Measures against Poisoning in Small Workplaces

1. Japan Society of Occupational Health (JSOH) recommends occupational exposure limits (OELs) of about 205 hazardous substances[6], and American Conference of Governmental Industrial Hygienists (ACGIH) recommend about 674 Threshold Limit Values (TLVs)[7]. The hazardous substances in the workplaces should keep under the recommended values to prevent the workers from being poisoned. However, the numbers of the hazardous substances that have OEL or TLV is less than 2% of mainly available substances. Many substances are used without enough information on its toxicity.
2. Mutagenicity of new chemicals must be tested before commercial use according to the law in Japan which was enforced in 1979. But generally speaking, chemicals have many kinds of toxicity in addition to it. Some new chemicals have caused unexpected serious poisoning.
3. Producers and suppliers of chemicals must provide the users with Material Safety Data Sheets (MSDSs) containing up-to-date data, and employers keep them in the workplaces where the workers can easily see them. These are helpful for the workers to get information on the chemicals used by them.
4. The workers handling hazardous chemicals must have health check-up twice a year by the law in Japan. The health check-up could be expected to detect the damaging working conditions as well as early health disorders of workers.
5. The employers of small enterprises must employ a part-time industrial physician licensed by the Japan Medical Association and others. The licensed industrial physicians are expected to serve for occupational health in small workplaces.

6. Researches to clarify causative agents and preventive measures could provide useful new information to the staff for occupational health in the workplaces.

Conclusion

Lots of chemicals are used in daily life and industry and many workers are exposed to chemicals and injured particularly in small workplaces. In order to protect the workers against hazardous chemicals, comprehensive cooperation among personnel such as employers, workers, researchers, industrial physicians and administrative officers, and support by concerning organizations such as trade associations, labor unions, institutes, universities, academic societies, administrative offices and others are indispensable in small workplaces.

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