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Articles

Evaluation of respiratory exposure to 4,4-methylene diphenyl diisocyanate (MDI) vapors in foam injection workers in a household appliance manufacturing company: An Occupational Carcinogen

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Background: Appliance manufacturing boom is very high hand customers always have a great deal of attention to products that have low energy consumption, therefore the use of isocyanates MDI as a thermal insulation in the body of the refrigerator and is also widely used as a binder in the production of washing machines. MDI isocyanate study the effects on the respiratory capacity of formers injection was done foam material in a household appliance company

Method: this case control study in 1395 and a household appliance manufacturing company in the province of Qazvin 20 personnel working injected foam material is exposed to isocyanates ,for example administrative personnel and 20 served as controls using medical records these values breathing capacity FVC , FEV1 , FEV1/FVC in both 1390 and 1394 extracted using SPSS software and paired T-TEST data were analyzed.

Results: Measuring the concentration of isocyanate in 90 blocks in the cabin and tap lid above the limit, which was due to the failure of the ventilation system, in 94 years due to the good performance of the ventilation system in the isocyanate concentration was at the limit. According to their experiences foam material is injected every three indexes FVC, FEV1, FEV1/FVC had significant losses, FEV1 and FVC decline among which were a significant level. ($p=0.036$, $p= 0.008$) the control samples also non- significant decline in the indicators that this can be attributed to aging.

Conclusion: It is known that exposure to isocyanate materials decreased respiratory capacity is personnel, to postpone it to the desired function ventilation system. it would be desirable to postpone the operation of the ventilation system and non-isocyanate leak on the ground, work, be a lot of attention. even with the improvement of the job must be conservative's injection foam material is exposed to isocyanates be included in the list of hard and hazardous jobs.

Keywords: MDI, respiratory exposure, respiratory capacity, workers inject foam material.

Introduction

The household appliance industry in Iran has a long history of supply the needs of domestic consumers and creating a good job market for youth [1]. The importance of the household appliance industry mainly comes from the fact that the industry relates to various industries (especially chemicals, petrochemicals, etc.). and the life of this industry and its expansion, given its broad economic aspects, such as employment and value-added, can be one of the most important goals for any country [2]. In view of the above, consumers always pay close attention to products with low energy consumption, and Methylene Diphenyl Diisocyanate (MDI), as a thermal insulator in the refrigerator, plays an important role in the energy consumption of the products and also in the production of washing machine is used as adhesive. World Health Organization statistics show that four million people worldwide work in the chemical industry, with one million dying or disabled annually due to unsafe exposure to chemicals [3]. MDI is an aromatic compound of the diisocyanate family, which is widely used in the production of hard polyurethane foams and is used by the foaming industry worldwide 4 million tons per year [4]. The Threshold Limit Value (TLV) of MDI is 51 µg / m3 and its vapor measurement in the workplace using the proposed NIOSH 5522 method. given that workers in Iran differ in terms of climatic conditions, customs, and work habits than workers in other countries, there are many complaints about the harmful effects of this matter. MDI is a liquid in its natural state and vaporizes into the environment during operation. These vapors are easily condensed and become aerosolized. However, some of the vapor may be inhaled before condensation by humans [5]. Some references have suggested TLV of MDI equal to 5 PPb.) [6-10]. Researches has shown that MDI causes various respiratory, skin, ocular and gastrointestinal complications in humans and is one of the causes of severe asthma attacks and deaths [11, 12]. Many studies have shown that isocyanate stimulates the respiratory system [11-20]. On the other hand, MDI is suggestive evidence for carcinogenicity in rats [21]. All isocyanate compounds have N = C = O bonds that are highly reactive and readily react with biological molecules and are very important stimuli in the respiratory tract and are the major cause of asthma and chemical bronchitis [22]. The health effects of exposure to these chemicals can be classified into three groups: acute or chronic effects, systemic or local effects, and reversible and irreversible effects [23, 24]. These risks are particularly relevant to the production and use of chemicals in various processes [25, 26]. To avoid the harmful side effects of these chemicals, it is important to observe precautions and control measures when handling them [27-31]. In a study of 245 new occupational asthma samples from 1976 to 1992, 39 percent with hexamethylene diisocyanate (HDI), 39 percent with diphenyl methane diisocyanate (MDI) and 17 percent with toluene diisocyanate (TDI) exposure [32]. In a study by Stretcher et al. (1998) on the determination of isocyanate occupational contact in the United States, they found that isocyanate-induced contaminants in all workers resulted in skin, mucous membranes, eyes, and respiratory system irritations, as well as have been associated with contact dermatitis, allergies Severe, pneumonia and asthma; they have also found that different methods are useful for monitoring and reassessment [33]. In another study conducted by Sennbro et al. On the determination of contact with isocyanates at 13 polyurethane plants in Sweden, workers were divided into four working groups and monitored for 8 hours. the results showed that there was a significant relationship between the decrease in respiratory capacity and exposure to isocyanates [34]. Based on the above description and providing an explanation of the application, usage, measurement and hazards of MDI in the workplace, the main objective of the present study was to evaluate the effects of MDI on the respiratory capacities of foam injection personnel in a 4-year period. Finally, we present an effective control strategy for the protection of human resources.

Methods

This study was a case-control study in a household appliance manufacturing company in 2016. In this study, 20 injectors exposed to MDI isocyanate vapors as the case group and 20 unexposed office personnel as the control group was selected. All had more than 4 years of work experience. The results of spirometry test in medical records were used. The results of the experiments in 2011 were compared with the results of the experiments in 2015. Exclusion criteria were asthma and tobacco use [35, 36]. Both conditions have a direct effect on the reduction of respiratory capacity.

The impinger apparatus was used to measure the vapor and particles of MDI and then the results were analyzed by HPLC. The sampling flow was max. 1 L / min in an impinger containing 15 ml of concentrated hydrochloric acid and acetic acid. The detection limit of the method is in the concentration range of 0.007-0.073 ppm. Due to the inherent limitations of working with impingers, sampling was performed at fix stations and at sites where workers were most likely to be exposed and most likely to have respiratory exposure. Threshold Limit Value-Time Weight Average (TLV - TWA) exposure was used by the survey method and taking into account the rest time. (At the time of measurement, it was 12 hours, including 11 hours of daily work and one hour of rest).

Spirometry was performed using a MiniSpire device. This is the cheapest and most important paraclinical method to detect pulmonary insufficiency [37], which measures the volume and capacity of the lung and the rate of airflow in the respiratory tract [38]. The most important parameter of respiratory capacity is the Forced Expiratory Volume in First Second (the volume of air exhaled by the lung in the first second) [39], Forced vital capacity (the volume of air exhaled from the lung after a deep tail) is their ratio (denotes the amount of forced vital capacity in the first second that is exhaled from the lung) and is very important in the diagnosis of obstructive pulmonary disease [40, 41]. With the new devices, all three indicators can be measured [42].

Therefore, height, weight, work experience and respiratory capacities such as: Forced Vital Capacity (FVC) and Forced Expiratory Volume in First Second (FEV1) in liters per second and ratio (FEV1 / FVC) in percent, extracted. The data were entered into SPSS statistical software and were analyzed by paired T-test.

Results

Measurements of vapor and particles of isocyanate in ppm and mg / m3 are shown in Table 1.

	Measurement in ppm	Measurement in Mg / m3
	2011	2015
Foam injection in cabin section	0.0068	0.003
Foam injection in the lid section	0.0021	0.002
Foam injection in the top lid section	0.0048	0.003

Tab 1 Measurement results of MDI isocyanate vapors

The analysis of height, weight and work experience of the case and control groups is shown in Table 2.

	Case group (Foam Injectors)	Control group (Office personnel (
	2011	2015

Work experience	10.05±3.33	14.05±3.33
Height	175.15±5.38	175.15±5.38
Weight	78.52±4.37	80.1±8.96

Tab 2 Analysis of indices affecting spirometry

The analysis of respiratory capacities including FVC, FEV1 and FEV1 / FVC is presented in Table 3.

	Case group (Foam Injectors)	Control group (Office personnel (
	2011	2015
FVE1	4±0.498	3.833±0.593
Correlation	0.901	0.942
P Value	P=0.008	P=0.185
FVC	4.98±0.784	4.804±0.798
Correlation	0.904	0.935
P Value	P=0.036	P=0.240
FVE1 / FVC	81.14±4.998	80.34±4.354
Correlation	0.787	0.964
P Value	P=0.265	P=0.075

Tab 3 Analysis of spirometry indices

Conclusion

As the foam injection in cabin, lid and top lid sections are separated from the adjacent parts by partition, so the contamination produced in these units is not transmitted to other parts and also the contamination of other parts of production is not transmitted to this part. Therefore, since the refrigerator body insulation is performed by the combination of 4-4 methylene diphenyl diisocyanate MDI and an alcohol called polyol in the presence of the cyclopentane volumetric agent, and MDI's reaction with polyol was exothermic, it is expected that respiratory exposure to MDI vapors may occur immediately at the site of extravasation from the injection site, but because of the 40 ° C melting point and low vapor pressure of MDI, most of the vapor released at a short distance from the exit site becomes secondary particles due to gas-to-particle reactions (the result of this study is consistent with the Sepai and Skarping studies) [5, 43], therefore, The impinger was used for measurement. The reason for the high concentration of MDI isocyanate contaminants in the foam cabinets and tabloid units in 2011 is that the ventilation was poor at the time of sampling, and practically the measurement was done in conditions without environmental conditioning (Tab

1). After measuring the year 2011 and justifying the management of the present environmental ventilation company was used and the measurement was done. In 2015, measurements were carried out to ensure that the ventilation was safe and that the values were in the standard range (Tab 1). Therefore, based on the above, it can be concluded that injecting workers exposed to MDI isocyanate may prevent the development and severity of respiratory capacity by ensuring proper functioning of local and environmental ventilation in the workplace, therefore, the correct operation of its environmental ventilation must always be approved by the responsible units (maintenance, safety and health). Comparison of the respiratory capacities of foam injectors exposed to MDI isocyanates showed that all three spirometry indices FEV1, FVC, FEV1 / FVC showed a significant decrease, which was significant for FEV1 values ($P = 0.008$), and for FVC was significant ($P = 0.036$) and there was no significant decrease for FEV1 / FVC ratio ($P = 0.265$). Given the assurance of the function of local ventilation systems in these sectors (especially in the last 2 years leading to pollution (2014 to 2015)), it can be concluded that dealing with isocyanate materials over time reduces respiratory capacity. The above results are consistent with the results of studies in Iran and other countries that were mentioned in this study [11-20, 33, 34]. The main point that can be attributed to the decrease in respiratory capacity of the injector personnel is that, as mentioned in the methods section, the personnel have a 12-hour shift (11 working hours and 1-hour rest). Given that the Iranian Occupational Exposure Limits (OEL) Baseline is based on exposure to pollutants every day for 8 hours and 40 hours per week, and according to the Briff and Scala model, this should be noted. Where, on a 12-hour shift, exposure to a chemical agent is 50% more than an 8-hour shift under similar conditions, and the rehabilitation and detoxification period is 25% less than an 8-hour shift, therefore, the possible effect of MDI on the reduction of respiratory capacity of personnel can be justified [44]. Comparison of the respiratory capacities of office personnel showed a slight decrease, but it was not significant in all three indicators. The cause of the decline can be attributed to their aging. The above result is consistent with the results of similar studies [45-47], the studies have also shown that age, sex, growth, and the likelihood of a pulmonary disease decrease for respiratory capacities (FEV1 / FVC, FVC, FEV1). Since all the control personnel were male in the present study and no signs of respiratory disease were seen in spirometry results, therefore, the results of the present study can be compared with the results of previous studies. Finally, it is recommended for researchers interested in further research in other isocyanate industries to examine their respiratory capacities over a period of 4 years and in view of the harmful effects of this substance, Provide a replacement for it.

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