

## The effect of the use of NP305 masks in improving respiratory symptoms in workers exposed to sulfuric acid mists in plating and pickling units

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### Abstract:

**Background:** Plating and pickling processes are the most effective ways for increasing the strength of metal structures, and workers in these units are exposed to various contaminants, including acid mists. The aim of this study was to investigate the effect of protective masks in decreasing the respiratory symptoms and the aerobic capacity of workers that are exposed sulfuric acid mist.

**Methods:** This interventional study was based on National Institute for Occupational Safety and Health (NIOSH) standard 7903 in which silica gel tubes are used for sampling the air in plating and pickling units for eight hours. After the samples were acquired and prepared, they were analyzed by ion chromatography and were compared with the American Conference of Governmental Industrial Hygienists (ACGIH) exposure limits. Respiratory symptoms were evaluated among two sets of test subjects, i.e., those who used NP305 masks in the workplace and those who did not use the mask.

**Results:** The results showed that the concentration of sulfuric acid mist in the plating units was greater than the exposure limits, and concentrations at this level can cause an increase in symptoms related to irritation of the airway and a slight decrease in respiratory capacity. In this study, smoking had no significant effect on the severity of pulmonary dysfunction.

**Conclusion:** The results indicated that the use of an NP305 mask is effective for decreasing symptoms resulting from exposure to sulfuric acid mist and improving respiratory capacity.

**Keywords:** Plating, Sulfuric acid mist, Respiratory symptoms, NP305 mask

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### Additional Information for citing this article:

Title of Journal: Electronic physician; Abbreviated title of journal: Electron. Physician

doi: 10.14661/2013.616-622

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### Editorial information:

Type of article: Original

Published: February.01.2013

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### 1. Introduction

In today's competitive environment, society in general should be grateful for the efforts of those who work in various industries; because each country's economic development depends on their work. Obviously, then, the

health of such workers can affect the economic development of a country, both directly and indirectly. Economic development in Iran is based on the industrial production of many kinds of products using numerous chemical materials in order to meet social needs. One such industry that has experienced remarkable growth is the plating process in which several chemicals are used.

Among the most important chemical pollutants in plating units is acid mist that can have adverse effects on workers' health as well as producing damaging environmental effects. Sulfuric acid is extensively used in plating units, and many people come in contact with sulfuric acid mist every day in the workplace. Based on statistics presented by National Institute for Occupational Safety and Health (NIOSH), around 800 thousand American workers are exposed to sulfuric acid mist (1). Sulfuric acid is one of the strongest mineral acids. It is used extensively as an industrial chemical solvent in the several production activities, such as making chemical fertilizers, extracting metals, treating waste, plating metals, and producing explosives, such as trinitrotoluene (TNT) and nitroglycerin (1). During the production process, especially in industries that have high temperature operations, part of the sulfuric acid that is used will become particulate mist in the air. When this mist comes in contact with the skin or mucous membranes, it can cause irritation and inflammation (2). It also may result in systemic effects after inhalation and dermal exposure. The severity of the effects depends on the concentration and time of exposure. Long-term inhalation of sulfuric acid mist can burn the digestive and respiratory organs, such as the larynx, pharynx, trachea, and stomach, causing edema, blockage of airways, and bronchial spasms (3). Its symptoms include salivation, runny nose, difficulty swallowing, intense thirst, nausea, cough, diarrhea, and abdominal pain (3, 4). In one case, a worker's intensive exposure to a high concentration of sulfuric acid mist led to a life-threatening respiratory syndrome (5). As part of a case study, Goldman et al. examined an image of the chest of a worker whose face had been damaged by 35% sulfuric acid mist. The images indicated that the worker had pulmonary congestion and severe inflammation of his lungs, causing reduction of pulmonary performance and extensive emphysema after seven years (6).

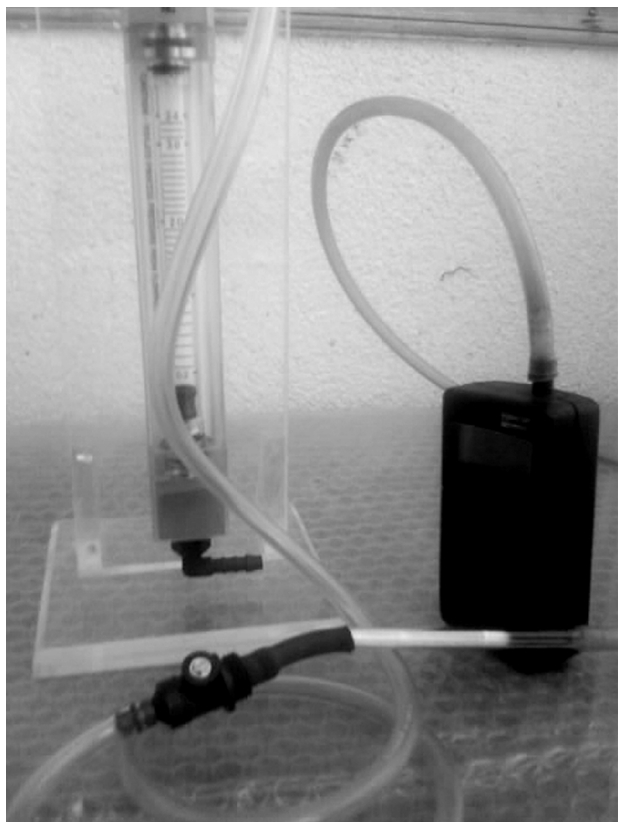
The systematic effects of sulfuric acid are often created due to the creation of free sulfate ions resulting from rapid changes in pH (1). Usually, these ions are excreted through with the urine and do not accumulate in the body (2). However, the retention of sulfuric acid particles in the airways causes the airways to swell. Particles that are small in size when they enter the airway become larger after they are distributed in the airway due to the absorption of moisture, and, as a result, they cannot be eliminated or removed when air is exhaled. Consequently, they will be more able to deposit than inert particles which are similar in size (7, 8). So, long-term exposure of workers in plating and pickling plants to sulfuric acid mist may result in their having serious damage that could jeopardize their health. Therefore, in this study, we investigated the effect of use of masks as a self-protective device for improving the respiratory symptoms of workers who are exposed to sulfuric acid mist in plating and pickling units.

## 2. Material and Methods

This was an interventional study that was conducted on workers in plating and pickling operational units located in the production factories of Central Province in Iran. In order to compare pulmonary performance with respiratory symptoms caused by sulfuric acid mist, some people who work in the administrative units were selected as the control sample. The people in the control sample were similar to the people who were studied in terms of lifestyle, dietary intake, demographics, age, and underlying diseases.

A calibrated rotameter and a sampler were used together to calibrate the flow rate of air sampler pump (Model 210-1002TX, SKC Inc.) at the rate of 0.2 liter per minute (Fig. 1). After calibrating the pump, sampling was conducted according to the National Institute for Occupational Safety and Health (NIOSH) 7903 standard method under operational conditions in two plating and pickling units. For this purpose, three sampling processes that took eight hours were conducted using 600 mg of silica gel sorbent tube manufactured by SKC Company consisting of one section of glass fiber filter plug followed by one section of ORBO-53 tube, under normal environmental condition (22-25 °C, 1 atm) (9). Also, to estimate the concentration of sulfuric acid mist in the workplace of the control group, samples with similar conditions were taken from the administrative and non-operational units. The process was conducted twice, once before the masks were used and once after the masks were used.

A TES-1361 electronic thermometer and a humidity gauge were used to measure air temperature and humidity at 10-minute intervals during the sampling process. The measured values were used to obtain the actual flow rate of the sampling pump. The air samples that were collected were injected into an ALLIANCE 2695 ion chromatographic analyzer equipped with C18 XBridge filled column.



**Figure 1.** Personal sampling pump calibration circuit



**Figure 2.** Use of NP305 mask in the pickling plant workers

The concentrations of the air pollutant samples were measured by comparing the average peak measured with the calibration curve drawn using 5 to 500 micrograms per milliliter concentrations of practical solutions of sulfuric

acid. Occurrences of respiratory symptoms among the sample and the control people were determined by using a questionnaire that each person completed. Also pulmonary volumes of the control and sample people were evaluated using a SpirolabII spirometry tool made in Italy. Then, after continuous use of the respiratory protective NP305 mask (Fig. 2) for six months, respiratory symptoms questionnaire and the spirometry tests were repeated, and the results of the two tests were compared. Also, the effects of smoking and BMI index on the control and sample people's pulmonary capacity were investigated. The results were analyzed using statistical tests including independent t-test, paired t-test, chi-squared and correlation, and  $p < 0.05$  was considered to be meaningful.

### 3. Results

In this study, 16 workers in two operational units, i.e., the plating and pickling units were selected as the sample group, and 24 workers in the non-operational units were selected as the control group. Some of their personal characteristics are noted in Table 1. None of them had any asthma or heart disease. Also, in order to estimate the concentration of acid mist in the air that the subjects were breathing, samples of the air in the operational region of both groups were acquired twice, once before the masks were used and once after the masks were used (Table 2). The results indicated that the concentrations of sulfuric acid mist in the plating and pickling units were significantly greater than the concentration in the administrative unit. Interestingly, the concentration measured the first time was considerably higher than the concentration that was measure the second time. Apparently, the first concentration was higher either because of increased production at that time or because it coincided with the beginning to the hot-climate season. Results obtained from the independent t-test showed that the two groups were remarkably different ( $p$ -value = 0.008) before applying the results of the spirometry tests (Tables 3 and 4).

**Table1.** Characteristics of the sample and control in the operational and administrative units

	Sample	Control
Number	16	24
Average age (years)	24.75±1.9	29±3
Having a history of smoking	%31.2	%41.7
Prone to seasonal allergies	4	9
Work Experience (years)	4.3	5.37
BMI Index	25	27

**Table2.** Concentrations of sulfuric acid mists in air the operational areas and nonoperational areas

	Average the concentration of sulfuric acid(mg/m <sup>3</sup> )	
	Area of operation (sample)	Area of operation (control)
First time	0.99	0
Second time	1.125	0

Also paired t-test showed that the use of the respiratory masks improved the respiratory capacity of those who were exposed to sulfuric acid mist ( $p$ -value = 0.002). In addition, the results indicated that the sample group experienced significantly more respiratory issues than the control group. When exposed to sulfuric acid mist, six months of continuous use of a NP305 respiratory protective mask could significantly decrease the occurrences of adverse respiratory effects (Table 3).

The results of the correlation tests showed that there was no meaningful relationship between age and respiratory capacity in the sample and control groups. Also, there was a meaningful relationship ( $p$ -value = 0.186) between BMI index and respiratory capacity in the sample group people, and there was a meaningful relationship between these variables in the control group as well ( $p$ -value = 0.045). The chi-squared test results showed that, in the present study, smoking does not have a remarkable effect on the respiratory capacity of either the sample group or the control group ( $p$ -value = 0.505).

**Table3.** Outbreak of respiratory signs before and after the use of respiratory masks

	Before the use of protective masks				After the use of protective masks			
	Sample		Control		Sample		Control	
Respiratory symptoms	Yes	No	Yes	No	Yes	No	Yes	No
Cough	15	1	2	22	5	11	2	22
Sneezing	9	7	5	19	2	14	4	20
Runny nose	16	0	5	19	3	13	3	21
Burning in the throat	9	7	3	21	3	13	5	19
Hoarseness	16	10	1	23	1	15	2	22
Eye and nose irritation	14	2	4	20	11	5	2	22
Phlegm	8	8	2	22	2	14	0	24
Wheezing	8	8	0	24	0	16	0	24

**Table4.** Spirometry test's result before and after the use of protective masks

Test's average of respiratory	Sample		Control
	Before the use of protective masks	After the use of protective masks	
FEV <sub>1</sub>	4.25	4.55	4.67
FVC	4.98	5.2	5.26
FEV <sub>1</sub> /FVC	76.74	81.1	83.4

#### 4. Discussion

According to results that were obtained, it can be stated that the concentrations of sulfuric acid mist in the plating and pickling units were significantly greater than the maximum allowable exposure. During a study, Sedghinia showed that the workers' exposure to sulfuric acid mist in the aluminum anodizing plant in Qazvin was almost eight times greater than the allowable exposure (10). Because of contact with sulfuric acid mist, workers in the plating unit are exposed to respiratory diseases that appear in the forms of increased irritation of the airway and a slight decrease (without any meaningful relationship) in their respiratory capacity. Furthermore, the results indicated that the use of some protective devices, such as respiratory masks, can be effective in protecting the workers in this environment from pulmonary diseases.

After conducting their research, Gamble et al. concluded that an insignificant decrease was seen in forced vital capacity (FVC) value in a group of workers who were exposed to approximately 0.21 mg m<sup>-3</sup> of sulfuric acid mist within 12.2 years (11). Also, research conducted in order to investigate the effect of sulfuric acid mists on the increase in asthmatic reactions in a group of people exposed to plants pollens indicated that these particles could have a remarkable, adverse effect on lung function (12). A study conducted on nine people who were exposed to sulfur trioxide and sulfuric acid fog indicated that these people were suffering from chest pain, eye irritation, dizziness, mild headache, coughing, an acid taste in the mouth, and respiratory tract inflammation (13).

In research conducted on 33 workers who made batteries and were exposed to a concentration of more than 35 mg m<sup>-3</sup> of sulfuric acid mist, it was indicated that the amount of forced expiratory volume in 1 second (FEV<sub>1</sub>) throughout their shift work significantly lesser than that of a control group. Also, the pH of these workers' saliva was lower (more acidic) than that in the control group (14). But, during similar research conducted on 225 workers in a battery factory to investigate changes in pulmonary performance after shift work, no evidence was reported by pulmonary performance tests done before and after the work time. Workers with a higher exposure to acid did not have an increased rate of acute work-related symptoms. Changes in pulmonary function over the shift were not related to levels of airborne lead or airborne acid, age, sex, or smoking status (15).

The results of present study indicated that the personal habit of smoking in plating and pickling workers had no significant effect on the workers' respiratory function, and some scientists have concluded that personal

characteristics, such as smoking and underlying diseases, such as asthma, could increase the effect of sulfuric acid mist on human body. During a study conducted by Soskolne et al. in 2011, it was proven that the potential of getting laryngeal cancer was greater in people who are exposed to high concentrations of sulfuric acid in their workplace and had a history of smoking (16). Avol and Hanley also showed that asthma and smoking exacerbated the respiratory distress caused by exposure to sulfuric acid mist (17, 18). So, these findings highlight the need for additional research in this area in the future. In addition, because most of the plating and pickling units were located near other production units, it is recommended that the effect of plating and pickling workers' simultaneous exposure to other air pollutants be investigated.

## 5. Conclusion

Considering the results obtained and their similarity to the results of previous studies, it seems that the improvement of the performance of ventilation system, educating people concerning the use of personal protective equipment, and, especially, engineering strategies, such as mechanizing the plating process, can be effective in decreasing respiratory diseases, health care costs, and missed days at work due to respiratory diseases.

## Acknowledgements

The authors thank Beheshti University of Medical Sciences and Arak University of Medical Sciences for their cooperation.

## Conflict of Interest

There is no conflict of interest to be declared.

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