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CO AND SO_2 GAS REMOVAL EFFICIENCIES OF FIRE MINI-GAS MASK

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Abstract

Time dependent fire mini-gas mask removal efficiency of CO and SO_2 gas produced by fire was investigated. The fire mini-gas mask was comprised of filter, CO catalyst, chemical adsorbent, and activated carbon. The fire mini-gas mask is portable and easy-to-use compared with conventional fire gas mask. Since CO and SO_2 gases are generally critical in case of fire, this research is focused in the removal efficiencies of CO and SO_2 gases. Fourier transform infrared spectroscopic method was employed for CO and SO_2 detection with 2241-2040 and 1191-1108 cm^{-1}, respectively. As a result, the removal efficiencies of the fire mini-gas mask for CO were 90.8 and 77.7 % after 5 and 10 min, respectively, with the initial concentration of 100.3 ppm. The removal efficiencies of the fire mini-gas mask for SO_2 were 100.0 and 99.8 % after 5 and 15 min, respectively, which the removal efficiencies of SO_2 are much better than that of CO. Further investigation of removal efficiency of CO_2, HCl, HCN, and H_2S with the fire mini-gas mask will be valuable for the protection of general public and fire fighters.

Keywords: fire mini-gas mask, CO, SO_2, removal efficiency.

1. Introduction

Carbon monoxide is a product of incomplete combustion of carbon compound produced by motor vehicles using carbon-based fuels, fire-places for heating homes and a fire. It is a toxic gas with colorless, odorless and tasteless[1-2]. Acute occasions of CO exposure are the leading cause of poisoning with more than 50 % of fatal poisonings in many industrial countries. The CO poisoning is the reason for up to 45,000 emergencies and is the cause of 5,000 – 6,000 deaths each year in the United States[3]. Sulfur dioxide is a colorless gas released from burning high sulfur content materials and can cause irritation and some respiratory diseases[4]. Throat irritation occurs when a healthy person

exposes for a very few minutes at 8-12 ppm level of SO_2. Immediate cough and eye irritation occurs when a healthy person exposes at 20 ppm of SO_2. The exposure of SO_2 at 400-500 ppm level is dangerous for life[5].

Gas mask is essential equipment for fire officials, military personals, and special officials for protecting from fire suppression, chemical and biological war[6]. It is also necessary equipment in case of fire or natural disaster for general personals to prevent the inhalation of toxic CO and SO_2[7-8]. Life protection mask with pre-treatment layer, toxic gas adsorption layer, ergonomic structure was reported by Jung-Il Won et al.[9] Investigations of design for face shape suit gas mask[10], glass for gas mask[11], and filter for fire gas mask[12] were reported. Although the fire gas mask must wear quickly and run away from the fire for the current general public, it is difficult, complicate to use, and too big to hold the fire gas mask, which makes difficult to escape from the fire. In this research, we fabricated fire mini-gas mask with small and easy to carry, which makes people easy to escape from the fire. The removal abilities of fire mini-gas mask for CO gas produced by almost all incomplete combustion and SO_2 gas having very toxic and fatal in case of large amount of inhalation were tested.

2. Experimental

2.1. Experimental method

Fire mini-gas mask is comprised of bottom air inhalation part inhaling the toxic CO and SO_2 gases, air purification part, air vent for exhausting the CO_2 gas, top air inhalation part for inhaling the purified air to the noise. Fig. 1 shows the pictures of fire mini-gas mask and principle of the exhausting the toxic gases.

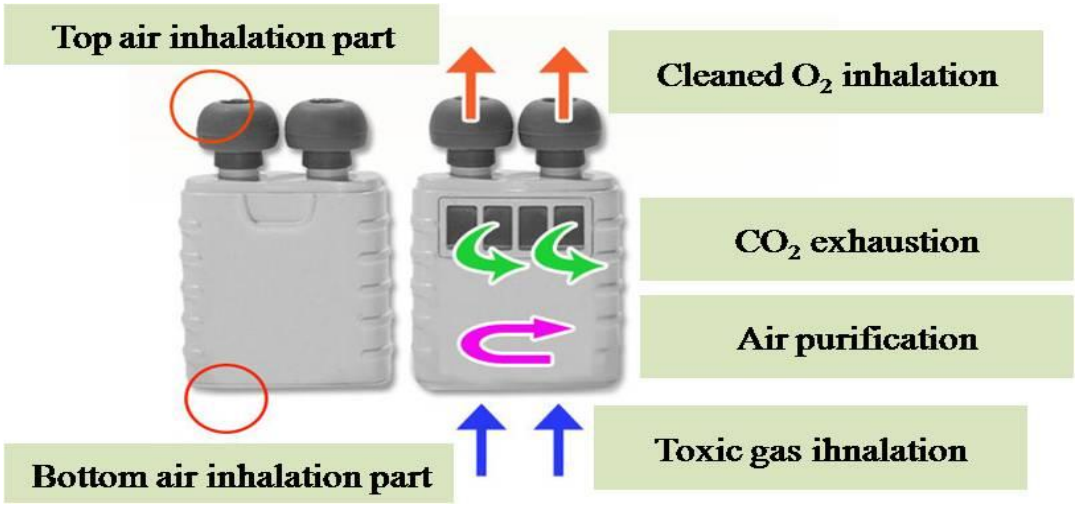

Fig. 1. The picture of fire mini-gas mask and principle of toxic gas removal

The bottom inhaling holes are comprised of filter, chemical adsorbing layer, catalyst for CO, activated carbon, which act as a remover for CO and SO_2 as show in Fig. 2. The CO and SO_2 gases with the concentrations of 100.3 and 103.0 ppm, respectively, were passed through the fire mini-gas mask at 23 ℃ and 50 % of relative humanity and measured

the concentration of the passed CO and SO_2 gases using ISO 19702:2006 (Toxicity testing of fire effluents-Analysis of gases and vapors in fire effluents using FTIR technology). Fig. 3(a), 3(b), and 3(c) show the measurement setup for before fire mini-gas setup, after fire mini-gas mask setup, the measurement of the CO and SO_2 concentrations, respectively.

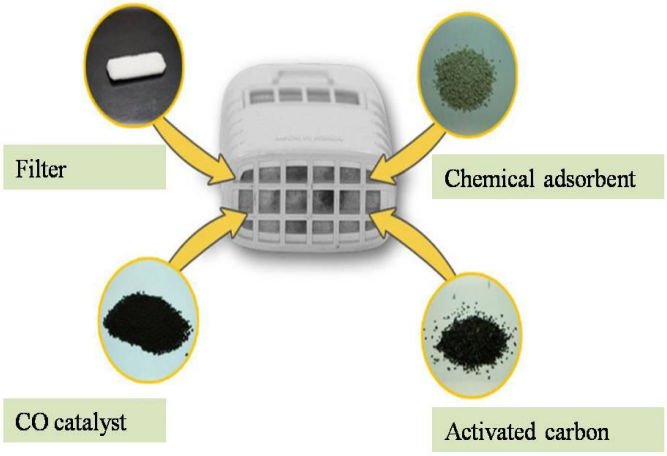

Fig. 2. Composition of a fire mini-gas mask. It is comprised of filter, CO catalyst, chemical adsorbent, and activated carbon

Fig. 3(a) Before setting up the fire mini-gas mask, (2) after setting up the fire mini-gas mask, and (3) measurement of CO and SO_2 concentration.

2.2. Experimental condition

The path length of the gas cell was 10 m, and the measurement mode was absorbance. The resolution of the instrument and number of scans are 0.5 cm^{-1} and 8 times, respectively. The wave numbers of the infrared for CO and SO_2 were 2241-2040 and 1191-1108 cm^{-1}, respectively.

3. Results and discussion

Fire mini-gas mask was set to the instrument and continuously passed through CO and SO_2 gases with initial concentrations of 100.3 and 103.0 ppm, respectively, with time. Table 1 shows the time dependent concentrations of CO and SO_2 gases passed through the fire mini-gas mask.

Table 1. Time dependent CO and SO_2 concentrations.

Gas species	Initial concentration (ppm)	Time and concentration						
CO	100.3	sec	153	305	449	601	753	953
		ppm	2.7	9.2	15.9	23.0	30.0	38.0
SO_2	103.0	sec	297	593	897	1193	1497	1793
		Ppm	0.0	0.2	0.2	0.7	3.7	7.1

The CO gas was continuously passed through the fire mini-gas mask for 953 seconds and monitored the concentration of the CO gas. After approximately 2.5 min (253 s), the CO concentration was 2.7 ppm with the removal rate of 97.3 %. The removal rate reduced to 90.3 % after approximately 5 min (305 s). The CO removal rate further reduced to 77.1 % after 10 min (601 s). Fig. 4 shows the time dependent CO concentration with the initial concentration of 100.3 ppm, and the CO concentration linearly increased with the time, which indicated that the removal efficiency of CO by the fire mini-gas mask linearly reduced with the time in the presence of CO.

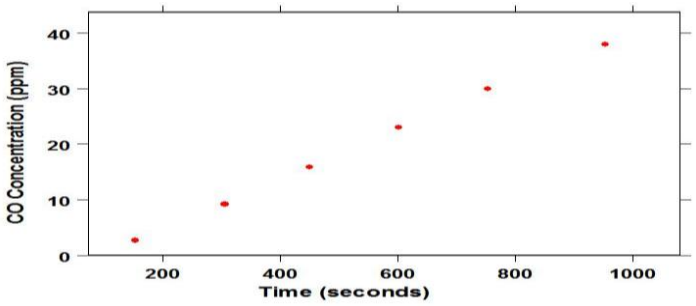

Fig. 4. Time dependent CO concentration with the initial concentration of 100.3 ppm.

The fire mini-gas mask was much more effective for the SO_2 gas compared with that of CO. The SO_2 gas was not detected until approximately 5 min (297 s) with the removal efficiency of 100 %. The removal rate was 99.8 % until approximately 10 min (593 s) and maintained about the same removal rate until 15 min (897 s). Removal rate started to reduce after approximately 20 min (1193 s). Fig. 5 shows the time dependent SO_2 concentration passed through the fire mini-gas mask with the initial concentration of 103.0 ppm, which showed non-linear removal rate with time in the presence of SO_2 gas.

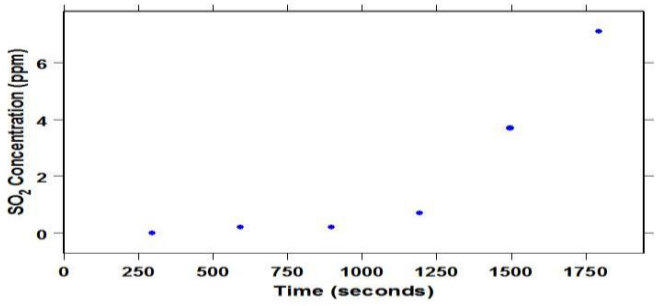

Fig. 5. Time dependent SO_2 concentration with the initial concentration of 103.0 ppm.

4. Conclusions

This research is focused on the removal efficiency of CO and SO_2 in the case of fire for the fire mini-gas mask with small, portable, and easy-to-use. The results were the followings: 1) The removal efficiency of the fire mini-gas mask for CO was 90.8 % after 5 min with the initial concentration of 100.3 ppm, was 77.1 % after 10 min, and linearly reduced with time in the presence of CO gas. 2) The removal efficiency of the fire mini-gas mask for SO_2 was 100.0 % for initial 5 min, was 99.8 % for 15 min, has non-linear relationship with time. It may need further investigation for CO_2, HCl, HCN, and H_2S gas for the protection of general public and fire fighter in case of fire.

References

1. Omaye ST. Metabolic modulation of carbon monoxide toxicity. *Toxicology* 2002; 180: 139-150.
2. Queiroga CSF, Almeida AS, Vieira LA. Carbon monoxide targeting mitochondria. *Biochemistry Research International* 2012; 749845.
3. Huzar TF, George T, Cross JM. Carbon monoxide and cyanide toxicity: etiology, pathophysiology and treatment in inhalation injury. Expert Rev. Respir. Med. 2013; 7: 159-170.
4. Meng Z, Qin G, Zhang B, Bai J. DNA damaging effects of sulfur dioxide derivatives in cells from various organs of mice. Mutagenesis 2004; 19; 465-468.
5. Khan RR, Siddiqui MJA. Review on effects of particulates; sulfur dioxide and nitrogen dioxide on human health. Int. Res. J. Environment Sci. 2014; 3: 70-73.
6. Thavaselvam D, Flora SS. Chapter 30 – Chemical and biological warfare agents. *Biomarkers in Toxicology* 2014; 521-538.
7. Hampson NB, Bodwin D. Toxic CO-ingestions in intentional carbon monoxide poisoning. *J. Emergency Medicine* 2013; 44: 625-630.
8. Li K, Yu H, Qi G, Feron P, Tade M, Yu J, Wang S. Rate-based modeling of combined SO_2 removal and NH_3 recycling integrated with an aqueous NH_3-based CO_2 capture process. *Applied Energy* 2015; 148: 66-77.
9. Won JI, Lee JS. A study on the development of portable life protective mask. *J. Korean Soc. Urban Environ.* 2014; 14: 145.
10. Oh YJ, Park SJ. The facial anthropometry with 3D head scanner Korean gas mask. *Proc. Conf. Korea CAD/CAM Review* 2010; 404.
11. Lee JY, Park JS, Jang WY. Development of gas-mask spectacles. *J. Korean Ophthalmic Optics Soc.* 2008; 13: 9.

12. Lee JY, Kim JH, Kim YH, Jung KC. A study on toxicity evaluation of combustion gases released from the residential container ffire efficiency test for the fire gas mask filters. *J. Korean Safety* 2004; 19: 48.