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연립 주택 화재시 유독가스 방출 특성과 Rats를 이용한 독성평가

Toxicity Evaluation of Effluent Gases from a Residental Fire by Rats

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요 약

화재에 의한 독성가스의 노출은 인간에게 있어서 화재시 생명에 아주 위험한 요소일 것이다. 다양한 화재에 의한 독성가스의 노출 중 본 논문에서는 경기도 안산시 재개발지구에서 한 연립주택을 이용하여 실재화재와 같은 조건으로 화재 시험을 하였다. 화재시 발생하는 가스 CO, CO_2, O_2, SO_2, NO 및 NO_2 등를 측정하였으며, 발생하는 가스를 실험동물인 백서(S.D.)에 노출시켜 2분간격으로 혈액을 체취하였다. 독성 평가를 위하여 백서의 혈액과 혈청 중 Glucose, AST(GOT), ALT(GPT), CBC Count 및 CO (carboxy)-Hb를 분석하였다. 폭로되는 CO의 농도와 백서의 혈액중 CO-Hb 농도사이에 양-반응 관계 (dose-response relationship)를 보였다.

ABSTRACT

It has long been recognized that exposure to fire-induced toxic gases is a fatal hazard confronting people in fires. In this study, an indoor fire experiment was conducted in an unoccupied residential building located in An-san city, Kyoung-gi province, and the composition of effluent gases, which include CO, CO_2, O_2, SO_2, NO and NO_2, were measured by a gas analyzer. A group of lab rats were exposed to the toxic gases released from fire, and the blood samples of the rats were gathered every 2 minutes. A toxicity evaluation was conducted by analyzing the concentrations of Glucose, AST(GOT), ALT(GPT), CBC Count and CO(carboxy)-Hb in the blood samples. Shown from the analysis is the does-response relationship between the CO concentration that rats were exposed to and the CO-Hb concentration in rat blood.

Keywords : Toxicity, Residential fire, Exposed, Blood and Serum, CO(carboxy)-Hb

1. Introduction

It has long been recognized that exposure to fire-induced toxic gases is a fatal hazard confronting people in fires. Carbon monoxide (CO), released in a large amount from wood and other carbon fires, is specially one of the fatal toxic gases. In this study, an indoor fire experiment was conducted in an unoccupied residential building located in An-san city, Kyoung-ji province, and the composition of effluent gases, which include CO, CO_2, O_2, SO_2, NO and NO_2, were measured by a gas analyzer. A group of lab rats (Sprague dawley) were exposed to the toxic gases released from the fire, and the blood samples of the rats were gathered every 2

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minutes. A toxicity evaluation was conducted by analyzing the concentrations of Glucose, AST (GOT), ALT(GPT), CBC Count and CO(carboxy)-Hb in blood samples.

2. Methodology

The fuels of the residential fire included furniture, paper, wood, clothes, and interior upholsteries such as sofa, chair, curtain, floor cover, etc. Fig. 1 shows the abandoned residential building, where the experiment of exposing rats to the fire-induced gases was performed. The lab rats used in the experiment are Sprague Dawley (age 7 weeks, male, 215 ± 15 g). The rats were exposed to the gases in two chambers(1 m × 1.2 m × 1.5 m), which were connected to the residential building by an induction pipe (Fig. 2). The pipes were suspended in the living room(4 m × 7 m × 3 m) and child room (3 m × 5 m × 3 m) at a height of 1.5 m, at which the respiration of human generally takes place.

The fire started from the living room, and all the openings (windows and doors) kept shut at the beginning. Then, due to the elevation of indoor temperature, all the window glass was bursted by the heat released from the fire, and all the window became open resultingly. Although the amount of gas flowing into the chambers could be determined according to the change of flow velocity, the gas concentrations in chambers were measured by a gas analyzer in this study.

Several types of blood tests were given to the rats, which includes glucose (enzyme method, reagent ; sinyang, Korea, Hitachi 7600 110), AST (GOT, UV method, reagent; sinyang, Korea, Hitachi 7600 110), ALT (GPT, UV method, reagent ; sinyang, Korea, Hitachi 7600 110), CBC Count (complete blood cell count method, reagent ; RBC/Plt, HGB, Baso, EZ Kleen, Defoamer, Sheath Rinse, Perox 1,2,3 Ret., ADVIA TM 120 Hematology System, Bayer, USA) and CO (carboxy)-Hb (method : alkali hematin, UV spectrometer, Hewlett Packard).

The composition of effluent gases were measured by the gas analyzer (ENERAC 2000(USA) and ECOM-A(COM America LTD., USA), which includes CO (carbon monoxide), CO_2 (carbon dioxide), O_2 (oxygen), SO_2 (sulfur dioxide), NO(nitro monoxide) and NO_2(nitro dioxide).

Toxicity of effluent gases released from the residential fire is evaluated according to CO-Hb curve, CBC curve obtained from the blood and serum of rats, and glucose, AST, ALT curves obtained from the serum of rats. These blood tests were conducted in Seoul Clinical Laboratory.

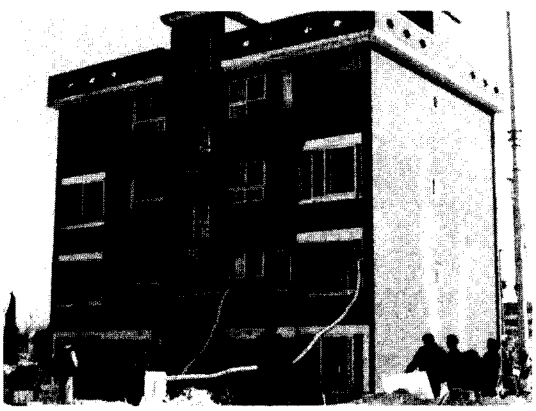

Fig. 1. View of the residential building.

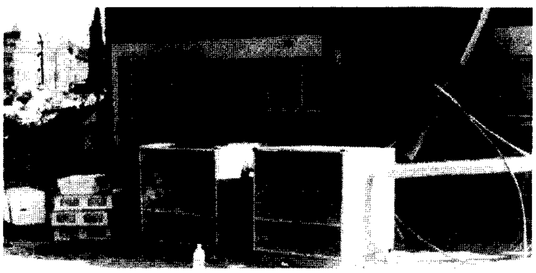

Fig. 2. Two chambers in which the lab rats were exposed to the gases released from the fire.

Fig. 3. Induction pipes suspended in living room and child room.

3. Results and Discussions

The concentrations of gases released from the experimental fire were measured for 30 minutes.

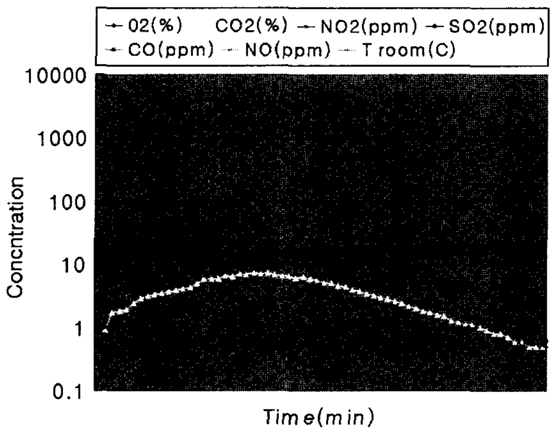

Fig. 4. Time dependent gas concentrations resulting from the residential fire.

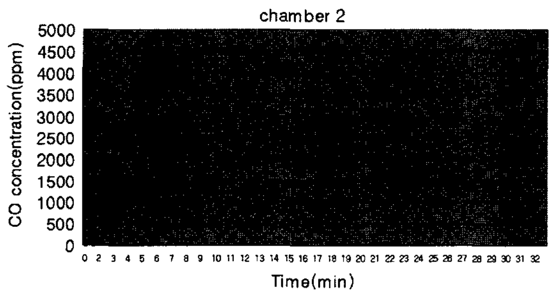

Fig. 5. Time dependent concentration of CO in chamber 2 (child room).

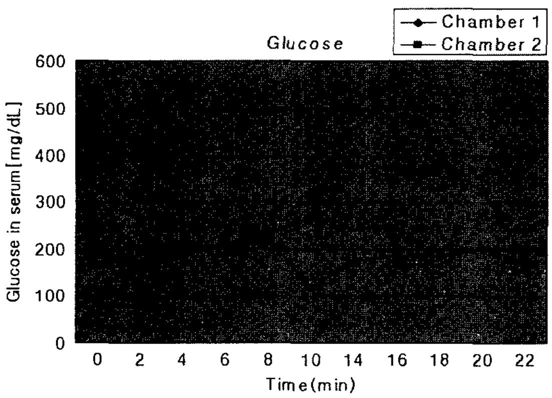

Fig. 6. Time dependent concentration of glucose in serum of rats.

The results are shown in Fig. 4 and 5.

Fig. 4 shows the change of gas concentrations within a period of 30 minutes after the fire ignition. It can be seen from this figure that a steep rise of the concentration of CO appeared 2 minutes after the fire ignition, and reached the maximum when 9 minutes elapsed. The concentrations of NO and CO_2 respectively reached the maximum when 5 minutes and 12 minutes elapsed. According to Fig. 5, 6 minutes after the concentration of CO reached the maximum, most rats were asphyxiated to death.

Table 1 lists the lethal concentrations of different toxic gases towards human and rat. According to this study, the concentration of CO that caused the death of rats accords the most with the data listed in Table 1. It is believed that CO plays the critical role in causing the death of rats, while the other gases play an additional role.

According to Fig. 6, the gases flowing to chamber 1 had greater influence on the glucose concentrations in serum of rats than those in chamber 2. Also, a steep increase of glucose concentration appeared 10 minutes after the fire ignition. It's believed that toxic gases with higher concentrations flowed into chamber 2. The burst of window glass is believed to cause the temperature change and the difference between the amount of toxic gases flowing into two chambers.

According to Fig. 7, chamber 1 had greater influence on the concentration of CO-Hb in blood than chamber 2 did. 4 minutes after the steep rise of CO concentration in test chamber, a rise of CO-Hb concentrations in rat blood appeared resultingly. This shows the dose-response relationship between CO concentration and CO-Hb concentration. The steep rise of CO concentration results in the increase of CO-Hb in blood, which disables the

Table 1. Lethal concentrations of different toxic gases

Toxic gases	Lethal Concentration /Rat[ppm]	Lethal Concentration /Human[ppm]
CO	5207 (30 minutes)	5000 (5 minutes)
CO_2	90,000 (5 minutes)/ mammal	90,000 (5 minutes)
NO	854 (4 hours)	315 (15 minutes)/ Rabbit
NO_2	138 (30 minutes)	200 (1 minutes)

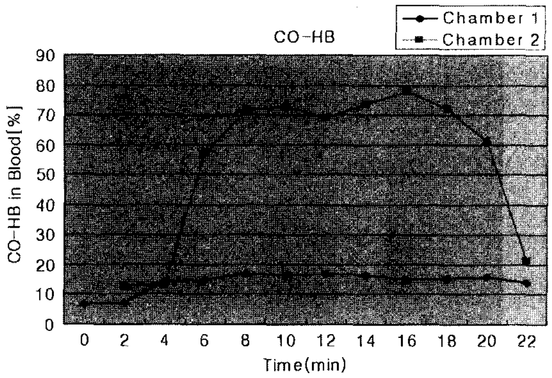

Fig. 7. Time-dependent CO-Hb concentrations in Blood of rats.

ability of blood to carry oxygen to cells, and leads to the paralysis of central nerve and the loss of capacity for locomotion. As a result, the occupant confronting the fire is unable to proceed evacuation, and is resultingly asphyxiated to death.

There were no significant changes with the concentration of GOT, GPT and CBC according to the results of blood tests. These indexes will show a significant change only if a specific exposure time passes. The change of these indexes will cause damages to the cells of liver and other organs. It is believed that a long term of exposure to the gas with low concentration will result in the rise of these indexes.

4. Conclusion

1. A steep rise of the concentration of CO appeared 2 minutes after the fire ignition, and reached the maximum when 9 minutes elapsed. The concentrations of NO and CO_2 respectively reached the maximum when 5 minutes and 12 minutes elapsed.

2. The gases inducted to chamber 1 had greater influence on the glucose concentrations in serum of rats than those in chamber 2. Also, glucose concentrations increased sharply after 10 minutes elapsed. It's believed that toxic gases with higher concentrations flowed into chamber 2.

3. Chamber 1 had greater influence on the concentration of CO-Hb in blood than chamber 2 did. 4 minutes after the steep rise of CO concentration in test chamber, a rise of CO-Hb concentrations in rat blood appeared resultingly. This shows the dose-response relationship between CO concentration and CO-Hb concentration. There were no signifiant changes with the concentration of GOT, GPT and CBC according to the results of blood tests.

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