FABA: Filter Assisted Breathing Apparatus for Fire Protection

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Executive Summary

Each year in the United States, approximately 3,000 mortalities and 13,000 injuries occur due to residential fires [1]. Over recent decades, increased use of synthetic materials (e.g. nylon and polyester carpeting, plastic appliances) has lead to a rise in the toxicity of gases released in residential fires. Combustion of synthetics produces high levels of the toxic gasses hydrogen cyanide (HCN) and carbon monoxide (CO). As few as two breaths containing high levels of CO or HCN can render a civilian or firefighter inanimate [2]. In recent years, deaths caused by smoke inhalation have begun to outnumber deaths caused by burns, currently at a ratio of over 2-to-1 [1].

FABA provides a solution to this problem. This novel filter system prevents the inhalation of CO and HCN, as well as smoke particulates. Currently, there is no other device on the market designed to be carried by a firefighter into a residential fire to help protect the victims inside. FABA is compact and lightweight, making it easy for firefighters to carry and deploy.

Problem and Clinical Need

There is a shortage of equipment and monitoring systems designed to protect firefighters and victims of fires from the toxic fumes and inhalants that are produced. The victims in fires are especially vulnerable to inhaling these toxins, which include CO and HCN. Currently, firefighters have no way to protect victims from inhalation injuries.

An estimated 50-80% of fire related deaths are caused by smoke inhalation [3]. Two of the deadliest inhalants produced in a fire are CO and HCN. Both of these toxins prevent the body from using oxygen, resulting in issues such as cardiac arrest or suffocation [4].

Market

According to the National Fire Incident Reporting System (NFIRS) in 2007, there were approximately 33,800 fire departments in the United States alone, of which 20,000 report to the NFIRS [5]. The participating fire departments have reported 1,000,000 fires each year [6].

Novelty

- FABA is the only device that would be available to firefighters to protect victims from exposure to CO and HCN fumes. Current methods entail dousing a sheet in water and wrap around a victim's head; this method is only successful in removing smoke particulates
- The specialty filter consists of a combination of materials that are specific to filtering some of the most hazardous toxins: CO and HCN.

Overview of Device

Our device consists of a filter, a flexible mask to cover the nose and mouth, and a flange mouthpiece.
The three-layer filter contains the following component layers:

- A basic aloe solution with HCN adsorbent properties spread over polystyrene balls to maximize exposed surface area.
- a catalyst called CARULITE® 300 capable of catalysis of CO into carbon dioxide
- activated charcoal cloth impregnated with heavy metals to maximize adsorption of HCN
- Polyester and nylon mesh will be divide the layers and provide a particulate filter.

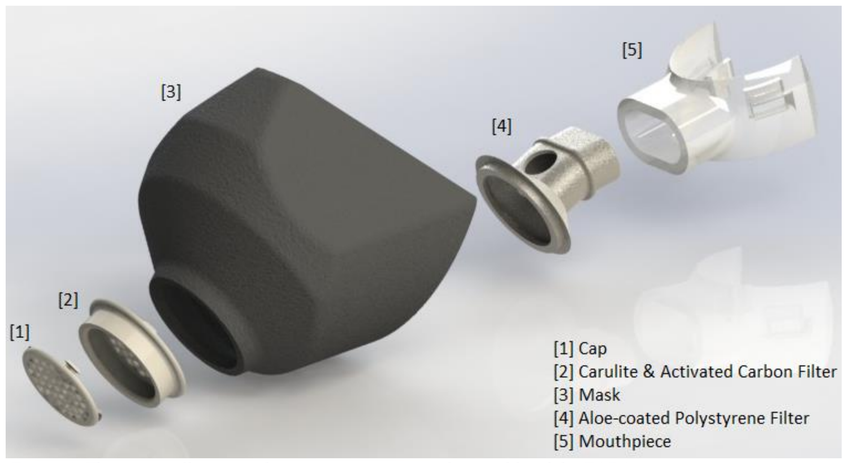

Figure 1: This image illustrates design, components and assembly of the FABA

Results

- Filter met or exceeded **73% reduction** in CO
- Reduced CO concentration in all trials to below OSHA Maximum Recommended Exposure Limit (figure 2, below)
- Qualitative results in hydrogen cyanide filtration tests (figure 3, below) clearly show presence of HCN in all three unfiltered smoke samples while none appears in filtered smoke samples, however HCN generated in testing was insufficient to enter the quantifiable range of the meter.

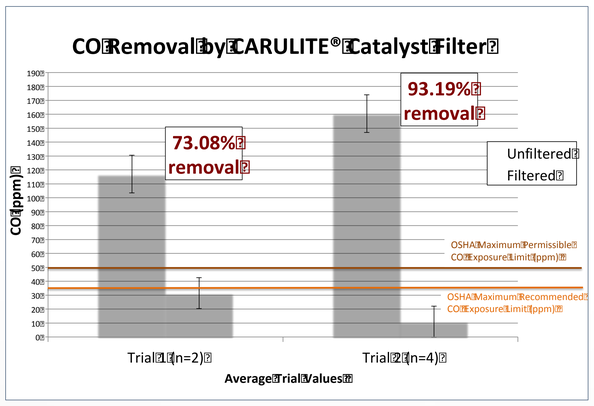

Figure 2: Tests on the CARULITE® filter component show quantifiable reduction of CO in filtered samples. A piston chamber was used to regulate airflow through the filter in rates and at volumes sufficient to mimic adult lung capacity.

Figure 3: These HCN testing meters show results for three consecutive trials of HCN filter efficacy of the activated carbon cloth component. From left to right: Trial 1 unfiltered; Trial 1 filtered; Trial 2 unfiltered; Trail 2 filtered; Trial 3 unfiltered; Trial 3 filtered.

Estimated Cost

- FABA is estimated to cost $7.53per respirator
- Volume: 300,000 respirators
- Labor cost: $15 / hour
- Production Rate: 6 respirators / hour

Regulatory Pathway

This device will be used by firefighters and victims in fires, so it must meet several standards set by the Occupational Safety and Health Administration (OSHA) and Centers for Disease Prevention (CDC), rather than the FDA. These regulations include several standard testing procedures that would need to be passed for successful release into the market [7,8,9].

Future Work

- Additional testing for hydrogen cyanide to obtain quantitative measurements
- Market device to firefighters for use during the overhaul process, which involves significant exposure to toxic fumes as firefighters search for smoldering and hidden fire sources following the extinguishment of the primary fires

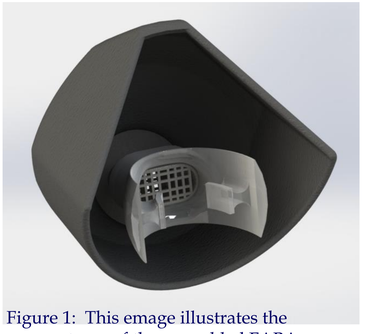

Figure 1: This emage illustrates the compactness of the assembled FABA

Acknowledgements

We would like to thank Professor Conrad Zapanta and Molly Blank for their guidance and support throughout the year.

We also give special thanks to PJ Ostrowski for providing expertise and invaluable advice.

References

[1] Flynn, Jennifer D. (March, 2010). Characteristics of Home Fire Victims. *National Fire Protection Association Fire Analysis and Research Division*.
[2] "The U.S. Fire Problem." NFPA. National Fire Protection Association, n.d. Web. 24 Oct. 2012.
[3] Holstege, Christopher P. "Smoke Inhalation." EMedicine Health. EMedicine Health, n.d. Web. 23 Oct. 2012.
[4] Lee, M. Cyanide poisoning poses hidden threat. Fire Service, Firefighters & Departments | Fire Rescue 1, n.d. Web. 16 Oct. 2012.
[5] United States. FEMA. U.S. Fire Administration. *Fire in the United States 2003-2007*. Fifteenth ed. 2009. Web. 12 Apr. 2013.
[6] "National Fire Incident Reporting System (NFIRS)." *U.S. Fire Administration*. FEMA, 5 Sept. 2012. Web. 12 Apr. 2013.
[7] Grant, Casey C. *Respiratory Exposure Study for Fire Fighters and Other Emergency Responders*. Rep. National Fire Protection Association, Dec. 2007. Web. 15 Apr. 2013.
[8] "Certified Equipment List." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 29 May 2012. Web. 15 Apr. 2013.
[9] "Standard Respirator Testing Procedures: Air-Purifying Respirators." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 23 Oct. 2012. Web. 15 Apr. 2013.