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Thermal Degradation of Chemical Warfare Agents Utilizing Pyrolyzed Cotton Balls

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Introduction

Since the Chemical Warfare Convention (CWC) Treaty was established in 1997, it has been prohibited for countries to stockpile, produce, or use chemical warfare agents (CWAs). However, it can be assumed that not every country or group is in accordance with these regulations, and therefore a method to deactivate and destroy these agents is necessary for international security. Current methods for destroying chemical warfare agents have predominantly relied up hydrolysis, high pressure peroxides, or oxidation reactions utilizing bleaching agents.[1-2] While these methods are effective, they require a large quantity of decontamination agents relative to the amount of CWA present and can produce secondary hazardous byproducts. Previous research into pyrolysis of agents has focused around submitting small quantities of the agents to high temperatures for an extended period of time.[3-4] While this method has shown to be highly effective, it requires intensive sample preparation and only reduces small volumes of the agents. Recent methods to ignite CWAs have utilized metal oxides and perchlorates to create conditions which support sustained combustion.[5] Pyrolyzed cotton balls (PCBs) are an effective vessel for igniting the agents with napalm due to their increased surface area and hydrophobic qualities. These PCBs coated in napalm suggest a quick and effective method to destroy a wide variety of chemical warfare agents with limited residue or byproducts. This presents a simple, low cost, and effective method to rapidly decompose large quantities of CWAs with limited waste or cross contamination.

Experimental Considerations

- Standard Cotton balls pyrolyzed in a quartz tube furnace at 1000° C for 60 minutes in presence of Argon gas
- Chemical warfare agent simulant chemicals (See Figure 1)
- Mass balance to measure rate of overflow from sample pan while pumping agent into system both with and without burning (See Figure 2). Syringe pump rate maintained constant at 4.00mL/min throughout all experiments.
- Overflow rate for each pan determined internal to each experiments and compared against overflow rate during burning to determine average and maximum burn rates

Applications of Research

- To develop a low cost and effective method to degrade a wide range of chemical warfare agents
- Reduce the amount of chemical waste produced by decontamination of CWAs
- Develop a field expedient method of destroying CWAs with minimal sample preparation and supplies

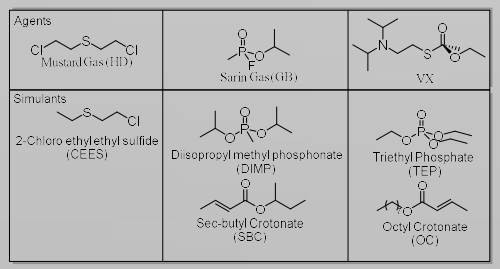

Figure 1: Chemical Warfare Agents and their associated simulant molecules examined in this study

Results

Figure 2: Experimental setup of steady state experiment. Burning of CEES shown in left sample pan using a pyrolyzed cotton ball coated in napalm

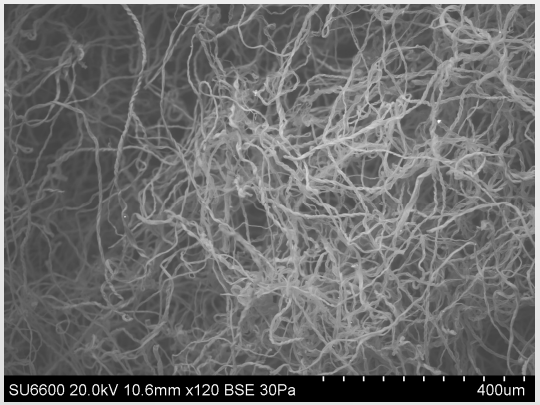

Figure 3: Scanning electron microscope images of the bare carbon following pyrolysis. The fibrous structure of the cellulose is retained with significant voids which allow for the napalm mixture to integrate throughout the pyrolyzed cotton ball

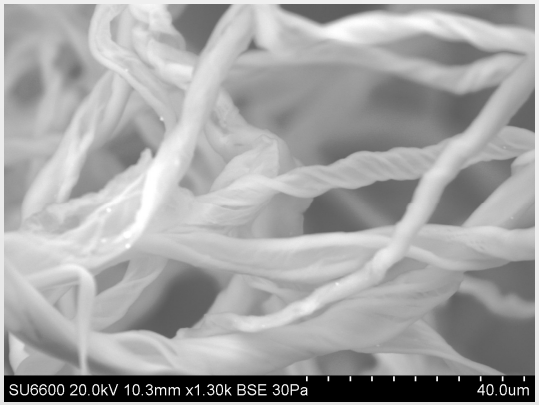

Figure 4: Scanning Electron microscope image of pyrolyzed cotton ball fibers showing the increased surface area and structure of the individual fibers

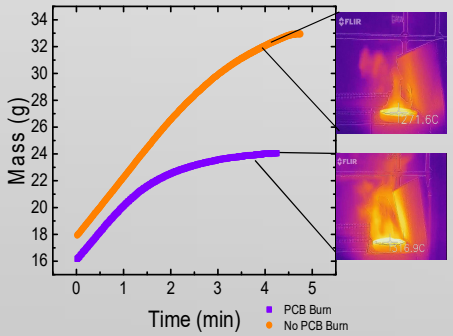

Figure 5: Comparison of overflow of CEES during burning in 8.5 cm pan with pyrolyzed cotton balls and without pyrolyzed cotton balls

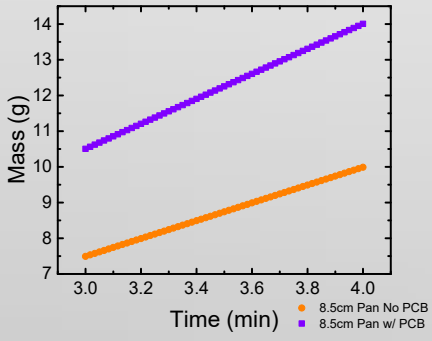

Figure 6: Comparison of max burn rate of CEES in 8.5 cm pan with pyrolyzed cotton balls and without pyrolyzed cotton balls

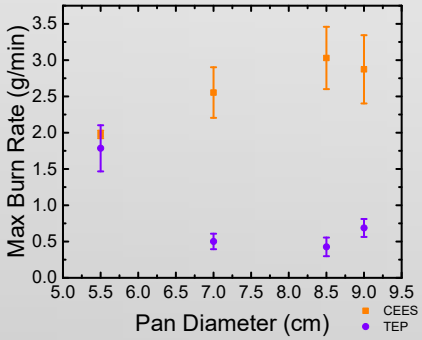

Figure 7: Comparison of Max Burn Rates for CEES and TEP as a function of pan size

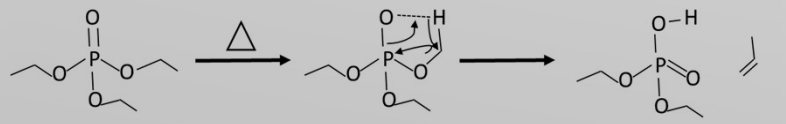

Figure 8: Proposed Retro Ene Reaction Mechanism for TEP generating flammable and less toxic products

Conclusions

- CEES and TEP will readily decompose through burning with limited byproducts produced, indicating a simple and effective method for destroying large quantities of the agent
- Pyrolyzed cotton balls increase the rate of burning for CEES and enable the burning of TEP due to the increase surface area and increased volume of the burning agent, napalm, which is introduced to the sample
- While larger pans do not necessarily have a higher burn rate, the samples are able to reach the a temperature above 400°C at a faster rate, indicating that the increased surface area increases the rate where maximum decomposition can occur.

References

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Acknowledgements

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