All-Weather Dry Decontaminate Fibers for 2-CEES Degradation

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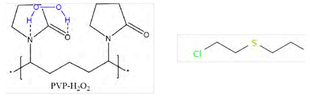
Abstract

Hydrogen peroxide (H_2O_2) is a highly effective decontaminate against a 2-CEES simulant, both when present in a liquid or as a solid powder. For the latter this can be in the form of the H_2O_2 being complexed to a polymer, such as polyvinylpyrrolidone (PVP). However, this complex dissociates at high levels of relative humidity, releasing the H_2O_2 and thereby making the complex ineffective as a 2-CEES decontaminate. In this paper, we demonstrate that the crosslinked version of PVP is a highly stable complex with H_2O_2 that can withstand a large temperature range (-20 to 40 °C) and large RH (90%) over the course of several days. We show that when the crosslinked complex is exposed to these extreme conditions, it remains an effective decontaminate against the simulant 2-CEES. Finally, using the above as a framework we demonstrate that the H_2O_2-PVP complex can be processed in a variety of form factors and we highlight its use as a decontaminate fibrous wipe.



Schematic 1: Scheme of H_2O_2-PVP complex with 2-CEES.

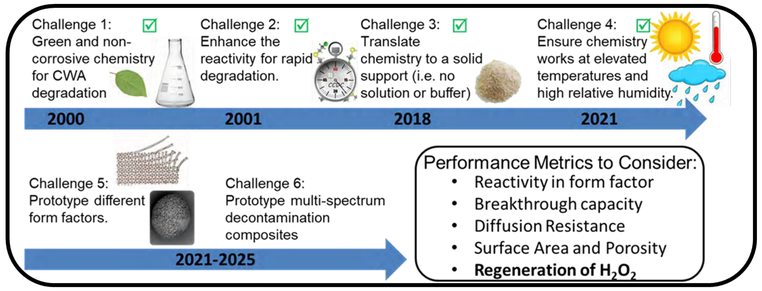


Figure 1: Timeline for the development of H_2O_2-PVP fibers for 2-CEES decontamination.

Results: Varying Temperature and Humidity 2-CEES Degradation

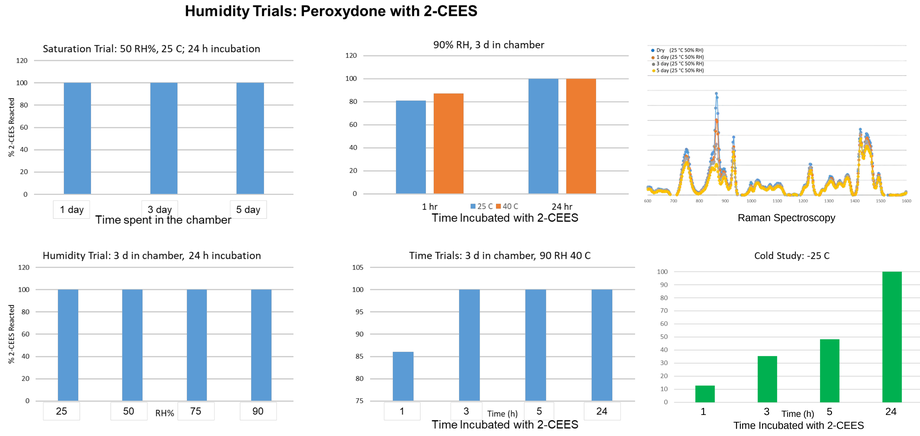


Figure 2: Varying the environmental conditions in assessing the efficacy of the peroxide polymer complex.

Results: PVP Form Factors

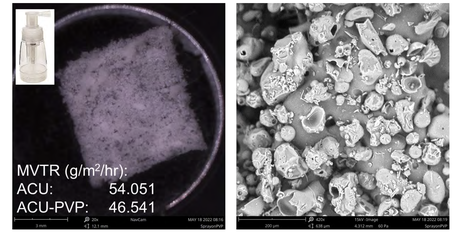
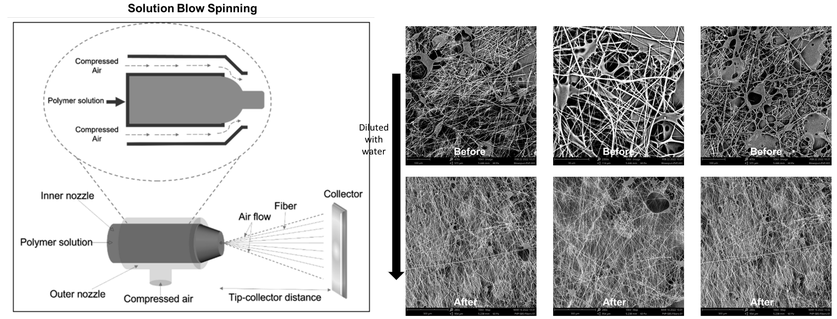


Figure 3: Form factors for PVP fibers. (Left) Crosslinked PVP particles dry sprayed onto ACU and corresponding MVTR values. (Below) Blowspun fibers with schematic of blowspinning apparatus and subsequent SEM of fibers. Dilution of the blow spun solution leads to better fiber formation.



Results: H_2O_2 Regeneration

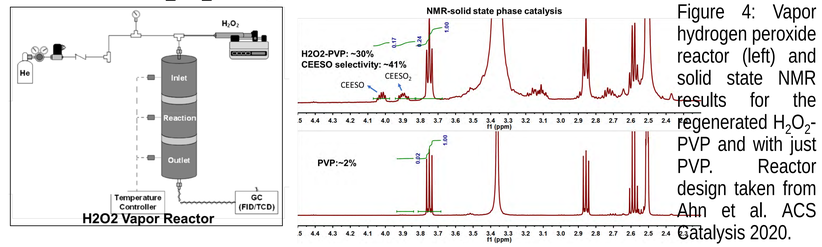


Figure 4: Vapor hydrogen peroxide reactor (left) and solid state NMR results for the regenerated H_2O_2-PVP and with just PVP. Reactor design taken from Ahn et al. ACS Catalysis 2020.

Conclusions

We have demonstrated that known solution based approaches for the decontamination of 2-CEES can be translated to the solid phase by using a peroxide polymer complex. This complex is effective at high relative humidity and temperature as well as at very cold temperatures approaching -30 C. Lastly we demonstrate that the polymer can be made into fibrous form factors and the peroxide can be regenerated back onto the polymer.

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Acknowledgements: The authors would like to express our thanks to the Notestein group at Northwestern University for assisting in the solid state NMR and advice on building the hydrogen peroxide vapor reactor. The views expressed in this abstract are those of the authors and do not necessarily reflect the official policy or position of the Department of Defense or the U.S. Government.)

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