Analysis of Removal and Decomposition Pathways of Vaporized Hydrogen Peroxide (VHP) for Aircraft Decontamination Operation

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CONTENTS

Background

The Need for Infection Control in Aviation:

- The modern civil aviation system exposes potential risks for the rapid spread of infectious disease. Thus there are significant ongoing concerns over routine air travel (e.g.SARS in 2003).
- Simultaneously, there are ongoing concerns over the use of chemical and biological (chem.–bio.) agents by terrorists against aircraft.

Background

- the concerns for infectious diseases are vastly magnified in the event of an epidemic/pandemic event, because:
  - Air travel transports infected individuals to new locations rapidly
  - Aerosol person to person transmission can occur within the cabin
  - Transmission can occur via cabin surfaces.

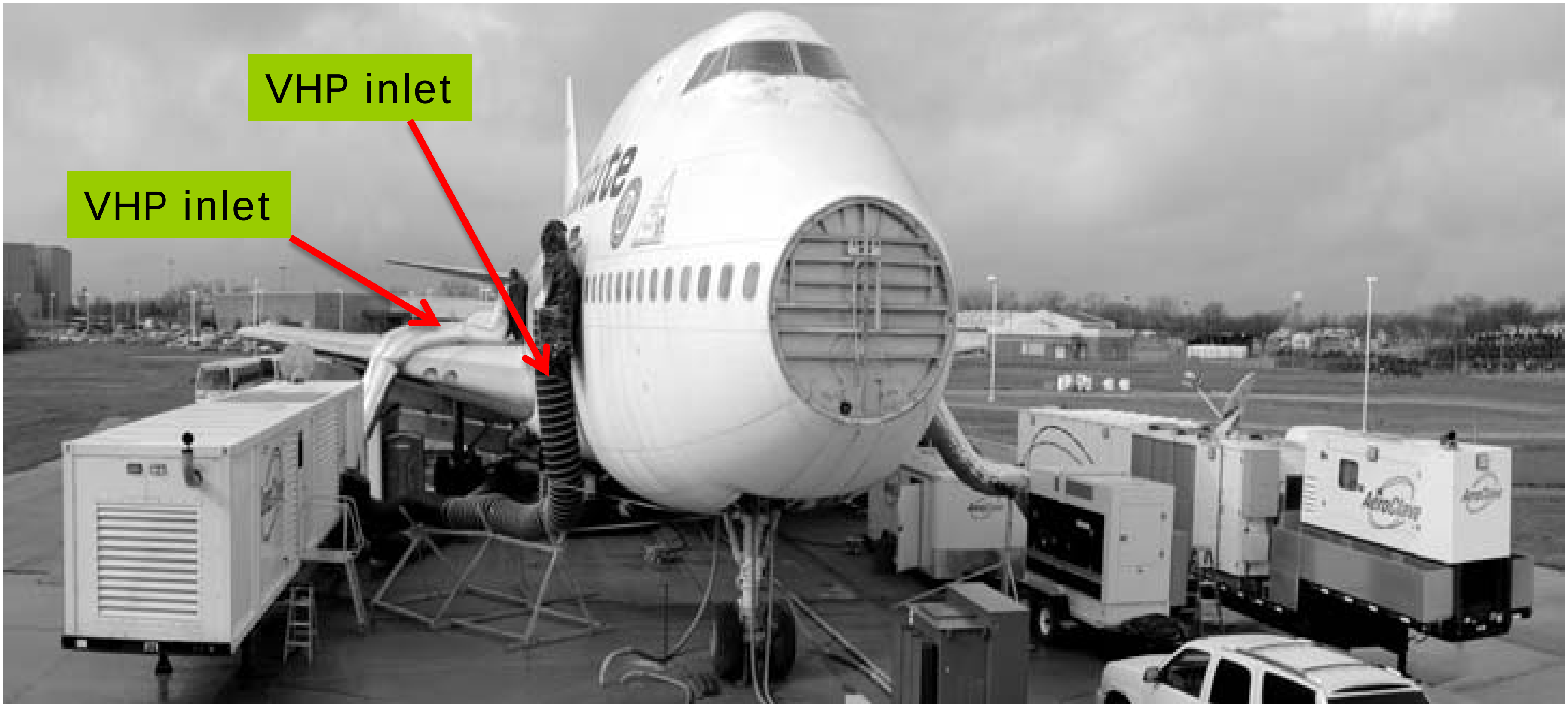
Background

Efficient infection control strategies are needed such as decontamination or sanitization of aircraft.

- This must be both efficacious as an antimicrobial for the pathogens
- It is safe to deploy in the context of flight/safety critical aircraft materials and systems.

VHP Aircraft Decontamination

VHP Aircraft Decontamination consists of delivering VHP (Vaporized Hydrogen Peroxide) through a stand-alone system, in an efficient way, without requiring bulky vaporizers or other heavy equipment within the cabin, such that the system is capable of delivering controlled quantities of VHP to achieve sporicidal conditions throughout the cabin.



The first demonstration of whole widebody airliner VHP decontamination, March 2007,following on from a narrow body aircraft demonstration in 2006 (Air Transportation Center of Excellence for Airliner Cabin Environment Research, Auburn University, USA).

VHP Aircraft Decontamination

hydrogen peroxide from a concentrated liquid source (35 % hydrogen peroxide) is flash vaporized and delivered to the space to be decontaminated in the vapour phase.

- VHP concentrations: 120~170 ppm
- Temperatures were ~65C
- At least 2 hours operation
- Biological indicators (BIs) were placed throughout the cabin for the formal evaluation

Challenges

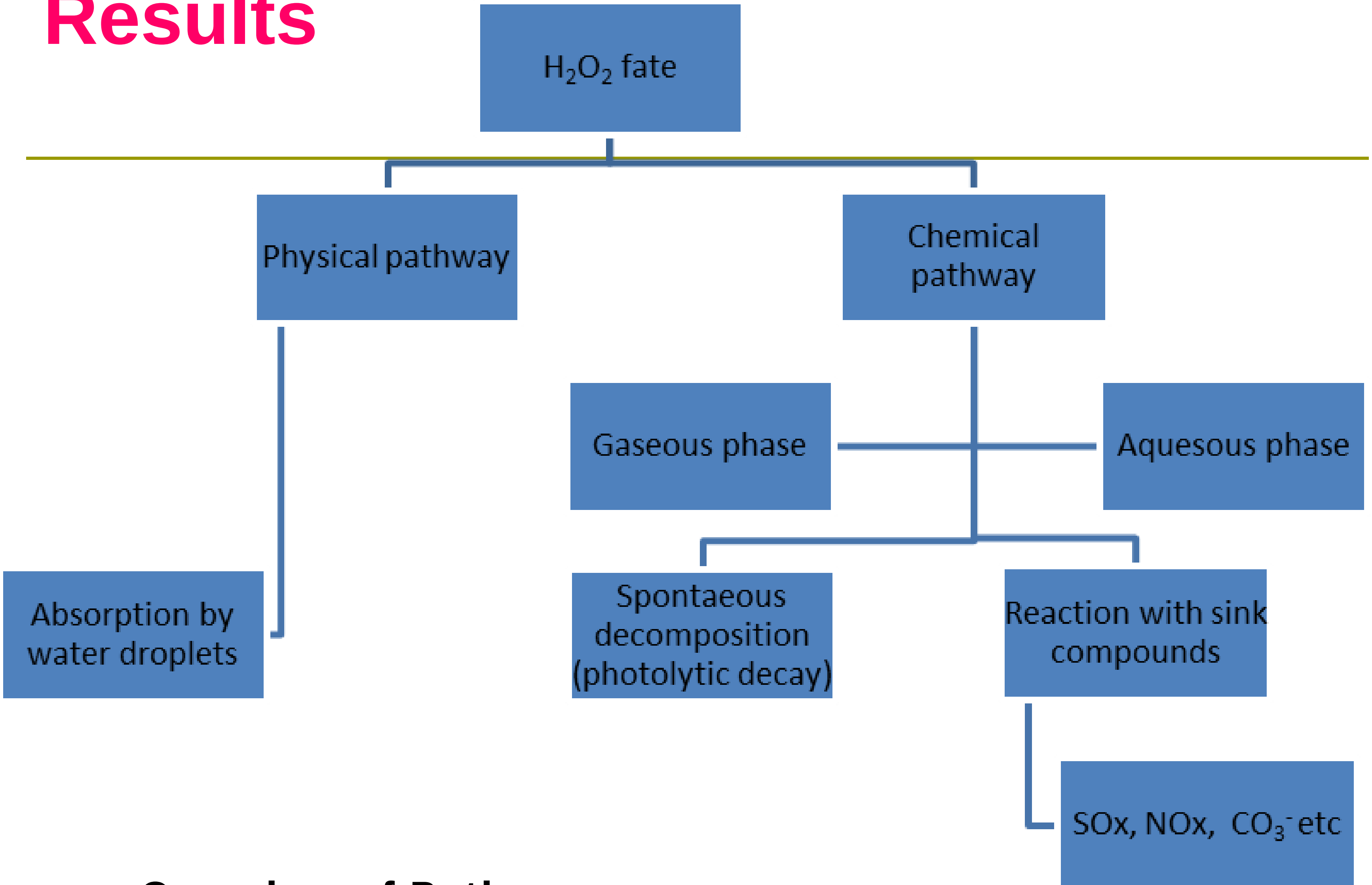
In seeking industry and government input on the deployment of VHP for civil aviation applications, two key concerns were raised frequently in workshops and consultations:

- Compatibility with aircraft materials and systems.
- The extent to which any environmental release of hydrogen peroxide presents a safety threat to adjacent aviation operations.

Objectives

To investigate the fate of vaporized hydrogen peroxide released to atmosphere from aircraft decontamination operation.

Results



Overview of Pathways

Results

Physical Pathway - Uptake to Water Droplets

Partition between gaseous and aqueous phase

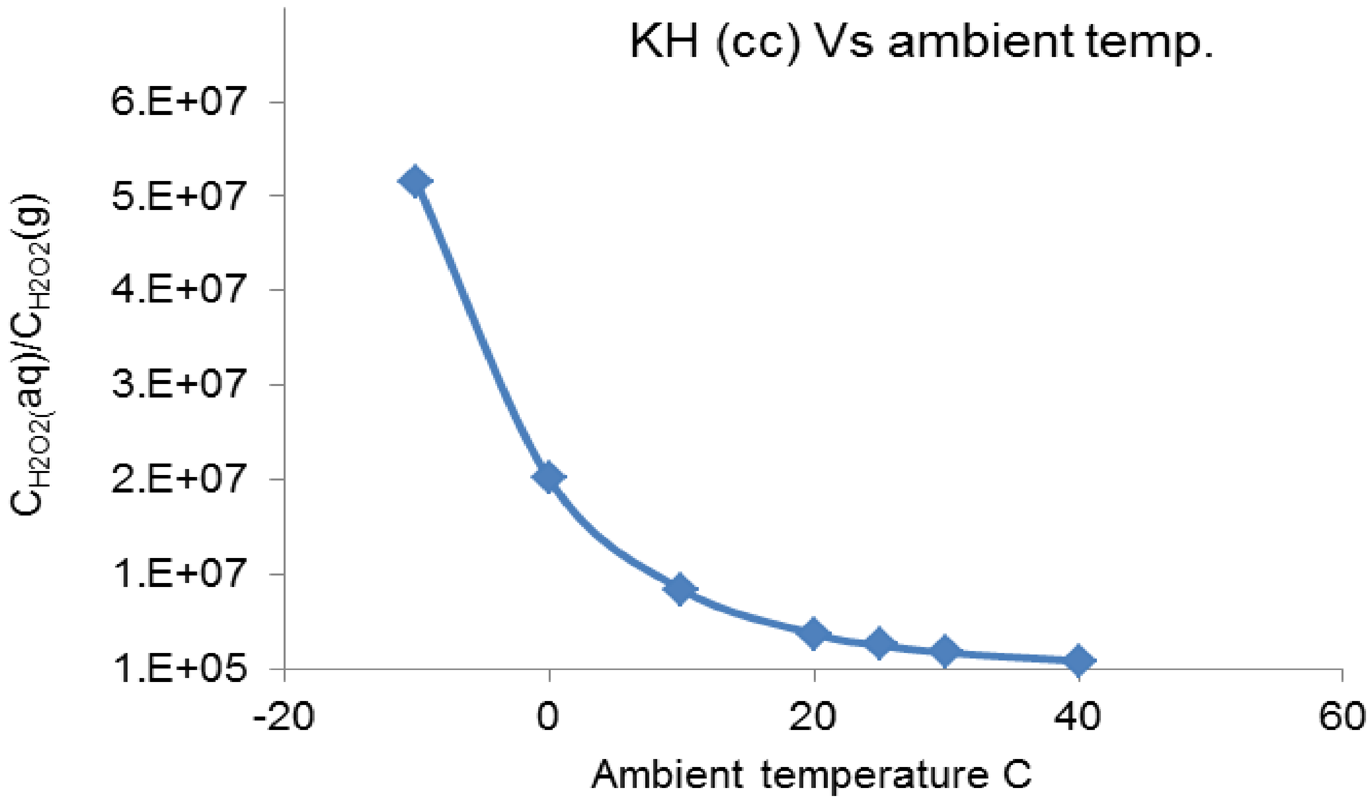
The solubility of H_2O_2 in water droplets is determined by the Henry's law,

$$K_{H,(cp)} = C_{H2O2(aq)} / P_{H2O2(g)}$$

$$K_{H,(cc)} = C_{(H2O2aq)} / C_{H2O2(g)}$$

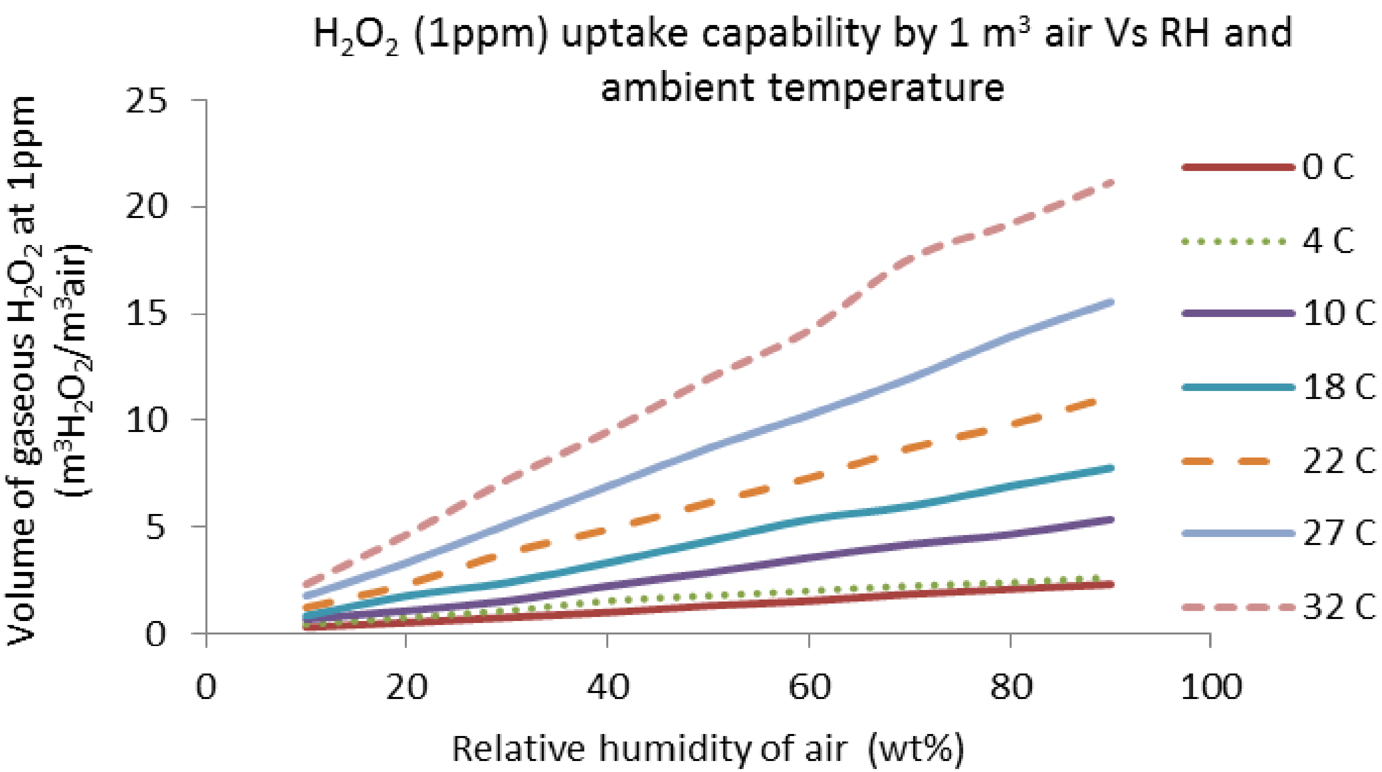
Results

The partition between aqueous and gas phase H_2O_2 as a function of ambient temperature.



Results

Volume of gaseous H_2O_2 (1ppm) that can be absorbed by 1 m^3 of air as a function of relative humidity and ambient temperature



Results

Spontaneous decomposition (Photolytic decay)

The decomposition of hydrogen peroxide is a spontaneous process at room temperature. The rate of the reaction is increased by the presence of light.

$$H_2O_2 + h\nu \rightarrow 2OH^*$$

$$d[c]/dt = -k[c]$$

$$\ln([c]/[c_0]) = -kt$$

Results

Where,

[c] is the concentration of hydrogen peroxide at t time, mol/L.

[c_0] is the initial concentration of hydrogen peroxide, mol/L.

k is the rate constant, here corresponding to the photolysis rate, h^{-1}. k is a function of radiation intensity

Results

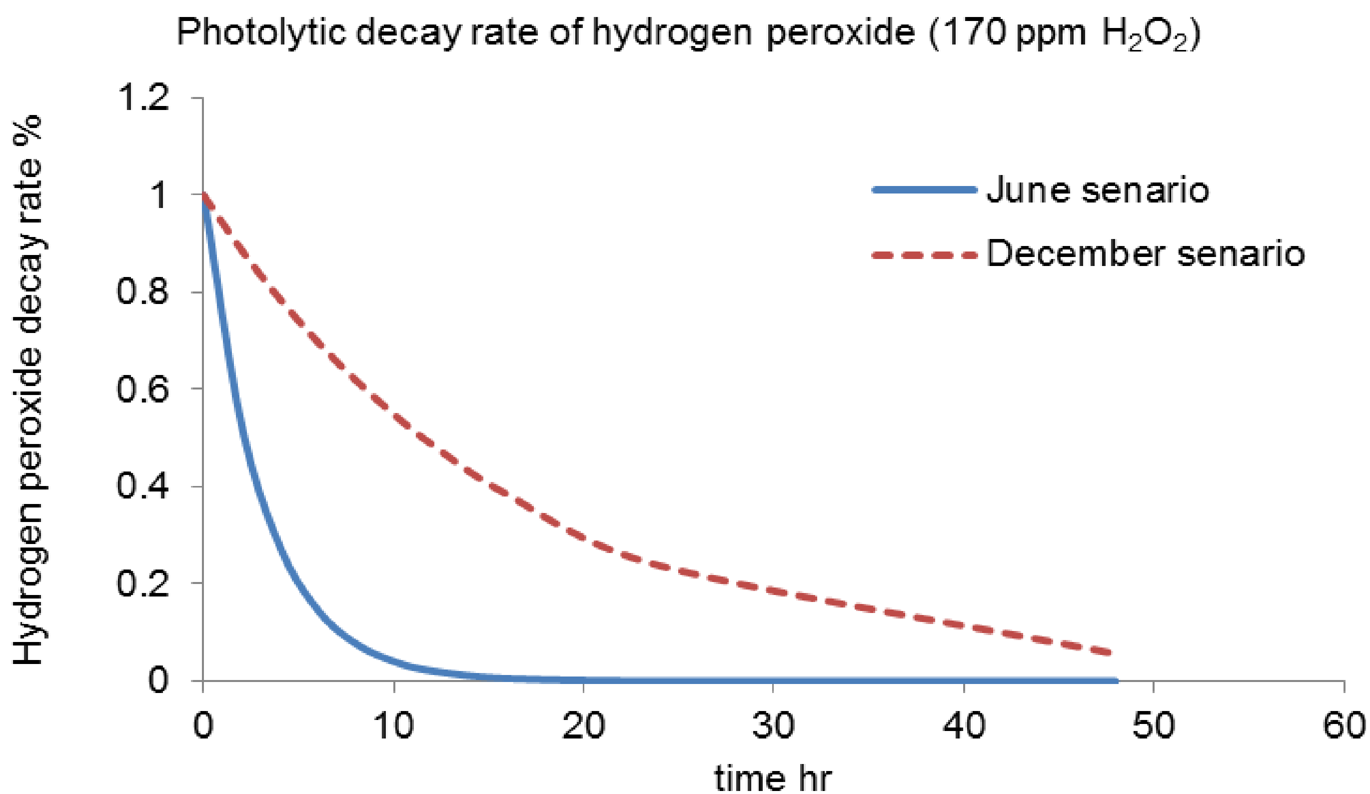
Two scenarios:

The maximum solar radiation intensity observed at 52°N (about north of London) was 800 W m^{-2} in June and 150 W m^{-2} in December for clear days.

Two k values, one for summer and the other for winter scenario, were obtained as 0.32 h^{-1} and 0.16 h^{-1} based on 800 W m^{-2} and 150 W m^{-2} radiation intensity

Results

The rate of photolytic decay of 170 ppm H2O2 based on a summer and a winter scenario in the UK



Conclusions-1

- Vaporized hydrogen peroxide (VHP) is a promising method for infection control and sanitization of aircraft. However, there is a concern on the environmental impact and safety threat to adjacent aviation operations by released hydrogen peroxide from decontamination operation. So it is essential to fully understand its impact to avoid any detrimental consequence caused by aircraft VHP decontamination.

- In general, the pathway can be classified as physical and chemical pathways. The uptake to water droplets in the air, as a physical pathway, appears to be a major pathway for the removal of VHP due to high Henry's law constant of hydrogen peroxide. The removal efficacy of hydrogen peroxide by water droplets is increased as the ambient temperature and humidity increases.

Conclusions-2

- Photolytic decay, as a chemical decomposition pathway, is a slow process. Based on example scenarios (UK, summer and winter) calculation in the paper, it needs approximately 8 hours in summer and 40 hours in winter for 90% of hydrogen peroxide to decay or decompose.

- There are other chemical pathways such as reactions with air pollutants SO_2. The mechanism for that is more complicated and will be reported in a separate paper.

Acknowledgments

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The end

Thanks for your attentions

Any questions?