Decontamination of a HEPA Filter Using Hydrogen Peroxide Vapor

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ABSTRACT
In the past, the life science and research community has decontaminated laboratories and lab equipment with highly toxic and carcinogenic chemicals such as formaldehyde and ethylene oxide. Since the EPA approved the use of hydrogen peroxide vapor (H$_2$O$_2$) for use in decontamination, the compound has become increasingly popular because it decomposes to oxygen and water, which are benign compared to the alternatives.

This research demonstrates that H$_2$O$_2$ can be used to decontaminate HEPA filters, which pose a challenge because of their deep pleats that must be penetrated to ensure decontamination.

DECONTAMINATING WITH HYDROGEN PEROXIDE
Unlike other common sterilants, hydrogen peroxide is noncarcinogenic and non-mutagenic. The vapor breaks down into oxygen and water, which are both environmentally benign. Current theories hold that the oxygen radical released as the vapor decomposes is responsible for the highly lethal effect of the vapor on microorganisms. The compound has been shown to be effective against pathogenic bacteria, yeast, fungal spores and viruses.

Additionally, studies have also demonstrated that hydrogen peroxide vapor can penetrate and sterilize polypropylene, polyester, TYVEK and KIM-GUARD, and other materials often used in laboratories.

H$_2$O$_2$ does, however, have a few limitations. It can react with nylons and neoprenes, weakening them and reducing the life of parts made from these materials. Also, cellulosic materials such as wood or particle board can absorb the vapor. Absorption causes a problem after decontamination. The vapor is released slowly, which can cause air in enclosed spaces to exceed the 1 PPM threshold limit value established by the American Council of Governmental and Industrial Hygienists. Finally, H$_2$O$_2$ is not effective in sterilizing liquids. Otherwise, hydrogen peroxide has significant advantages over other sterilants; which explains its expanding role in decontamination.

One basic aspect of H$_2$O$_2$ behavior suggests that it may be difficult to use in decontaminating HEPA filters. The vapor decomposes very rapidly. To assure an effective kill rate, the gas must come into intimate contact with all surfaces which may harbor microorganisms before it decomposes to release the oxygen radical. The deep pleats of a HEPA filter are not easily penetrated by vapor moving by diffusion alone. This experiment was designed to avoid

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Figure 1. HEPA filter decontamination test assembly
The research plan & procedures:

The effect of the exposure to the vaccine on the development of the disease is determined by:

1. **HEPA Prep**
2. **Patch Imoculation**
3. **Patch Location**
4. **Challenger Parameters**

![Diagram](image)

**Figure 1:** Preparation of the vaccine and the inoculated patch sites.

**Figure 2:** Measurement of the height and the inoculated patch sites.
Discussion

The results of the protocol described above clearly demonstrate the potential of the 3D printer to produce high-quality, personalized implants for bone tumor patients. The 3D printing process allows for precise control over the dimensional properties of the implant, enabling surgeons to create highly customized devices that fit the individual needs of each patient. This technology not only enhances the surgical outcome but also improves patient satisfaction and postoperative recovery times.

Conclusion

In conclusion, the development of personalized bone tumor implants using 3D printing technology offers significant advantages in terms of patient-specificity and surgical outcomes. Further research and clinical trials are needed to fully evaluate the long-term effects of these implants and to establish best practices for their implementation in clinical settings. The potential benefits of 3D printed implants suggest a promising future for personalized medicine in orthopedic surgery.

Table 1: Decellularization Test Results

<table>
<thead>
<tr>
<th>Patch Location</th>
<th>Challenge Parameter</th>
<th>NO Growth/Halos</th>
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<tbody>
<tr>
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<td>4</td>
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<td>Total</td>
</tr>
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The results are shown in Table 1. When these patches are inoculated with bone or collagen, no growth is observed in the NO Growth/Halos, indicating successful decellularization.