Applications of Germicidal Ultraviolet in Infectious Disease Laboratories

II. An Ultraviolet Pass-Through Chamber for Disinfecting Single Sheets of Paper

G. Briggs Phillips and Frank E. Novak

Camp Detrick, Frederick, Maryland

Received for publication November 2, 1955

In infectious disease laboratories "contaminated" areas are sometimes physically separated from adjoining "clean" areas such as offices, libraries and conference rooms. Where such an arrangement exists, it is often desirable to preserve the separation of areas by disinfecting or sterilizing materials removed from the infectious section. The extent to which this separation of areas is needed or used depends upon the infectiousness of the organisms under study and the nature of the experiments.

In some instances it is desirable to disinfect or sterilize papers used for recording data in the laboratory before they are passed to the clean area. Although sterilization can be effected by autoclaving or by treatment with ethylene oxide gas (Kaye, 1950), time or facilities may make these methods impractical.

A pass-through chamber utilizing high intensity ultraviolet (UV) radiations has been developed for disinfecting single sheets of paper. The apparatus has been tested using strips of paper contaminated with four organisms.

Materials and Methods

Exterior and interior views of the chamber are shown in figures 1 and 2. The housing is fabricated from sheet aluminum and measures 24½ x 5 x 5 inches. When a single sheet of paper, 15 inches or less in width, is inserted into the slot, it is caught by two synchronously revolving rollers which push the paper at a controlled rate past four, 15-watt UV lamps. Each side of the sheet receives radiations from two lamps. The rollers are driven by a small 10 rpm electric motor which moves the paper at the rate of one inch every 3.25 seconds. The paper as it passes through the apparatus is subjected on each side to UV intensities varying from 8,000 to approximately 28,000 microwatts per sq cm. The total UV radiation is about 7,500 microwatt-minutes per sq cm or 4,500,000 ergs per sq cm.

The chamber is designed for installation in a wall or doorway separating an infectious unit from a clean section. To facilitate maintenance, the front panel of the unit is hinged to permit removal of the inside structure (figure 2). A switch located on the front of the chamber operates the motor and two of the UV lamps. The other two lamps burn continuously to prevent the passage of viable aerosols.

The design described herein represents the most effective of several developed and evaluated. Further details are available from the authors on request.

The effectiveness of the machine was evaluated by passing artificially contaminated 8 x 1½ inch strips of white bond paper through the machine and comparing the number of viable organisms remaining per square inch of paper with the number before UV treatment. Test organisms were Bacillus subtilis var. niger spores, Serratia marcescens, Escherichia coli B/r and T-3 coliphage. The strips were contaminated with spores by exposing them in a rectangular plastic cabinet (Phillips et al., 1955) in which a spore aerosol was generated. Liquid cultures of the other organisms were spread evenly over the paper strips. Unirradiated inoculated strips served as controls. Organisms were washed from the strips by shaking in 100 ml of sterile saline. Dilution aliquots were plated from the controls, but the entire 100 ml of wash fluid from the irradiated strips was cultured.

Results

The results are shown in table 1. The UV chamber was 100 per cent effective against S. marcescens and coliphage and 99.97 per cent effective against bacterial spores.

To determine the possible effect of photoreactivation (Kelner, 1951) on cells "killed" in the chamber, experiments were included in which UV resistant E. coli B/r cells on paper were treated with UV and exposed to reactivating illumination in the visible or near ultraviolet range. Without reactivating light, UV treatment reduced the cell concentration from 19,000 to 0.55 cells per sq inch of paper (table 1). When UV treated cells were washed from the paper and exposed for 50 minutes to illumination from daylight fluorescent lamps.
TABLE 1. Bactericidal effectiveness of an ultraviolet pass-through chamber

<table>
<thead>
<tr>
<th>Test Organism</th>
<th>Control Paper</th>
<th>UV Exposed Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Average number</td>
</tr>
<tr>
<td></td>
<td>of paper</td>
<td>of organisms</td>
</tr>
<tr>
<td></td>
<td>strips</td>
<td>per sq inch of paper</td>
</tr>
<tr>
<td>Bacillus subtilis var. niger spores</td>
<td>20</td>
<td>8300</td>
</tr>
<tr>
<td>Serratia marcescens</td>
<td>5</td>
<td>41,700</td>
</tr>
<tr>
<td>T-3 coliphage</td>
<td>5</td>
<td>1,160,000</td>
</tr>
<tr>
<td>Escherichia coli B/r</td>
<td>5</td>
<td>19,000</td>
</tr>
<tr>
<td>Escherichia coli B/r</td>
<td>5</td>
<td>19,000</td>
</tr>
</tbody>
</table>

* Wash liquid or recovery plates exposed to reactivating light.

or fluorescent “black light” lamps (maximum spectral peak at 3660A), no significant increase in cell recovery was noted. The average kill as determined after exposure to UV and reactivating light was 99.996 per cent and after UV alone, 99.997 per cent. Using B/r cells exposed in Petri plates to radiation intensities lower than those obtained in the paper chamber, reactivation of a portion of the irradiated cells was demonstrated. Although it is evident that the UV chamber will not provide sterilization of paper heavily contaminated with spore cultures, it is believed suitable for normal operations in infectious disease laboratories. It is possible the UV chamber would prove useful in other types of installations, for example, for introducing sheets of paper into sterile filling rooms and for the treatment of sheets of paper from contagious wards of hospitals.

SUMMARY

An UV pass-through chamber for rapid disinfection of single sheets of paper has been designed. The device provides about 7500 microwatt-minutes of irradiation per sq cm of paper. An ordinary sheet of paper can be disinfected in 30 seconds. One hundred per cent of Serratia marcescens cells and T-3 coliphage, and 99.97 per cent of Bacillus subtilis var. niger spores were killed when paper contaminated with these organisms was passed through the apparatus. Photoreactivation of Escherichia coli B/r cells exposed to UV in the chamber could not be demonstrated. The chamber is useful for processing laboratory data sheets as they are passed from a contaminated to a clean area.

REFERENCES

