UV/Ozone Cleaning of Surfaces

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1. Introduction

The ability of ultraviolet (UV) light to decompose organic molecules has been known for a long time, but it is only during the past decade that UV cleaning of surfaces has been explored.

In 1972, Bolon and Kunz(1) reported that UV light had the capability to depolymerize a variety of photoresistant polymers. The polymer films were enclosed in a quartz tube that was evacuated and then backfilled with oxygen. The samples were irradiated with UV light from a medium-pressure mercury lamp that generated ozone. The several-thousand-angstroms-thick polymer films were successfully depolymerized in less than one hour. The major products of depolymerization were found to be water and carbon dioxide. Subsequent to depolymerization, the substrates were examined by Auger electron spectroscopy (AES) and were found to be free of carbonaceous residues. Only inorganic residues, such as tin and chlorine, were found. When a Pyrex filter was placed between the UV light and the films or when a nitrogen atmosphere was used instead of oxygen, the depolymerization was hindered. Thus, Bolon and Kunz recognized that oxygen and wavelengths shorter than 300 nm played a role in the depolymerization.

In 1974, Sowell et al.(2) described UV cleaning of adsorbed hydrocarbons from glass and gold surfaces, in air and in a vacuum system. A clean glass surface was obtained after 15 hours of exposure to the UV radiation in air. In a vacuum system at 10^{-4} torr of oxygen, clean gold surfaces were produced after about two hours of UV exposure. During cleaning, the partial pressure of O_2 decreased, while that of CO_2 and H_2O increased. The UV also desorbed gases from the vacuum chamber walls. In air, gold surfaces which had been

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contaminated by adsorbed hydrocarbons could be cleaned by "several hours of exposure to the UV radiation." Sowell et al. also noted that storing clean surfaces under UV radiation maintained the surface cleanliness indefinitely.

During the period 1974–1976, Vig et al.\(^{(3-5)}\) described a series of experiments aimed at determining the optimum conditions for producing clean surfaces by UV irradiation. The variables of cleaning by UV light were defined, and it was shown that, under the proper conditions, UV/ozone cleaning has the capability of producing clean surfaces in less than one minute. Since 1976, use of the UV/ozone cleaning method has grown steadily. UV/ozone cleaners are now available commercially.

2. The Variables of UV/Ozone Cleaning

2.1. The Wavelengths Emitted by the UV Sources

To study the variables of the UV cleaning procedure, Vig and LeBus\(^{(5)}\) constructed the two UV cleaning boxes shown in Figure 1. Both were made of aluminum, and both contained low-pressure mercury discharge lamps and an aluminum stand with Alzak\(^{(6)}\) reflectors. The two lamps produced nearly equal intensities of short-wavelength UV light, about 1.6 mW/cm\(^2\) for a sample 1 cm from the tube. Both boxes contained room air (in a clean room) throughout these experiments. The boxes were completely enclosed to reduce recontamination by air circulation.

Since only the light which is absorbed can be effective in producing photochemical changes, the wavelengths emitted by the UV sources are important variables. The low-pressure mercury discharge tubes generate two wavelengths

![Figure 1. Apparatus for UV/ozone cleaning experiments.](image-url)