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Kinetics of Free Radicals Decay Reactions in Cellulosic Based Heritage Materials Disinfected by Gamma Radiation

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Abstract

In this study, contemporary paper samples were irradiated using gamma radiation from Co-60 with different absorbed doses. The absorbed dose range was chosen taking into account the effective values to promote insect eradication, fungal disinfection and sterilization. The kinetics of decay of the cellulose free radicals induced by irradiation was analyzed using Electron Paramagnetic Resonance. Several spectra were obtained at room temperature for each applied absorbed dose immediately after irradiation as reference measurements. In order to understand the decay process of free radicals, additional spectra were obtained for different decay times up to almost 50 days after irradiation. De-noising treatment of the original obtained spectra signals were performed using wavelets. By integrating the electron paramagnetic resonance curves were calculated the area values and correlated to concentration, it is equivalent to spin concentration. Comparison of spectra was done by normalization of calculated area corresponding to cellulose spin concentration, considering the first measurement after irradiation as 100%. Further analyses and calculations were made to study the half-life and the kinetics models of the free radicals created. X-ray diffraction was carried out to identify crystalline phases and the effect of ionizing radiation on the crystalline structure of cellulose in paper. Scanning electron microscopy and Scanning Electron Microscopy Energy Dispersive Spectrometry were performed to analyze structure modifications by ionizing radiation, identifying cellulose fiber agglomeration zones and to quantify chemical elements. Likewise, samples were analyzed by infrared spectroscopy to determinate changes on the carbonyl groups. Results shown that for sterilization dose, 80% of the cellulose free radicals induced by ionizing radiation disappear in almost 40 days and for disinfection dose in 8 days. It can be concluded that if no significant modifications (side-effects) appear in the irradiated material after the radical decay time, the material will stay stable for the remaining lifetime. Proposed method using electron paramagnetic resonance results showed suitably to study the behavior of radicals on cellulosic based cultural heritage materials.