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UV versus MV irradiation response of 3D dosimeters

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Introduction of the study:

Due to limitations in accessing clinical linear accelerators and other MV sources of radiation, preliminary assessments of radiation sensitivity and response of 3D dosimeter materials have been conducted using easily accessible and inexpensive UV irradiation devices. These results are generally not published due to their irrelevance for MV radiation therapy treatments but may be valuable for UV phototherapy quality assurance (QA) applications. This study demonstrated the differences in sensitivities of iron based radiochromic dosimeters for UV phototherapy and MV radiotherapy QA applications.

Methodology:

Three iron-reduction formulations and two iron-oxidation formulations were created in-house and tested for this study. All formulations were water-based except for one iron-reduction formulation that used chloroform as the solvent and free radical source. All irradiations were conducted in cuvettes for optical readout using a spectrophotometer. Samples were exposed to UV irradiation at 365 nm in the UVA phototherapy range with four bulbs at 36 W, and MV irradiations were delivered with a Co-60 source (1.25 MeV).

Results:

All of the water-based iron-reduction formulations demonstrated a linear response to UVA dose to a saturation dose with a net optical change of more than 4 cm^{-1} . One of the iron-reduction formulations demonstrated a non-linear relationship upon incorporation into a gelatin matrix while the water-based formulations maintained a linear relationship. The two water-based iron-oxidation formulations demonstrated almost no response to UVA dose with a net optical change of no more than 0.5 cm^{-1} after exposures up to 43200 J/cm^2 . The two iron-oxidation formulations in gelatin matrix demonstrated a linear response to UVA dose to a peak optical density followed by a non-linear decrease in response. All three iron-reduction formulations demonstrated greater response to UVA dose compared to the two iron-oxidation formulations.

Following MV irradiation, one of the iron-reduction formulations showed an immediate linear response with respect to MV dose up to 100 Gy, and two of the formulations showed a linear response delayed by at least 4 days. The two iron-oxidation formulations showed immediate linear response with respect to MV dose up to a saturation dose of around 20 Gy. Both iron-oxidation formulations demonstrated greater optical response to MV irradiations compared to the three iron-reduction formulations. The optimal formulations and representative calibration curves for both UVA and MV responses are shown in Figure 1.

Conclusion:

Iron-reduction formulations are recommended for UV phototherapy QA applications, and iron-oxidation formulations are recommended for MV radiotherapy QA applications due to greater sensitivity and linear optical response for each energy range, respectively. All of the water-based formulations can easily be incorporated into gelatin and molded into the desired 3D dosimeter form.

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