Formulation Studies

Dosimetric characteristics of a reusable 3D radiochromic dosimetry material

Park, J.M., Park, S.-Y., Choi, C.H., Chun, M., Han, J.H., Cho, J.D., Kim, J.-I. (2017) PLoS ONE, 12 (7), art. no. e0180970

Purpose To investigate the dosimetric characteristics of PRESAGEREU dosimeters. Methods Commercially available PRESAGEREU dosimeters (size of 10 mm × 10 mm × 45 mm) were divided into two groups, with one of the groups placed at room temperature of 22°C (RT group) and another group placed at low temperature of 10°C (LT group). A total of 3 dosimeters (set of dosimeters) were irradiated at a time, with doses of 1 Gy, 2 Gy, 4 Gy, 8 Gy, 12 Gy, 16 Gy, and 20 Gy, at a nominal dose rate of 400 MU/min at temperature of 22°C. The dosimeters were irradiated three additional times by delivering the same doses as those during the initial irradiations (4 irradiation cycles). Optical density (OD) was assessed using optical CT scanning. Results Considering both linearity and sensitivity of the OD curves, R2 above 0.95 and sensitivity above 0.04 δOD/Gy were observed at the 1st irradiation (reading time ≤ 6 h) and 2nd irradiation (reading time = 0.5 h) for the RT group. For the LT group, those values were observed at the 1st irradiation (reading time ≤ 2 h), and the 3rd and 4th irradiations (both reading times = 0.5 h). Considering the reproducibility of signals in response to the same dose, dosimeters in the RT group showed average deviations among dosimeters less than 5% (the 1st and 2nd irradiations at the reading time of 0.5 h), while for dosimeters in the LT group showed average deviations among dosimeters less than 6% (the 3rd and 4th irradiations at the reading time of 0.5 h). For the rest, the OD curves were not linear, sensitivities of the dosimeters were lower than 0.04 δOD/Gy, and OD deviations at the same dose were larger than 6%. Conclusions At room temperature, PRESAGEREU dosimeters could be used for dose measurement only for up to two dose measurement sessions. At low temperatures, usage of PRESAGEREU dosimeters for dose measurement seems to be possible from the 3rd irradiation. When reusing PRESAGEREU dosimeters, the OD curve should be re-defined for every measurement session because the shape of this curve depends on the irradiation history.

Characterization of novel water-equivalent PRESAGE® dosimeters for megavoltage and kilovoltage x-ray beam dosimetry

Alqathami, M., Blencowe, A., Geso, M., Ibbott, G.

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In this paper we introduce three novel PRESAGE® dosimeters referred to as metal optimized dosimeters (MODs) 1, 2 and 3, and determine their sensitivity, as well as their water equivalency. All three formulations contained very small concentrations (0.01 wt%) of metal compounds. The radiological properties were key factors that were considered when designing and formulating the new dosimeters. The dosimeters were prepared in spectrophotometric cuvettes, irradiated with a 6 MV X-ray beam, and the change in optical density of each dosimeter was measured using a spectrophotometer. Results show that all three MOD formulations exhibit radiological properties closer to water than the recently introduced PRESAGE® dosimeter formulation referred to as formulation A, with mass densities of the novel formulations varying by only 3.9% from that of water, as compared to 5.3% for the commercial formulation. Whereas the novel formulations have almost identical Z<inf>eff</inf> values to that of water (Z<inf>eff</inf> = 7.42), the Z<inf>eff</inf> for the commercial formulation was 3.7% higher than that of water. Comparison of mass energy coefficients for all MOD formulations showed a maximum variation of approximately 0.6 times closer to water especially MOD 3 whereas commercial formulation was 1.23 times larger than water at approximately 40 keV. The same effect was observed for mass attenuation coefficients comparison. MOD 3 was also more sensitive to radiation than MOD 1 and 2 as a result of the inclusion of bromine-based halocarbons in the formulation. All novel MOD formulations were comparable to commercial formulation in terms of probability of Compton scatter and pair production compared to water. However, the probability of photoelectric absorption in the three novel MOD formulations varied significantly less (1.3 times greater) from that of water as compared to the commercial formulation (1.8 times greater). Given that all three novel MOD formulations displayed improved radiological properties over any of the currently available PRESAGE® dosimeter formulations makes them ideal candidates for tissue mimics in dosimetry of clinical megavoltage and kilovoltage x-ray beams.

Evaluation of ultra-sensitive leucomalachite dye derivatives for use in the

PRESAGE dosimeter

Alqathami, Mamdooh; Adamovics, John; Benning, Ron; Qiao, Greg; Geso,Moshi; Blencowe, Anton

Radiation Physics and Chemistry, . In this study we carry out a comparison between the com. available leucomalachite green (LMG) dye and three newly synthesized derivs. (with either methoxy, chloro or bromo substituents) incorporated into the PRESAGE dosimeter to det. their effect on the sensitivity and post-response photostability of the dosimeter. In addn., the influence of the new LMG derivs. on the basic radiol. properties of the PRESAGE dosimeter was also investigated. The dosimeters were prepd. in spectrophotometric cuvettes, irradiated with a 6 MV X-ray beam, and the change in optical d. of each dosimeter was measured.

Optimizing the sensitivity and radiological properties of the PRESAGE dosimeter using metal compounds

Alqathami, Mamdooh; Blencowe, Anton; Qiao, Greg; Adamovics, John; Geso, Moshi

Radiation Physics and Chemistry (2012), 81(11), 1688-1695.

The aim of this study is to investigate the radiation-modifying effects of incorporating com. available bismuth-, tin- and zinc-based compds. in the compn. of the PRESAGE dosimeter, and the feasibility of employing such compds. for radiation dose enhancement. Furthermore, we demonstrate that metal compds. can be included in the formulation to yield water-equiv. PRESAGE dosimeters with enhanced dose response. Various concns. of the metal compds. were added to a newly developed PRESAGE formulation and the resulting dosimeters were irradiated with 100 kV and 6 MV photon beams.

Optimization of the sensitivity and stability of the PRESAGE dosimeter using trihalomethane radical initiators

Alqathami, Mamdooh; Blencowe, Anton; Qiao, Greg; Butler, Duncan; Geso, Moshi. Radiation Physics and Chemistry (2012), 81(7), 867-873.

The aim of this study is to investigate the effect of trihalomethane radical initiators on the radiol. properties, radiation dose sensitivity and post response photo-stability of the PRESAGE dosimeter. Different PRESAGE dosimeters contg. 50 and 100 mM of iodoform (CHI_3), bromoform ($CHBr_3$) or chloroform ($CHCl_3$) radical initiators where fabricated and irradiated with 6 MV photons for a range of radiation doses from 0 to 30 Gy. A comparison between sensitivity and radiol. properties of the PRESAGE

dosimeters with the different radical initiators was carried out.

Novel multicompartment 3-dimensional radiochromic radiation dosimeters for nanoparticle-enhanced radiation therapy dosimetry

Alqathami Mamdooh; Blencowe Anton; Yeo Un Jin; Doran Simon J; Qiao Greg; Geso Moshi

International journal of radiation oncology, biology, physics (2012), 84(4), e549-55.

Gold nanoparticles (AuNps), because of their high atomic number (Z), have been demonstrated to absorb low-energy X-rays preferentially, compared with tissue, and may be used to achieve localized radiation dose enhancement in tumors. The purpose of this study is to introduce the first example of a novel multicompartment radiochromic radiation dosimeter and to demonstrate its applicability for 3-dimensional (3D) dosimetry of nanoparticle-enhanced radiation therapy. METHODS AND MATERIALS: A novel multicompartment phantom radiochromic dosimeter was developed.