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RADIOMETRIC EFFECTS CAUSED BY THE INCORPORATION OF COPPER IN POLYMERIC GEL DOSIMETERS

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Introduction: Radiotherapy is broadly applied in the treatment of cancer. Therefore, novel equipment and techniques for precise delivery of high doses of ionizing radiation are constantly under development. Consequently, it is necessary to develop reliable devices for the spatially-defined quantification of the absorbed dose to guarantee treatment planning quality. In this regard, polymer gel dosimeters (PGDs) are tissue-equivalent and radiosensitive devices used to precisely quantify, with spatial resolution, the absorption of ionizing radiation. However, it is still necessary to optimize the radiosensitivity of PGDs to achieve better time-stability and spatial resolution of the dosimetric response [1]. The present study hypothesizes that the incorporation of copper (Cu) atoms into a PGD formulation could improve its performance while maintaining tissue-equivalence. Cu may promote a local enhancement in the deposited dose through the emission of secondary electrons. In addition, Cu^{2+} ions could be formed by the effect of the ionizing radiation, which might be useful to improve the optical sensitivity of PGDs through the formation of highly-coloured metal-organic complexes [2]. These two effects may be useful for improving the characterization of low levels of deposited dose.

This work reports on the radiological effects of incorporating Cu atoms into PGDs. In particular, dose-response and water-equivalence were characterized.

Materials and methods: Dedicated Monte Carlo subroutines were adapted from the PENELOPE and FLUKA main codes. PGDs composition was: 89% w/w water; 3% w/w *N*-isopropylacrylamide (NIPAm); 3% w/w *N*,*N*′-methylenebisacrylamide (MBA); 5% w/w Gelatin and 10 mM THPC. Cu concentration was varied between 0 and 1.5% w/w and water was reduced accordingly. Phantom dimensiones were 4x1x1 cm and source-phantom distance was set to 80 cm. X-ray beam field size was 1x1 cm, using a experimentally measured spectrum from a 44 kVp W anode.

Results: The presence of Cu changed the absorption behavior of the PGDs, as compared with liquid water (Fig 1). In general terms, an increase in Cu concentration caused a proportional increase in the local absorption of radiation. This phenomenon could be caused by: *i*) the higher attenuation coefficient of Cu and/or *ii*) a local dosimetric reinforcement caused by the emission of secondary (mainly Auger and Coster-Kronig) electrons. Therefore, this issue should be accounted for when dealing with potential variations of the sensitivity of the experimental dose-response curve.

Conclusions: The incorporation of Cu increases the local deposition of radiation and thus could improve the sensitivity of PGDs, while representing a potentially suitable scheme to evaluate the local dose enhancement.

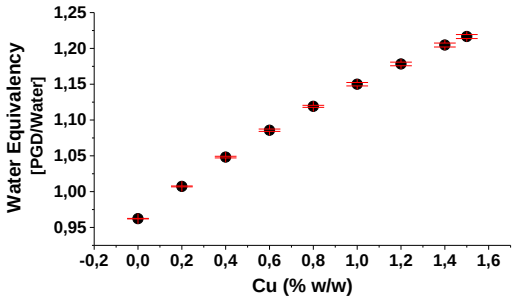

Fig 1: Water equivalency of PGDs vs. Cu concentration.

References:

1. C. Baldock and Y. De Deene, *Phys. Med. Biol.* ***55(5)***, 1-63 (2010).
2. A. Wolfel *et. al.*, *Radiat. Phys. Chem.* **180**, 109295 (2021).