PhD Thesis title: 'A STUDY ON RADIOCHEMICAL ERRORS IN POLYMER GEL DOSIMETERS'

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ABSTRACT:
Development of modern three-dimensional radiotherapy where the beam intensity can be drastically modulated raises issues concerning safety and accuracy of treatments. Emerging sophisticated technology escalates the risks of potential dosimetric and geometric inaccuracies in calculation and delivery of radiation dose to patients such that the capability of traditional 1D or 2D dose measuring instruments for verification and quality assurance of the treatments are challenged. Polymer gel dosimetry is one of the very few techniques under development for true 3D dosimetry of complex clinical dose distributions. A growing number of unexplained dosimetric discrepancies were reported in the literature in calibrating polymer gel dosimeters attempts. The trend and extent of these discrepancies suggested that they may have a radiochemical origin. This hypothesis is investigated in detail in several types of polymer gel dosimeters.

The basic assumption that chemical oxygen removal eliminates oxygen-related discrepancies was investigated and proved to be wrong. A methodology was developed to isolate the effect of oxygen on polymer gel dosimeters containing antioxidants and was applied on several gel compositions to enable comparison. Results revealed that the interplay between oxygen and antioxidant modifies the polymer yield and hence the dose response of polymer gel dosimeters. Regardless of the gel composition and antioxidant, this effect can induce severe dose errors in practical measurements whose origin may not be easily recognized, if the assumption of minimal oxygen influence is considered valid.

Several other physicochemical factors were hypothesized to have an impact on the dose response of polymer gel dosimeters. These factors included heat-induced polymer shrinkage and variations in the rates of propagation/termination reactions during irradiation due to exothermal polymerization of monomers. Detailed studies in different gel compositions refuted these hypotheses. In view of the findings of these investigations, discrepancies reported in the literature were analyzed and an attempt was made to categorize them and provide explanations on their origins.

Finally, the effect of a specific oxygen scavenger, tetrakis(hydroxymethyl) phosphonium chloride (THPC), was studied on the polymer structure of an acrylamide-based dosimeter. THPC is the antioxidant of choice in most polymer gel dosimetry studies. FT-Raman spectroscopy and electron microscopy studies revealed

that THPC modifies the dose response of polyacrylamide gel dosimeters potentially by interfering in polymerization of the monomers and changing the polymer morphology.

It is concluded that the major source of dosimetric inaccuracy in normoxic polymer gel dosimeters is local variations in the concentration of antioxidant that is continually consumed primarily by oxygen and in other chemical reactions during gel fabrication and storage. In principle, the linearity of the dose response of polymer gel dosimeters as obtained by any calibration method does not guarantee that the dose response of the gel in a different phantom is similarly linear.

References to author publications that relate specifically to the dissertation:

1. Sedaghat M, Bujold R and Lepage M 2011a 'Severe dose inaccuracies caused by an oxygen-antioxidant imbalance in normoxic polymer gel dosimeters' *Phys. Med. Biol.* **56** 601–25

2. Sedaghat M, Bujold R and Lepage M 2011b 'Investigating potential physicochemical errors in polymer gel dosimeters' *Phys. Med. Biol.* **56** 6083–107

3. Sedaghat M, Bujold R and Lepage M 2012 'Preliminary studies on the role and reactions of tetrakis(hydroxymethyl)phosphonium chloride in polyacrylamide gel dosimeters' *Phys. Med. Biol.* **57** 5981–94