Low-energy spectral changes in NIPAM polymer gel dosimeters from a 220 kVp x-ray beam

Leah N Turner, Blake R Smith[1], and Wesley S Culberson[1]

[1]Department of Medical Physics, School of Medicine and Public Health, University of Wisconsin-Madison

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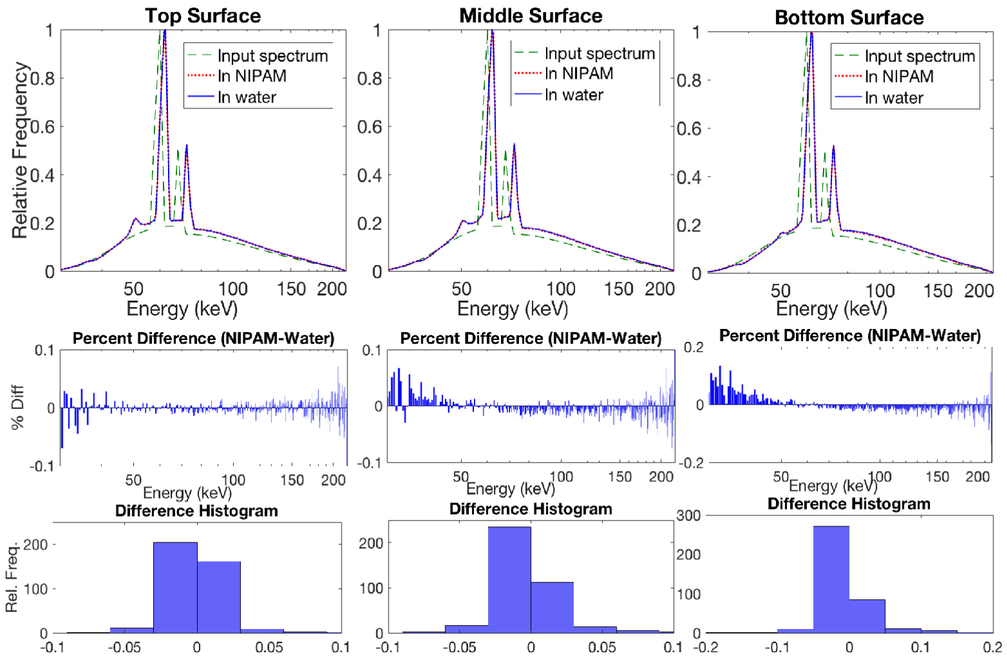
INTRODUCTION

- Polymer gel dosimeters (PGDs) are 3-dimensional chemical dosimeters that change properties with absorbed dose.
- N-isopropylacrylamide-based PGDs have a lower toxicity than nPAG PGDs and have a higher saturation point[1].
- PGDs must be calibrated before use; either in a reference radiation beam, or with a calibrated dosimeter in the measured beam[2].
- The PGD response must be corrected for energy dependence. However, if the energy spectrum change within the medium is not significantly different than water, no energy correction is needed.
- The energy spectrum from a 220 kVp radiobiology treatment beam was generated, and an MCNP6 simulation was used to calculate the energy spectrum at different depths of NIPAM PGD[3].

METHODS

- An input energy spectrum of a 220 kVp radiobiology treatment beam was generated in SpekCalc (Institute of Cancer Research, London, UK).
- MCNP6 simulations were performed using the input spectrum incident on a 2 cm^3 cube of NIPAM PGD or water.
- F1 surface current tallies with 0.5 keV energy bins from 20-220 keV were used to calculate the energy spectrum at the top surface, 1-cm depth, and the bottom surface of the cube.
- A *F8 pulse-height tally was used to calculate dose-to-water to a 0.2 cm^3 cube located on the CAX at a depth of 1.5 cm in both the NIPAM PGD and water cubes.

RESULTS



- The top row shows the input 220 kVp spectrum, the spectra calculated at the top, middle, and bottom planes of the cells containing either NIPAM or water. The middle row shows the percent difference in the spectra (NIPAM minus water). The highest percent difference seen is **0.13%** in the bottom surface. The average percent difference for the top, middle, and bottom surfaces are **0.07%, 0.07%**, and **0.13%** respectively. The bottom row shows a histogram of the difference between NIPAM and water. Most differences are within **0.1%**, which is within the simulation uncertainty.
- The absorbed-dose-to-water in the NIPAM slab was **0.84%** lower than in the water slab. This value will be incorporated into an uncertainty budget for dose measurements made using NIPAM PGDs.

CONCLUSION

- Low-energy spectral changes in NIPAM include beam hardening of ~2 keV and the generation of a Compton backscatter peak at ~50 kev.
- Beam hardening increases as depth in medium increases.
- The highest percent difference seen in the spectra between water and NIPAM PGD is 0.13% at the bottom surface and the absorbed-dose-to-water difference between NIPAM and water is 0.84%.
- Differences in spectral changes for a 220 kVp beam between NIPAM PGD and water are negligible.
- The difference in absorbed dose to water is small and will be incorporated into an uncertainty budget.

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