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#9-77 Impact of Ultra-High Dose Rate on Water Radiolysis till Homogeneous Chemistry: A Monte Carlo Simulation Study

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Introduction: Ultra-high-dose rate FLASH radiation therapy (UHDR) is an innovative modality that delivers higher dose rates (40 Gy/s) in a pulsed beam structure. At the core of this exciting approach lies the ability to reduce major normal tissue complications without compromising tumor control efficacy, referred to as the "FLASH effect." However, the underlying mechanisms governing the biological FLASH effect remain elusive. Numerous studies have shown that UHDR can reduce the production of hydrogen peroxide (H_2O_2) in irradiated water under physiological O_2 conditions. The main objective of this study is to track the yields of water radiolysis under UHDR compared to Conventionel dose rates , with particular focus on H_2O_2, over a long time scale (1 hour post-processing).

Materials and Methods: This investigation uses the TOPAS-nBio Monte Carlo track structure and the Gillespy package to analyze steady-state chemical yields under varying dose rates and dissolved oxygen levels. TOPAS-nBio delivers the required dose with a microsecond pulsed beam to achieve UHDR up to 500 Gy/s. Species are tracked until the system reaches stability (escape yield), after which the yields are fed into Gillespy for the homogeneous stage simulation over 1 hour. A water phantom with a volume of 27 μm^3 was used, and proton beams (100 MeV) were compared to electrons (1 MeV).

Results: A significant reduction in H_2O_2 yields was observed at ultra-high dose rates compared to lower dose rates for both proton and electron beams. These findings highlight the importance of considering homogeneous chemistry, where reactions occurring on a 10-second timescale influence H_2O_2 generation, in understanding the FLASH effect. This study contributes to ongoing efforts to elucidate the complex mechanisms behind the FLASH effect, potentially leading to improved cancer treatments and patient outcomes.

Conclusion: The study emphasizes the significance of homogeneous chemistry, particularly in reactions related to O2 removal and H2O2 generation, occurring within a late timeframe (10 s) and being influenced by dose rates. In addition, our findings support experimental observations.

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