Contribution ID: **408** Type: **Verbal**

Effects of Dose Rate on the Response of a Fluorescence Chemical Dosimeter for Ultra-fast Pulse Radiolysis

Wednesday, 14 May 2014 11:30 (15 minutes)

Recent developments in the utilization of high-power femtosecond lasers for generation of X-ray and particle radiation sources as well as the on-going deployment of the first multi-keV X-ray free-electron laser facilities (such as are the LCLS, SACLA and the European XFEL) have opened an opportunity for application of these ultrashort pulsed radiation sources to study radiation chemistry with truly femtosecond temporal resolution that has so far not been accessible to experimental observation.
In the study of radiolytic processes in condensed liquids on femtosecond time-scales a serious challenge is the effect of the group velocity mismatch between the pulses of ionizing radiation and the probing light. A feasible solution is to use very thin renewable windowless targets based on liquid jets of 10 100 micrometers in diameter. On the other hand, determination of the delivered final radiation doses might be complicated in these liquid-jet systems, especially if these doses are small. Several suitable fluorescence dosimeters based on hydroxyl-radical scavenging aromatic carboxylic acids were developed in the past for use in aqueous solutions and are particularly useful for determination of doses down to 0.1 Gy. A system based on fast on-line detection of fluorescence from their fluorescent radiolytic products would be capable of measuring the dose delivered by each radiation pulse.
An important issue in the development of such a fluorescence-based dosimetry system for use in ultra-fast pulse radiolysis is to identify any potential dose rate effects resulting from the vastly increased dose rates (over 15 orders of magnitude) compared to standard radiation sources that have been used in the past to calibrate their response (e.g., cobalt-60 radionuclide sources or X-ray tubes). Preliminary experiments revealing observable differences in these fluorescence yields at different dose rates were performed with a fluorescent dosimeter based on trimesic acid at the picosecond pulse radiolysis facility ELYSE of the Laboratoire de Chimie Physique at Université Paris-Sud in France.

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Session Classification: Radiation Chemistry 2

Track Classification: Radiation Chemistry