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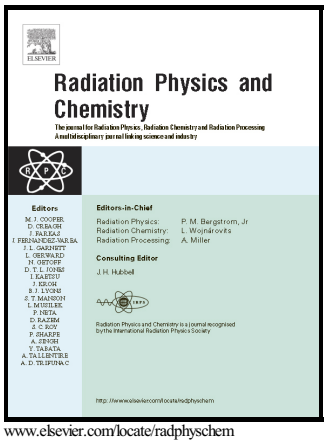

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A quantitative model of water radiolysis and chemical production rates near radionuclide-containing solids

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Abstract

We present a mathematical model that quantifies the rate of water radiolysis near radionuclide-containing solids. Our model incorporates the radioactivity of the solid along with the energies and attenuation properties for alpha (α), beta (β), and gamma (γ) radiation to calculate volume normalized dose rate profiles. In the model, these dose rate profiles are then used to calculate radiolytic hydrogen (H_2) and hydrogen peroxide (H_2O_2) production rates as a function of distance from the solid-water interface. It expands on previous water radiolysis models by incorporating planar or cylindrical solid-water interfaces and by explicitly including γ radiation in dose rate calculations. To illustrate our model's utility, we quantify radiolytic H_2 and H_2O_2 production rates surrounding spent nuclear fuel under different conditions (at 20 years and 1000 years of storage, as well as before and after barrier failure). These examples demonstrate the extent to which α, β and γ radiation contributes to total absorbed dose rate and radiolytic production rates. The different cases also illustrate how H_2 and H_2O_2 yields depend on initial composition, shielding and age of the solid. In this way, the examples demonstrate the