

1-6 Safe Long-Term Storage of Secondary Wastes after Decontamination of Radioactive Water

— Evolution of Radiolysis Studies to Support Practical Issues in the Decommissioning of 1F —

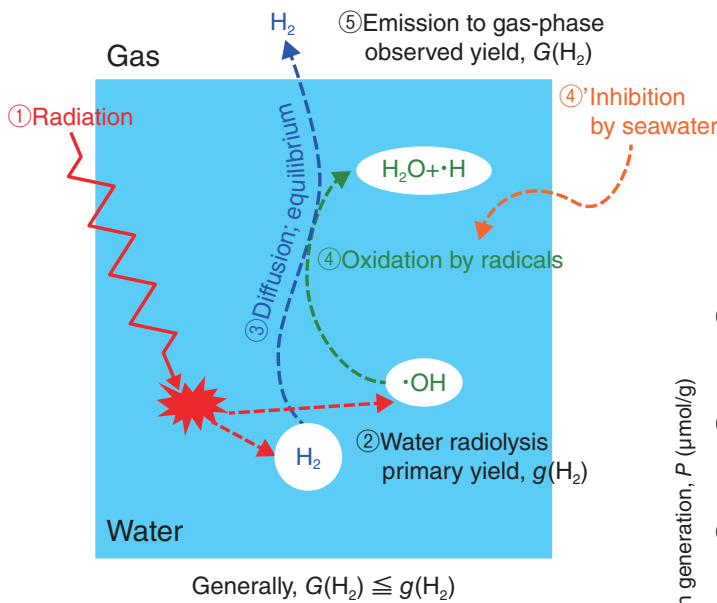


Table 1-1 H₂-generation factors relevant to the decommissioning of 1F

Effect factor	Main phenomenon (this work)
Seawater salt (halide ions, X ⁻)	X ⁻ scavenging of oxidizing ·OH radical in its H ₂ oxidation
Zeolites; solid oxides	Surface interaction with (binding to) oxidizing products including ·OH
Liquid depth; viscosity	H ₂ escaping from reactions in liquid phase (water) dependent on time for reaching gas phase
Liquid flow	
Dose rate	Reaction between H ₂ and ·OH present in different isolated spurs

Following the accident at the TEPCO's Fukushima Daiichi NPS (1F), we have focused upon water decontamination and secondary-waste storage, and performed R&D on cesium adsorption, hydrogen (H₂) generation, corrosion of structural materials, and gas and heat flows. We then provided the data obtained as information indispensable for safety measures to TEPCO and 1F-related companies. Moreover, according to the medium- and long-term roadmap for decommissioning 1F, we have quickly complied with requests for studying and solving urgent problems and events in cooperation with TEPCO and the companies.

R&D upon H₂ generation is related to the explosion of this gas just after the accident; it is considered to be the most dangerous phenomenon in the management of radioactive materials. Since water radiolysis in H₂-generation sources is brought about by ionizing radiations emitted from radioactive materials, the temperature need not be higher than several hundred degrees centigrade; this process takes place continuously anywhere the materials for it exist. Thus, studies on water radiolysis have been performed at every step of the roadmap.

Reference

Nagaishi, R., Evolution of Water Radiolysis Studies for Measures against Post-Severe Accidents, *Radioisotopes*, vol.66, no.11, 2017, p.601–610 (in Japanese).

Fig.1-14 Diagram of radiolytic-H₂ formation and reaction in water

H₂ would be emitted into the air in the open condition in a severe accident but dissolved into water in the closed condition typical of reactors. H₂ (2) formed by radiation (1) is scavenged by radicals (4) on the way to the water surface (3), but the scavenging can be blocked by seawater salts (4').

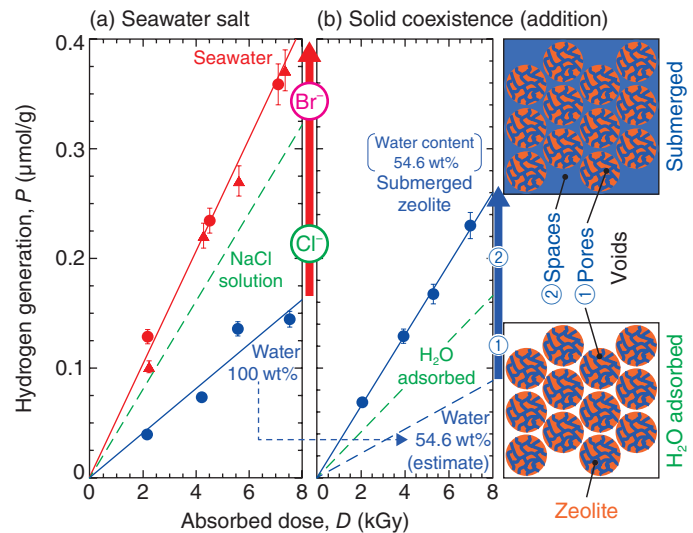


Fig.1-15 Effects of seawater salt (a) and solid coexistence (b) upon H₂ generation (constant-height (1-cm) condition)

In seawater (a), Cl⁻ and Br⁻ ions affect H₂ generation, making its amount larger than in pure water (PW). In submerged zeolites (b), pores and spaces affect H₂ generation, leading to an enhancement that cannot be explained only by the water content within the zeolites.

Unlike that derived from other sources, H₂ formed from water decomposition by radiation is emitted into the air through numerous processes and reactions (Fig.1-14). H₂ generation is complexly affected by many conditions and factors. Using practical materials under real conditions, several effects upon the generation have been investigated in detail and determined to be important for 1F decommissioning (Table 1-1).

Fig.1-15 shows representative experimental results. Seawater supplied at the accident works as a coolant as well as pure water (PW), while more H₂ was generated in seawater than in PW (a). This was because chloride (Cl⁻) and bromide (Br⁻) ions in seawater suppress H₂ consumption. The full amount of H₂ generation in zeolites submerged by PW could not be explained only by their water content (b). This enhancement indicates an interaction between the radiolysis products of water and the solid surface of zeolite, giving useful information for improvement in conventional safety analysis of the generation without solids.

In these radiolysis studies, hydrogen peroxide (H₂O₂) and its decomposed product of oxygen (O₂) are also studied.