The Behavior of Tellurium in the Containment Sump During Severe Nuclear Accident

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Abstract

In the case of a severe nuclear accident, tellurium isotopes are among the most important radionuclides released. Especially, ^{132}Te ($t_{1/2}$=3.2 d) has to be taken into account when assessing the consequences of an accident since it decays to iodine-132 and thus affects the iodine release behavior. Tellurium isotopes released during an accident have half-lives raging from few hours to several days and thus are important in severe accident research.

After released from the fuel, tellurium is transported into the containment and subjected to the containment spray system and further on to the sump conditions. The behavior of tellurium in these liquid phases is currently rather unclear. The behavior of Te is highly dependent on multiple factors, such as pH, redox potential, radiolysis and other fission products present in the sump. Moreover, Te has a very complex chemistry with oxidation states ranging from -II to +VI. Thus, it is difficult to predict the behavior, reactions and possible re-volatilization of tellurium in the sump. In addition, not only are Te isotopes important but also the possible reactions between tellurium and iodine in the sump might be of interest. Te(VI) can potentially oxidize iodide to molecular iodine and thus increase the iodine source-term.

In this work, the tellurium behavior was investigated in alkaline borate buffer solution, ABS with and without sodium thiosulphate ($Na_2S_2O_3$) as a reductant. The solubility of TeO_2 was investigated during gamma irradiation and at an elevated temperature (313K). The preliminary results indicate that both, irradiation and $Na_2S_2O_3$ have an effect on the behavior of TeO_2. When irradiation was applied to the samples consisting of ABS with $Na_2S_2O_3$, Te(IV)O_2 was reduced to metalloid tellurium, which was confirmed with X-ray diffraction, XRD. In addition, the solubility decreased with increasing dose. When samples consisting of only ABS were irradiated, the solubility of Te increased with increasing dose. The concentration of Te in the solution after 10 days of irradiation (dose rate=5500Gy/h) was approximately 4 times higher in the samples without $Na_2S_2O_3$ compared to the ones with the reducing agent present. Reference samples from both solutions reached equilibrium at approximately 10mmol/L at room temperature and 15mmol/L at 313 K. Although the irradiation had a clear effect, also the reference samples had higher solubility of tellurium compared to the literature values at same pH. This finding is also something that has to be considered when assessing the behavior of tellurium in the containment sump and the reliability of current thermodynamic data used for concentration estimations.

Keywords: Severe accident, tellurium, source-term, containment sump