Abstract: Organic ligands can promote dissolution of sparsely dissolving metal oxides by forming complexes with their constituent metal ions in solution and/or directly adsorbing on their surfaces. The dissolution of zirconium oxide (ZrO$_2$), a well-known refractory oxide, is important to understand the behavior of fuel debris of a damaged nuclear reactor core in contact with (ground) water and to develop effective decontamination techniques for contamination with the debris, as Zr is contained in the debris at relatively large concentrations and likely determines their dissolution. Nevertheless, the effects of organic ligands on the dissolution of ZrO$_2$ has been unknown, which is being pursued in this research by batch-wise dissolution experiments of ZrO$_2$ in the presence of various organic ligands and in-situ ATR-FTIR spectroscopy. The dissolution of ZrO$_2$ was promoted by EDTA, NTA, and Ox; nevertheless, with DFO-B virtually no dissolution of ZrO$_2$ was observed. The magnitude of the dissolution increased as follows: NTA > Ox > EDTA (pH 8) ≈ EDTA (pH 4). This suggests the dissolution of ZrO$_2$ is not controlled by aqueous complexation of Zr$^{4+}$ with the ligands, as the corresponding stability constants follow EDTA > NTA > Ox. It was also found that the observed dissolution amounts showed no correlation with the adsorption amounts of the ligands. These findings clearly indicate an important role of detailed sorption structures of the ligands for the dissolution.

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