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Photo- and radiation-induced synthesis of nanocrystalline UO2, ThO2 and mixed UO2–ThO2 oxides

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In recent years, much attention has been drawn to the photo- and radiation-induced synthesis of various materials. In presented work, radiation-induced synthesis of nanocrystalline uranium and/or thorium oxides is investigated. Uranium(IV) oxide is widely used as a fuel in various types of nuclear reactors [T. Abe and K. Asakura: 2.15 Uranium Oxide and MOX Production. In: Comprehensive Nuclear Materials. Amesterdam: Elsevier, 2012, 394-422. ISBN: 978-0-08-056027-4]; thorium(IV) oxide and mixed uranium-thorium oxides are currently tested as a promising alternative [P. R. Hania and F. C. Klaassen: 3.04 Thorium Oxide Fuel. In: Comprehensive Nuclear Materials. Amesterdam: Elsevier, 2012, 88-108. ISBN: 978-0-08-056027-4].
Study of photo-/radiation- induced preparation of these oxides may contribute to the research in the field of nuclear fuel cycle in two ways:
1) Synthesis of oxides; these oxides are under suitable conditions highly pure and nanomentre-sized with narrow distribution of particle size.
2) Removal of radionuclides from solutions originated from irradiated fuel reprocessing.
Photo- and radiation-induced synthesis of nanocrystalline uranium and/or thorium oxides is based on formation of amorphous solid precursor in aqueous solutions containing uranium and/or thorium nitrate and ammonium formate under UV radiation (low/medium pressure mercury lamp) or ionizing radiation (accelerated electrons). Subsequent heat treatment under various atmospheres leads to formation of nanocrystalline UO2, ThO2 or UO2–ThO2 solid solution at minimum temperatures in the interval 300–550 ℃. The materials consist of nanoparticles from 3 to 15 nm in diameter and with narrow size distribution.
The most advantageous preparative method, consisting in irradiation of uranium and/or thorium nitrates (0.01 mol.dm-3) and ammonium formate (0.1 mol.dm-3) by low pressure mercury lamp, is distinguished by the yields of oxides –75 % for both UO2 and UO2–ThO2 solid solution, whereas the yield of ThO2 is 95 %.
Proposed method for uranium and/or thorium oxides synthesis is fast, simple and prepared oxides fulfil the prerequisites for the production of the high-quality nuclear fuel. The preparation of nanocrystalline UO2, ThO2 and mixed UO2–ThO2 oxides under medium pressure mercury lamp irradiation has been recently published [T. Pavelková, V. Čuba, F. Šebesta: Photo-induced low temperature synthesis of nanocrystalline UO2, ThO2 and mixed UO2–ThO2 oxides, J. Nucl. Mater. 442, 2013, 29-32. (Letter to the Editor)].

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