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► **To cite this version:**

E. Dalodiere, M. Viro, V. Morosini, T. Chave, T. Dumas, et al.. Sonochemical Preparation and Characterization of Intrinsic Pu Colloids. ESS16, Apr 2018, Besancon, France. cea-02339061

HAL Id: cea-02339061

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Submitted on 13 Dec 2019

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Sonochemical Preparation and Characterization of Intrinsic Pu Colloids

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Recent studies showed that plutonium migration into the environment can be facilitated by the presence and/or formation of colloids.[1,2] Particularly, intrinsic colloids are scarcely reported in the literature and their formation mechanism, stability and reactivity is poorly understood.[1,2]

Recently, it was shown that the extended sonication (20 kHz, 17 W.cm⁻²) of PuO₂ in pure water leads, after centrifugation to remove big particles that did not react, to the formation of stable Pu colloids free from salt or stabilizing agents.[3] Formation kinetics and yields are found to increase with sonication duration and the specific surface area of the oxide. The investigations showed that both physical and chemical effects driven by acoustic cavitation are responsible for the formation of such intrinsic colloids. A two-step mechanism is proposed where the erosion and fragmentation of PuO₂ particles first occur, followed by redox reactions which allow the accumulation in solution of Pu(IV) that can then hydrolyze and yield colloids (Figure 1). Among the various tested oxides, PuO₂ is the only material exhibiting such a behavior. Sonochemical Pu colloids were compared to more classical colloids obtained by controlled hydrolysis of Pu(IV) beforehand stabilized in nitric media.

Both colloids were compared using several characterization techniques including UV-Vis absorption spectroscopy, TEM-HR, XAS, and STXM/NEXAFS. Results showed that both colloid suspensions are composed by quasi-spherical and crystalline PuO₂ particles measuring 7 nm for sonochemical colloid, and 3 nm for hydrolytic colloid. The combination of EXAFS, STXM and TEM measurements allowed to distinguish the Pu-O coordination sphere and evidence a correlation between the number and distance of Pu-O interactions and the size of the particles. In comparison to sonochemical colloids, NEXAFS measurements showed that

hydrolytic colloid is much more influenced by hydrolyzed Pu(IV) species which finally allows us to generally describe Pu colloids as core-shell nanoparticles composed of quasi-stoichiometric PuO₂ cores covered by hydrolyzed Pu(IV) species at the surface shell.[3]

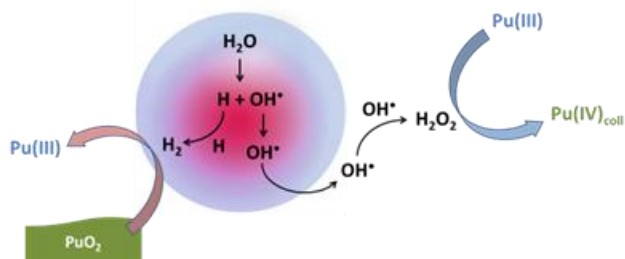


Figure 1. Diagram of the proposed redox mechanism representing Pu(IV) colloid formation under ultrasound irradiation (20 kHz, Ar/10% CO, 20°C, 0.34 W mL⁻¹)

References

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