Ph.D. defense

Institut de Chimie Séparative de Marcoule / CEA Marcoule
(UMR 5257, CEA, CNRS, Université Montpellier, ENSCM)

RAN JI

will present his Ph.D. dissertation

Study of Acoustic Cavitation near Metal Surfaces Contaminated by Uranium

The defense will take place on **Tuesday, November 13, 2018** at **10.00 am**

in the ICSM Auditorium

The dismantling of UNGG reactors produces large volumes of contaminated metallic materials. Among these, magnesium-based alloys, which are known as highly reactive metals, have a high risk of corrosion and can generate hydrogen gas that can cause serious damages during storage. In order to reduce the volume of generated radioactive effluents and downgrade nuclear wastes, sonochemistry can be considered as an original and efficient alternative for metallic surface decontamination. Sonochemistry deals with the effects of ultrasound waves on chemical reactions in solution. The effects observed in sonochemistry originate from the acoustic cavitation phenomenon, which is the nucleation, growth and rapid implosive collapse of gas and vapor filled microbubbles. Excited species and radicals can be generated in the formed plasma and light (sonoluminescence) is emitted. When the bubble collapse takes place in the vicinity of a solid surface, it produces violent shock waves and microjets directed towards the surface. These physical effects strongly contribute in ultrasonic cleaning, surface depassivation and decontamination.

This study focuses on the decontamination of magnesium metal surfaces under ultrasonic irradiation. After a bibliographic synthesis making a state of the art on the treatment of metallic surfaces by ultrasonic power, the experimental tools and analytical techniques used in this work are described. The results and discussion section are then presented in three separate chapters: 1) a fundamental 100 kHz sonoluminescence study for the characterization of the acoustic cavitation phenomenon in solution and near extended solid surfaces; 2) a study of the structuring of Mg-based surfaces under ultrasonic irradiation; 3) Ultrasonic treatment of radioactive metal surfaces contaminated in the laboratory with natural uranium.

This work highlights the strong impact of ultrasonic frequency on sonochemical activity, its spatial distribution and the effects generated on magnesium samples. A homogeneous spatial distribution of sonochemical activity is observed at frequencies ≥ 100 kHz. The results confirm that asymmetrical bubble collapse is likely to occur near extended solid surfaces. The formation of an elongated structure similar to a golf ball is observed for frequencies between 100 and 362 kHz. Such architectures result from controlled sonochemical dissolution of the Mg surface. It is likely that the heterogeneous nucleation provided by the creation of ultrasonic flaws combined with the release of H_2 gas is at the origin of this structuring. The tests carried out on a Mg-Zr alloy show a similar behavior making it possible to simulate the behavior of a UNGG reactor cladding. Rapid and total decontamination of these different materials is observed in dilute oxalic medium at 20°C. A low and slow recontamination process of Mg-based materials is observed due to uranyl adsorption by brucite formed on the surfaces. Tests on samples with complex geometry also highlight the high potential of sonochemistry for effective decontamination of Mg-based surfaces.