Study on the influence of microorganism on fuel debris degradation
(1) Disintegration of simulant fuel debris by widespread bacteria

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Abstract: There is a possibility that some microorganisms coexist with damaged fuel debris in nuclear power plant after severe accident, and they might affect the physical and chemical properties of fuel debris. In this work, the effect of widespread bacteria on simulant fuel debris was studied, and it was found that these bacteria would promote the disintegration of fuel debris.

Keywords: fuel debris, microorganism, corrosion mechanism.

1. Introduction

During the Fukushima Daiichi accident molten core flowed down the structural materials and formed the fuel debris, which consists of uranium dioxide fuel, iron, zirconium, and concrete. To decommission the damaged nuclear plant, it is necessary to understand the current status of fuel debris and possible change trend during the defueling activities. After the discovery of some possible microorganism communities in Fukushima Daiichi Nuclear Power Plant (FDNPP) in 2018[1], the microbial effect on fuel debris has drawn much attention. Here, the microbial disintegration of simulant fuel debris was studied.

2. Experiment

To simulate the tetravalent actinides (UO_2 and PuO_2), CeO_2 was applied because of its similar physical chemical properties.[2] The mixture of CeO_2 and ZrO_2 at a molecular ratio of 1:1 was pressed into pellet and heated at 1773K for 13 hours. $CeZrO_4$ was then shattered into powder. The simulant fuel debris consisted of $CeZrO_4$, pure iron powder and SiO_2 at a molecular ratio of 1:2:1. Two kinds of widespread bacteria were applied, *pseudomonas fluorescens* (Gram-negative) and *Bacillus subtilis* (Gram-positive). The bacteria were cultured in a transparent liquid medium in the presence of simulant fuel debris (2g/L) at 30°C for 20 days. The medium and simulant fuel debris were sampled at certain intervals. They were analyzed by ICP-OES and SEM-EDS, respectively.

3. Results and conclusions

During batch culture, the simulant fuel debris became red from the second day for both of the two kinds of bacteria. It suggested that iron was oxidized. After about 12 days' culture, metallic iron almost disappeared. At the same time, these bacteria entered death phase by analyzing the turbidity of medium (OD600nm). The morphology of simulant fuel debris was shown in **Fig.1**. It can be seen that after 20 days' culture metallic iron became spherical pieces less than 1 μm, however, others didn't change so much. The results implied that the disintegration of iron may be involved in the microbial metabolic activity. In addition, it was found that part of iron and a little zirconium can dissolve into the medium, but cerium and silicon can not. The study provided some understanding that iron would be key element in the microbial corrosion of fuel debris.

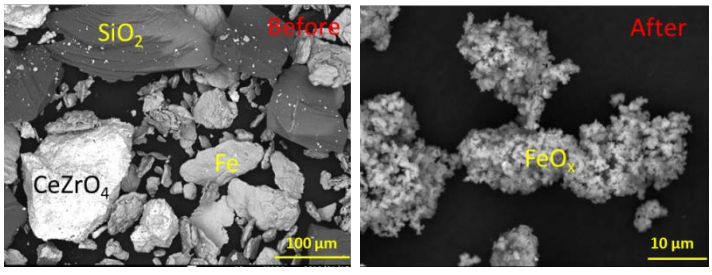

Fig.1 Simulant fuel debris before and after culture

References

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