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A comparative study of UO_2 ceramic pellets for nuclear applications made from different Wet process industrial manufacturing routes

Franklin Palheiros[(1)*], Reinaldo Gonzaga[(1)] and Alexandre Soares[(1)]

(1) Indústrias Nucleares do Brasil S.A. (INB). Rodovia Presidente Dutra - Km 330, Engenheiro Passos 27555-000, Resende, RJ Brazil. geaco@inb.gov.br

Abstract – Different UO_2 ceramic pellets types originated from AUC and ADU industrial routes are compared based on their common product specification key parameters. The AUC type pellets manufactured by INB are compared and demonstrated to be lied within the several ranges defined by a ADU common specification. It has been demonstrated that with additional analysis and a more rigorous process control, the INB AUC pellet product meet all the requirements established by the ADU targeted specification. However, considering the powder characteristics for both products are different - leading to pellet microstructure changes and product properties – the performance under irradiation is expected to change. This study also brings a brief review on how pellet densification, swelling and fission gas release are expected to vary from AUC to ADU products.

In the fuel cycle, converting UF_6 to UO_2 powder is an intermediate step for fabrication of pellets for nuclear fuel assemblies. The wet processes is the most often used industrially and are divided in two categories: the ADU (Ammonium Diuranate) and AUC (Ammonium Uranyl Carbonate) processes, whose names originate in the precipitate obtained in aqueous solution during the intermediate steps of UO_2 powder fabrication.

INB has used the AUC process to produce UO_2 pellets and supply fuel to Angra 1 and 2 Nuclear Power Plants [1]. Despite of this process is characterized by the precipitation of a different intermediate precipitate compared to the AUC route (i.e., $(NH4)_4UO_2(CO_3)_3$, in the ADU process, and $(NH_4)_2U_2O_7$ in ADU process) leading to some differences in the final pellet microstructure [2]. In order to evaluate how different the pellets originated from these two industrial routes are, this paper aims to compare the INB production historical data (Angra 1, Cycles 14 and 15) with the key parameters of a common product specification from the ADU process.

The results have shown that INB pellets made from AUC route met most of the ADU specification requirements. Most of the quality parameters are identical for the mentioned specification processes. Some chemical analyses are not covered by the AUC product specification, considering their process characteristics. The parameters which do not met the ADU specification demands a more rigorous process control, using statistical techniques which are not difficult to implement.

Considering the powder characteristics for both products are different - leading to pellet microstructure changes and product properties – the performance under irradiation is expected to change. This study also brings a brief review on how pellet densification, swelling and fission gas release are expected to vary from AUC to ADU products.

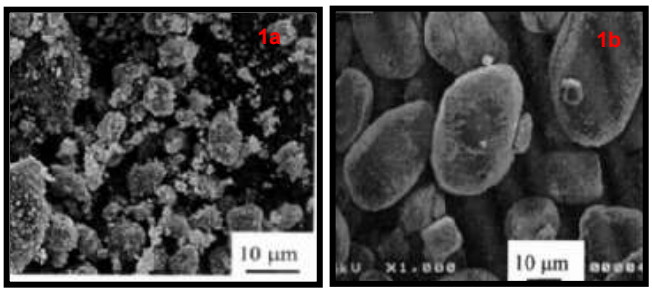

Figure 1 – Morphology of UO_2 powder produced by the ADU (1a) and AUC processes (1b)

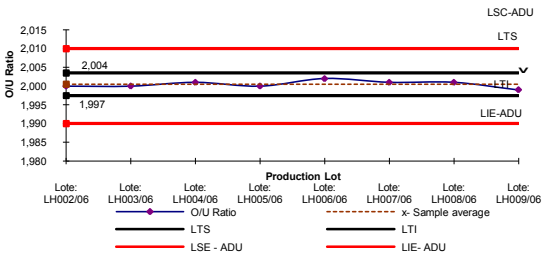

Figure 2 – AUC Product parameter control example

References

[1] INB Product Specification INB ESP/PT-59.c
[2] Gonzaga, R. and Gonçalves, J. S., "Theoretical Comparative Study of the Industrial Fabrication Routes for UO_2 Powder", 16th Pacific Basin Nuclear Conference (16PBNC), Aomori, Japan, Oct. 13-18, 2008.