



Contribution ID: 208

Type: Poster

## Composition analysis of zirconium alloys by $k=0$ -based PGAA using Budapest cold neutron beam facility

Tuesday, 20 April 2010 11:45 (20 minutes)

Zirconium and its alloys are important materials in nuclear power technology. Zirconium alloys namely zircaloy 2, zircaloy 4 and Zr-Nb alloy are mostly used for fuel cladding and pressure tubes in water-cooled nuclear power reactors due to their low neutron absorption cross section, high corrosion resistance and good thermal conductivity. For nuclear quality control, it is important to analyze these alloys to ensure their conformity to specifications. Analytical methods, which are non-destructive in nature, bulk sample analysis capability with negligible matrix effect, are preferred for the analysis of such materials. Neutron induced prompt gamma-ray activation analysis (PGAA) is one of the suitable methods. In the present work, PGAA was used for the composition analysis of three types of zircaloys namely zircaloy 2, zircaloy 4 and Zr-2.5%Nb alloy. All the measurements were performed at the PGAA facility of the Budapest Research Reactor using cold-neutron beam. The thermal equivalent neutron flux at this position is  $1.2 \times 10^8 \text{ cm}^{-2} \text{ s}^{-1}$ . Samples in the mass range of 0.3-0.5 g, kept inside thin Teflon bag, were irradiated in vacuum and the prompt  $\gamma$ -rays were measured for 3-10 h with a HPGe detector (sample-to-detector distance 23 cm) surrounded by a Compton-suppressor and passive shielding. The absolute counting efficiency of the detector was determined using  $^{133}\text{Ba}$  and  $^{152}\text{Eu}$  and prompt gamma rays from  $^{14}\text{N}(n,\gamma)^{15}\text{N}$  and  $^{37}\text{Cl}(n,\gamma)^{38}\text{Cl}$ . The  $\gamma$ -ray spectra were complex due to presence of multi- $\gamma$  producing elements/isotopes and they were analyzed for peak areas by Hypermet PC (MS DOS Version 5.01). The minor elements detected in three different zircaloys, in addition to major Zr, are: Sn, Fe, Cr and Ni in zircaloy 2, Sn, Fe and Cr in zircaloy 4, and Nb, Fe and Cr in Zr-2.5% Nb alloy. The trace elements detected in general are B, Hf, Ti, Mn and Co. Trace amounts of Cl were also detected in zircaloy 2 and 4. Since all the major and minor elements were amenable to PGAA, the absolute concentrations of all the elements were determined using mass balance procedure i.e., without using concentration of any external or internal standard. The advantages of the method are: (i) it is non-destructive, (ii) it could detect trace amounts of important elements like B, Hf and Cl in the presence of major/minor elements, and (iii) all elements determined except for B have multiple  $\gamma$ -rays, which help in self-validation of methodology.

### Acknowledgements

This work was carried out under INSA-HAS international exchange program (No. IA/Misc. 2009-2010/4237) and the financial assistance by INSA and BARC (India) and HAS (Hungary) is duly acknowledged. Authors from BARC acknowledge Institute of Isotopes, Budapest for providing PGAA facility.

### References

- 1.R. Acharya, A.G.C. Nair, A.V.R. Reddy, A. Goswami, J. Nucl. Mat., 326 (2004) 80.
- 2.C. Yonezawa, Anal. Sci., 9 (1993) 185.
- 3.Zs. Revay, Anal. Chem., 81 (2009) 6851.

**Primary author:** Dr ACHARYA, R. (Radiochemistry Division, Bhabha Atomic Research Centre, Trombay, Mumbai - 400 085, India)

**Co-authors:** Dr REDDY, A.V.R. (Analytical Chemistry Division, Bhabha Atomic Research Centre, Trombay, Mumbai - 400 085, India); Dr SUDARSHAN, K. (Radiochemistry Division, Bhabha Atomic Research Centre, Trombay, Mumbai - 400 085, India); Mr KULKARNI, R.V. (Post Irradiation Examination Division, Bhabha Atomic Re-

search Centre, Trombay, Mumbai - 400 085, India); Dr REVAY, Zs. (Department of Nuclear Research, Institute of Isotopes, H-1525 Budapest, Hungary)

**Presenter:** Dr REVAY, Zs. (Department of Nuclear Research, Institute of Isotopes, H-1525 Budapest, Hungary)

**Session Classification:** Poster Session - Nuclear Analytical Methods

**Track Classification:** Nuclear Analytical Methods