DECREASING THE SINTERING TEMPERATURE OF THO₂ FUEL PELLETS USING NANOCRystalline TORIA POWDER


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INTRODUCTION

²³³U bred in the thorium fuel cycle, exhibits the highest neutron yield of all fissile materials when used in reactors with a thermal neutron spectrum. So in the last two decades extensive R&D has been carried out on the thorium fuel cycle. The established procedures have been used industrially for the production of ThO₂ and (U,Th)O₂, and pellets successfully. Powder metallurgical process is a very well established route [0]. As these fuels are associated with radiation exposure problems, the sol-gel processes that use liquids ideally suited for fuel manufacture. In a sol-gel process, droplets of metal nitrate solution or oxide sol are converted into hard gel particles by a suitable gelation process. These particles are dried and to obtain high density pellets, calcined, pressed, and sintered [1]. In this paper thorium dioxide powder was synthesized through the sol-gel method using hydrated thorium nitrate and ammonium hydroxide as starting materials and Triton X100 as surfactant [1]. Then the nanocrystalline prepared powder was mixed by the microparticle thoria powder. The weight ratio of this mixture is 5 to 95. Mixed powder was pressed in 300 MPa and then sintered in 1500 °C and 8%H₂-92%Ar atmosphere. Sintered pellets possess 97% theoretical density with good pore distribution.

The prepared gel was subjected to thermogravimetric analysis (TGA) studies in an argon atmosphere using Rheometric Scientific STA 1500 machine. X-Ray Diffraction (XRD) experiments were performed in the 2θ range from 20° to 80° with a STOE-Stidy-mp XRD. Surface area determination and pore volume & size analyses were performed by Brunauer-Emett-Teller (BET) and Barret-Joyner-Halenda (BJH) methods using an Nova 2000 Convantocrom surface area analyzer. Two kind of powders and sintered pellets were subjected to SEM images. SEM images were taken with a COXEM scanning electron microscope. Pore volume of pellets was determined by boiling water test method.

RESULTS AND DISCUSSIONS

Fig. 2 shows the nitrogen adsorption/desorption isotherms for the nanocrystalline prepared thoria. Isotherms of prepared powder is of type IV which indicates the presence of mesopore. The surface area of powder after calcination is found to be 16.7 m²/g. The pore volume and size was 0.0423 cm³/g and 1.947 nm respectively. The average crystallite size of the synthesized pure thoria, calculated from the XRD data, according to Scherrer’s equation, is 12.6 nm (Fig. 1). SEM images show the agglomeration in thoria powder that corresponds to high calcination temperature. The average agglomerated particle size is 1μm as shown in SEM photograph (Fig. 4). Fig 3 shows the particle shape and size of microparticle thoria powder. These two pictures show the difference of two type powders. The sol gel prepared powder with its soft shape can be used as an adhesive for decreasing the sintering temperature. Fig 5 shows the microstructure of fabricated ThO₂ pellets by our method.

CONCLUSIONS

Most of experimental investigations in thorium fuel fabrication show that ThO₂ pellets sintering is carried out in temperatures more than 1500 °C. This research shows that nanocrystalline thoria powder can be used as a sintering aid material without increasing the impurities of the pellets.
Fig. 1: XRD analysis of prepared thoria [1]

Fig 2: Nitrogen adsorption/desorption isotherm for the nanocrystalline thoria [1]

Fig. 3: SEM image of microparticle thoria powder

Fig 4: SEM image of nanocrystalline thoria powder [1]

Fig. 5: SEM images of microstructure of ThO₂ Pellet fabricated in this research

REFERENCES