PHYSICO-CHEMICAL CHARACTERISTICS OF MIXED METAL OXIDES USED IN NUCLEAR TECHNOLOGY

A THESIS

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PHYSICO-CHEMICAL CHARACTERISTICS OF MIXED METAL OXIDES USED IN NUCLEAR TECHNOLOGY

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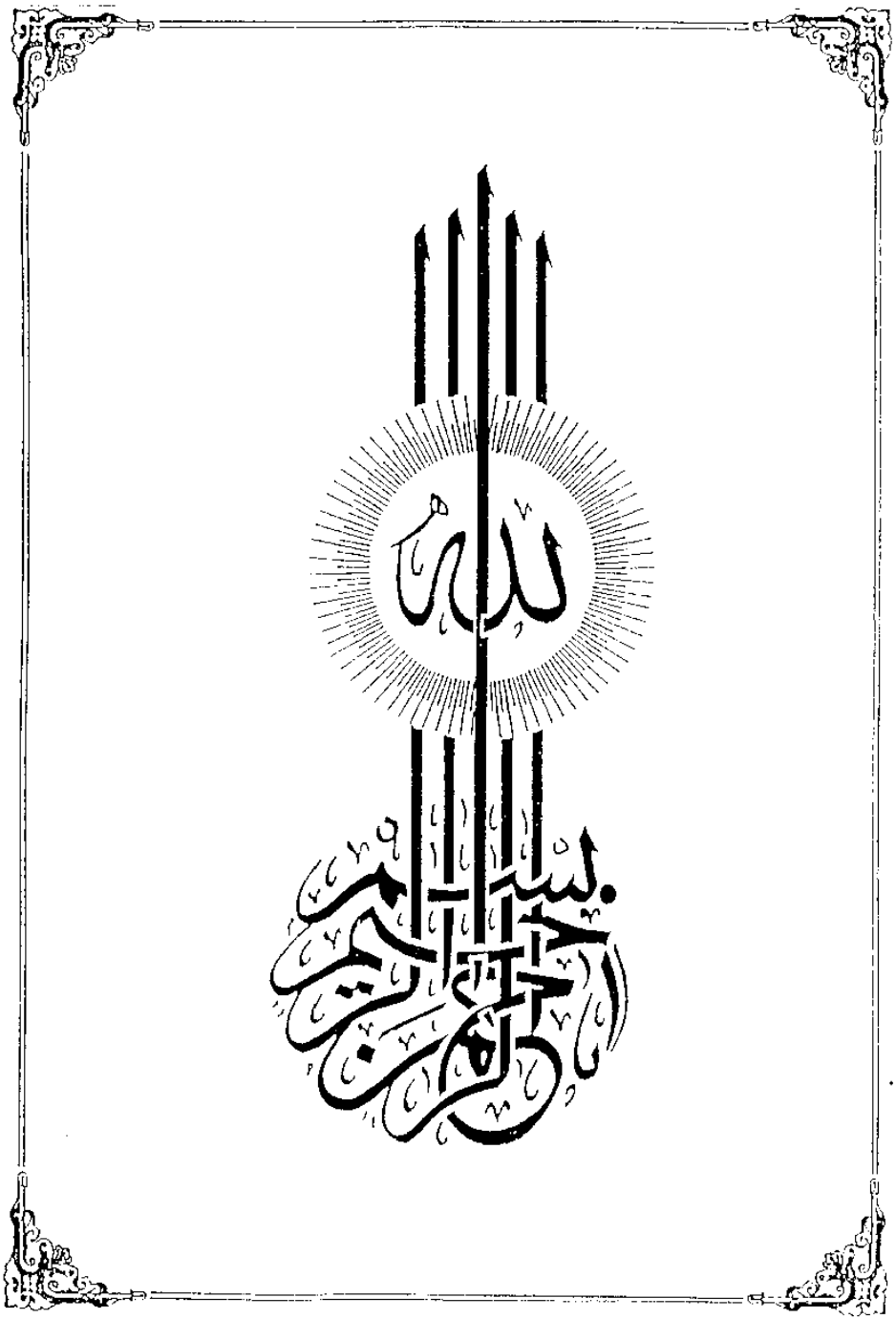

NOTE

Besides the work carried out in this thesis, the candidate has attended graduate courses for one year , covering the following topics :

1. Nuclear chemistry and its applications.
2. Solvent extraction and chromatography.
3. Spectroscopic applications of group theory.
4. Advanced polarography and corrosion.
5. Analytical chemistry (advanced instrumental analysis).
6. Computer science .
7. Inorganic reaction mechanisms.
8. Organometallic compounds.

He has successfully passed a written examination in these courses.

Prof. Dr. N. M. Guindy

Head of Chemistry Department,

TO

MY MOTHER, FATHER,

SISTER AND FIANCÉE.

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AIM OF THE WORK

Metal oxides have a wide application in many fields. One of these is their use in nuclear technology. As fuel, uranium dioxide, UO_2, has particular interest in nuclear technology. It is the nuclear fuel now most widely used in energy producing reactors, such as light water reactors (LWR), fast breeder reactors (FBR) and high temperature gas cooled reactors (HTGR).

Uranium dioxide used as nuclear fuel must fulfil certain specifications[1]. Different techniques may be followed to produce UO_2 nuclear fuel to fulfil the required specifications. From the advantages of UO_2 fuel are its high melting point of 2828 $\pm$ 20°C, its corrosion resistance to radiation damage, and its irradiation stability. The physico-chemical characteristics of UO_2 such as density, surface area, pore structure, grain size, crystallite size, sphericity, oxygen to uranium ratio ... etc. depend mainly on the method of its preparation[2].

UO_2-fuel must be shaped into different forms such as rods, tubes, pellets or spheres. Spherical fuel can be produced by either dry (e.g. powder agglomeration and pellet crushing) or wet methods[3]. The second methods are preferred and yield more valuable fuel than the first ones[4,5]. In addition, the wet chemical methods became an almost universal for producing spherical nuclear fuel. The spherical form of the fuel produced by the wet

chemical processes has several advantages over the conventional methods[6]. Therefore, sol-gel processes appear to be particularly promising methods for the production of nuclear fuel microspheres[7]. The sol-gel processes were developed and applied at the Oak Ridge National Laboratory, ORNL, USA[8], AERE, United Kingdom[9], KEMA, Netherlands[10], CNEN, Italy[11], KFA Jülich, FRG[12], and Tokai, Japan[13] for preparation of high density thoria and/or urania microspheres. In these processes three major operations take place:

i- Preparation of an aqueous sol,

ii- Removing of water producing UO_3 gel particles, and

iii- Thermal treatment of the UO_3-gel particles to produce a dense UO_2-microspheres.

In Chapter II of the present study the different gelation methods were described, while in the second experimental part of Chapter IV a developed gelation process, internal gelation hydrolysis process, was applied to produce a dense UO_2-microspheres suitable as nuclear fuel. The physico-chemical characteristics of UO_3- and UO_2-microspheres produced at different experimental conditions were studied and optimized to obtain UO_2-microspheres of maximum % theoretical density suitable as nuclear fuel.