Radiation preparation of Y_2O_3 nanopowder

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Evropský sociální fond
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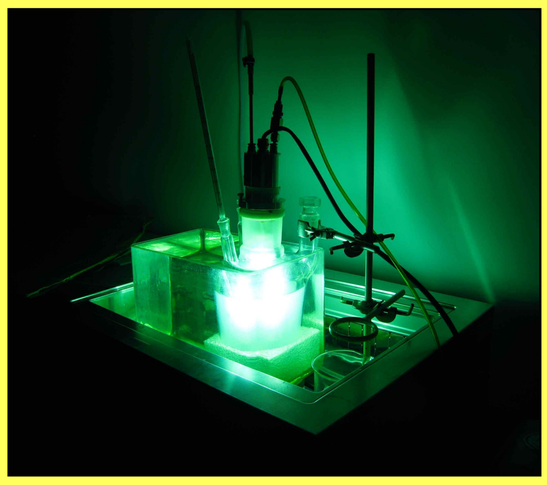
Introduction

The interaction of ionizing or UV radiation with matter causes formation of ionized and excited states. The irradiation of solutions with convenient composition using various types of radiation may cause formation of amorphous or crystalline nanoparticles with narrow size distribution and high chemical purity.

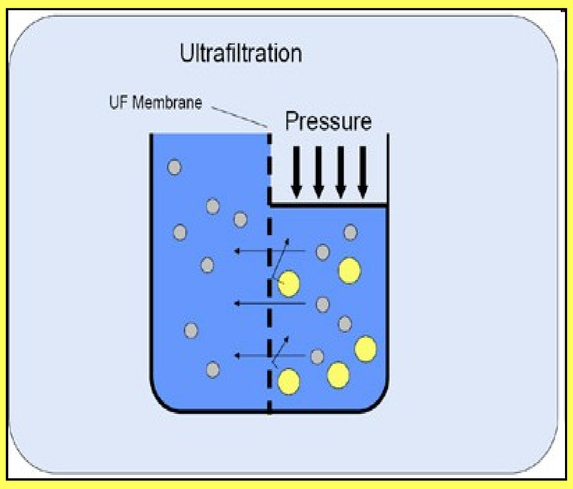
The aim of this work was:**a)** radiation induced preparation of crystalline yttrium oxide nanopowder from aqueous solutions using non-ionizing (UV) radiation; **b)** evaluating the conditions of nanoparticles' formation in the radiation field; **c)** separation and characterization of the product.

Preparation of a sample

First of all, an aqueous solution of yttrium nitrate (5,22.10-3 mol/l) and ammonium formate (12.10-3 mol/l) was prepared. Subsequently, its irradiation was performed using ultraviolet lamp with the most intensive wavelength of light about 280 nm.



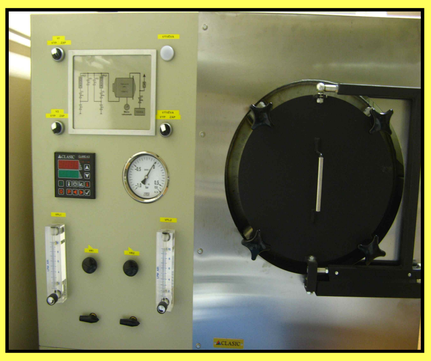
Ultraviolet lap used for irradiation of the solutions



Principle of ultrafiltration

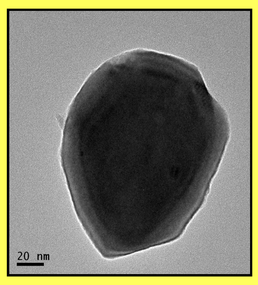
After irradiation, the finely dispersed solid matter was separated via ultrafiltration and dried at 40°C.

Finally, based on obtained results from thermal analysis, the powder was treated at various temperatures under vacuum and normal atmosphere in vacuum oven. The main point of my work was to find out the lowest temperature when Y_2O_3 nanocrystals were formed.

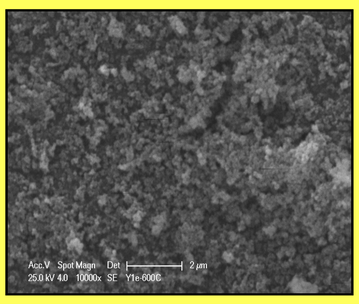


Vacuum oven (Clasic 0415VAK) used for our experiment

Images of crystalline Y_2O_3 nanopowder treated at 500° C



TEM image

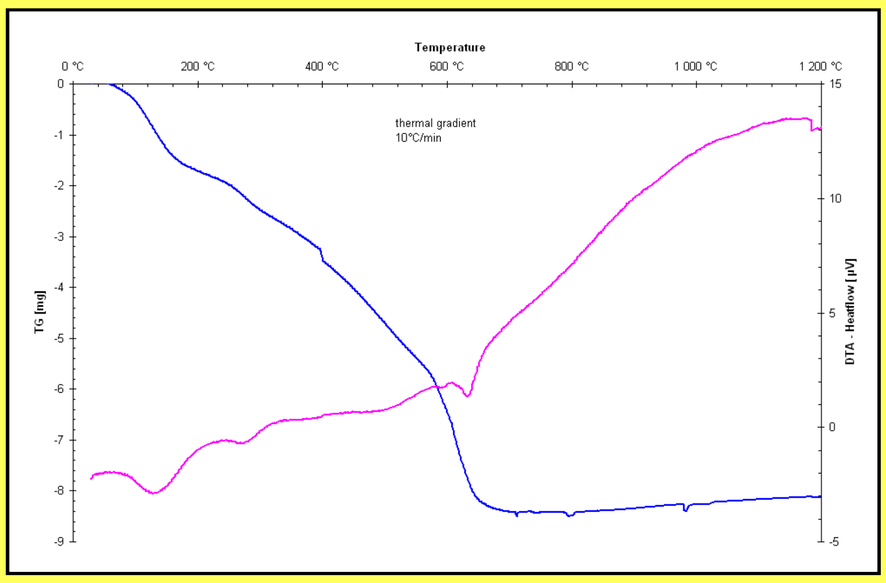


SEM image

The size of crystals cca. 100 nm shows that prepared Y_2O_3 consists of nanoparticles. To support this fact, we measured the specific surface area of the sample treated at 500° C. The result 53,7 m^2/g confirms, that it is obviously nanomaterial.

Thermal analysis

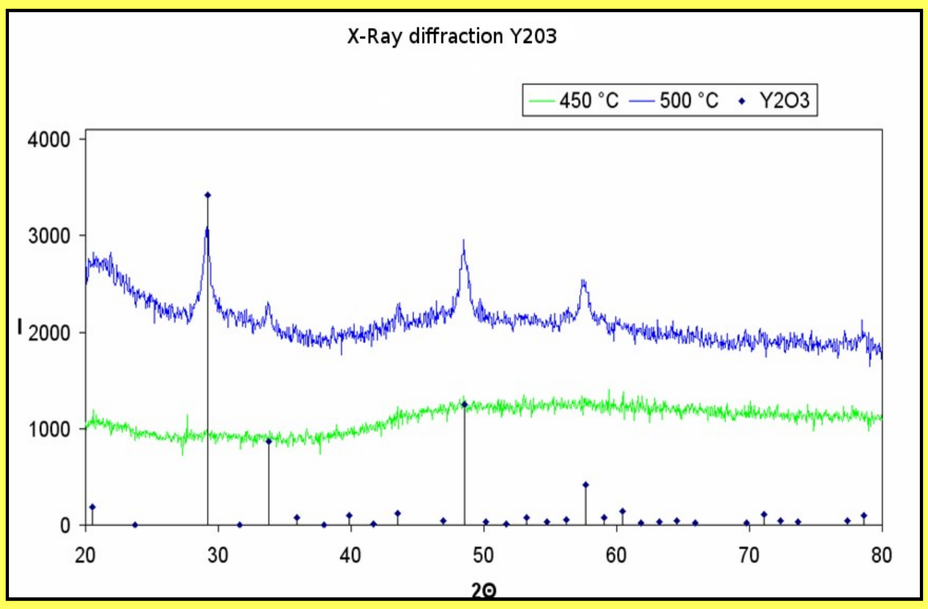
Thermal analysis is a branch of materials science where the properties of materials are studied as they change with temperature



It can be seen that at first, dehydratation of material occurs in temperature interval 80 – 200°C. TG measurement suggests that solid phase forms probably due to interactions of HCOO- anion present in irradiated solutions with products of water photolysis, namely with OH and H radicals.

X-Ray diffraction

When X-Ray beams diffract at the right diffraction angle *theta* (unique for each material), their interference occurs. Therefore, the collector detects stronger impulses at certain angles, which are shown in diffractogram.



The X-Ray diffraction was studied with samples treated at temperatures 400 and 500° C. A comparison with the database was performed. Although there are no recognizable diffraction lines of the sample treated at 400° C, the lines of the sample treated at 500° C, which are similar to the database, confirm that we achieved formation of Y_2O_3 crystalline nanoparticles.

Conclusions

Crystalline Y_2O_3 nanoparticles were successfully prepared by UV radiation induced synthesis. It was necessary to treat the amorphous phase formed during irradiation at higher temperature. Unlike other chemical methods of preparation in which temperatures between 600 and 800° C are required, the radiation induced synthesis requires only 500° C. After post-irradiation thermal treatment, the material consists of regular monocrystalline Y_2O_3 grains with size about 100 nm, with narrow size distribution. The material has an extremely large specific surface area (more than 50 m^2/g), while the other chemical methods of preparation result in values between 10 and 60 m^2/g. The radiation induced synthesis is promising for practical use – we have found it to be fast, effective and inexpensive.

Key references:

[1] *MFF UK*, X-Ray diffraction. From http://physics.mff.cuni.cz/vyuka/zfp/txt_421.pdf

[2] *Wikipedia* , Scintillator. From <http://en.wikipedia.org/wiki/Scintillator>.

[3] Yong-Nian Xu; Zhong-quan Gu; W. Y. Ching (1997). Electronic, structural, and optical properties of crystalline yttria.