Sol-gel template synthesis of mesoporous titania powder with photocatalytic activity under visible light

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INTRODUCTION

The high oxidizing power of photogenerated holes in titania coupled with the chemical stability of TiO_2 material allow to use it for many applications that exploit solar energy. One of them is photocatalytic degradation of organic pollutants in solution [1]. The present work is aimed at preparation and characterization of photoactive mesoporous titania powders using sol-gel template method.

EXPERIMENTAL

Titania powder was synthesized by sol-gel route using $TiCl_4$ as a precursor. Ammonia solution was added dropwise to $TiCl_4$ solution under stirring at 0 °C. The obtained precipitate was converted into concentrated sol (about 10 wt.%) by ultrasonic treatment with addition of small amount of nitric acid as a stabilizer. Pluronic F127 was used as a structure-directing template, which was added to the sol in different proportions (25 and 50 wt. % to TiO_2). Then the sols were freeze dried. The obtained xerogels were annealed at 400 °C during 1 h in air and then at 350 °C during 1 h in O_2. TiO_2 powders were characterized by TG/DSC, XRD, BET, Raman and FTIR spectroscopies. Photoactivity of the powders was evaluated in degradation of Rhodamine B under UV and visible irradiation.

RESULTS AND DISCUSSION

The titania sol obtained by the above described route consists of nanocrystalline anatase phase (mean size of the crystallites is 2-3 nm). When Pluronic F127 is added to the sol, its molecules self-organize due to the interactions of their hydrophilic and hydrophobic parts, providing a template structure in the sol. During subsequent thermal treatment of the samples, molecules of Pluronic F127 are decomposed and oxidized. According to the TG/DSC data, a sharp loss in mass is observed at 211 °C which is accompanied by elaboration of a large amount of heat (Fig. 1). This indicates that explosion occurs in the system that is caused by an intensive thermostimulated oxidative destruction of Pluronic F127 with participation of nitric acid used as a sol stabilizer. Thus, the formation of Pluronic F127 template in the sol, from one side, and the occurrence of explosion during the synthesis, from other side, provide the formation of titania powder with a high surface area and mesoporous structure (Table 1).

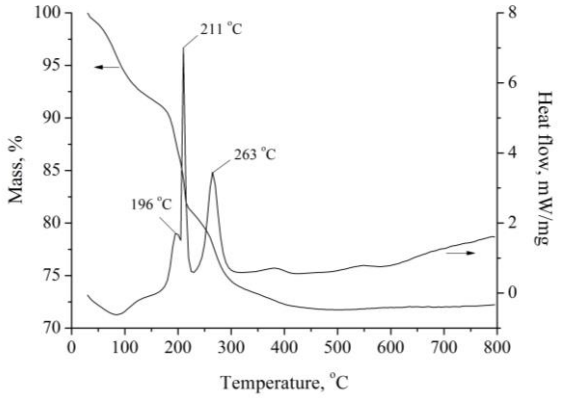

Fig. 1 TG/DSC for sol-gel-derived TiO_2 xerogel with 25 mass % of Pluronic freeze-dried at -70°C in vacuum

According to the FTIR and Raman data, some not fully oxidized carbon species remain in TiO_2 samples. The presence of these species cause the appearance of the photocatalytic activity of titania under visible irradiation.

Table 1. Results of XRD investigation, specific surface area (BET) and porosity measurements of TiO_2 samples.

Sample	CS, nm	S, m^2/g	d_{aver}, nm	V_{por}, cm^3/g
TiO_2	6.3	108.5	4.01	0.110
TiO_2 +25 % Pl	5.7	134.4	4.35	0.146
TiO_2 +50 % Pl	4.9	197.2	4.84	0.233

Pl – Pluronic F127; CS – crystallite size.

CONCLUSION

Mesoporous titania powders with a high surface area were prepared by the sol-gel template route. Using Pluronic F127 as structute-directing agent during synthesis decreases the crystallite size, increases the surface area and pore volume of the titania powder and provides its high photocatalytic activity under visible light.

REFERENCES

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