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ORIGINAL PAPER

Thermal degradation behavior and kinetic studies of polyacrylamide gel in TiO_2 nanoparticles synthesis

Masoud Rakhshani · Mohammad Mehdi Kamrannejad · Ali Akbar Babaluo · Mostafa Rezaei · Mirkarim Razavi Aghjeh

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Abstract Polyacrylamide gel (PAMG) method is a simple, fast and cheap method used for the synthesis of a wide variety of nanopowders. However, no adequate results have been reported on the thermal degradation behavior of PAMG which can be very effective on the final product properties. In this work, thermal degradation behavior of PAMG in the presence of $TiCl_4$ as a precursor salt for synthesis of TiO_2 nanoparticles was examined in comparison with linear polyacrylamide (LPAM) and pure PAMG by thermogravimetry/differential thermal analysis. Their thermal degradation kinetics was investigated, as well. The results showed that thermal degradation of all samples occurred in two stages at different onset temperatures. Despite the high thermal stability of pure PAMG compared to LPAM, the presence of $TiCl_4$ as a mineral material in PAMG structure decreases the thermal degradation onset temperature, considerably. Furthermore for LPAM and PAMG, majority of weight loss occurs in the second stage, but in PAMG with $TiCl_4$ the weight loss occurs mainly at the first stage. For more detailed investigation, residual materials were characterized by Fourier transform infrared spectroscopy and X-ray diffraction (XRD) techniques, attributing this trend to the presence of mineral materials in PAMG structure. XRD and transmission electron microscopy were also applied to confirm anatase crystalline structure and nanoscale distribution of the TiO_2 particles synthesized via PAMG method.

M. Rakhshani · M. M. Kamrannejad · A. A. Babaluo (✉)
Nanostructure Material Research Center,
Sahand University of Technology,
P.O. Box 51335/1996, Tabriz, Iran
e-mail: a.babaluo@sut.ac.ir

M. Rezaei · M. R. Aghjeh
Institute of Polymeric Materials, Sahand University
of Technology, P.O. Box 51335/1996, Tabriz, Iran

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Introduction

In recent years, synthesis of nanopowders via polyacrylamide gel (PAMG) method has been developed due to its high activity (low gelation time), simplicity and cheapness (using metal salts instead of alkoxides as precursor) [1–3]. In this method, thermal degradation behavior of polymeric gel has an effective impact on the final properties of the synthesized nanoparticles. Because, the net-like structure of PAMG and thermal stability of its network inhibit the aggregation of nanoparticles. According to this point, the synthesis procedure of TiO_2 nanoparticles is generally designed based on the thermal degradation behavior of pure PAMG. But, presence of mineral materials can be effective on the thermal degradation behavior of polymeric gel; therefore, investigating the thermal degradation behavior of polymeric gel in the presence of mineral materials for the synthesis of nanoparticles is very important, proposing a guideline to control the final product properties [2–4].

Thermal degradation of linear polyacrylamide (LPAM) has been investigated in several studies [5–7]. It can be concluded that thermal degradation of LPAM occurs in two main stages. First stage (220–340 °C) is attributed to the reaction of pendant amide groups and the weight loss of this stage is 20 %. Second stage of degradation (340–440 °C) is attributed to main chain breakdown and the majority of the weight loss (about 55 %) occurs in this stage [8, 9]. But, a few studies on the thermal degradation behavior of PAMG are available, and then more spacious investigations are appreciated.