THERMAL BEHAVIOUR OF MECHANICALLY AMORPHIZED COLEMANITE
I. Thermal decomposition of ground colemanite

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Abstract

The effect of mechanical treatment on the thermal decomposition of calcium borate, colemanite – Ca₅B₆O₁₆(OH)₆·2H₂O was studied by means of XRD, FTIR, SEM and thermal analysis methods. Grinding of colemanite causes the solid-state amorphization of this mineral, as a result of the destruction of its structure along the cleavage plane. The decrease in the particle size of the original material and the increase in its internal structural disorder affect the temperatures and the magnitudes of the thermal effects accompanying the processes of dehydration and dehydroxylation. The diminishing values of the enthalpies of these processes may be a quantitative measure of the degree of amorphization of colemanite.

Keywords: colemanite, dehydration, dehydroxylation, solid-state mechanical amorphization, thermal decomposition

Introduction

The conventional method of preparation of amorphous substances consists in a rapid solidification of alloys. Recently several studies have appeared on the possibilities of preparing amorphous substances, amorphous alloys in particular, by solid state amorphization reactions [1]. The formation of an amorphous substance then occurs through disordering of the lattice of a crystalline solid. Such phenomena take place in naturally occurring and in crystalline minerals (gadolinite, thorite, zircon) which, in the course of geological times, assumed the properties of an amorphous material. This phenomenon called the process of metamictization is the result of the destruction of the crystalline structure of minerals by irradiation. During the last 20 years irradiation-induced amorphization was intensively investigated in a wide variety of materials using high-energy ion accelerators [2].

Formation of amorphous materials may also occur in the course of heat treatment of crystalline, inorganic polymers such as silicates, phosphates and borates [3, 4].

The disordering of a crystalline lattice may also be attained by mechanical grinding (wet or dry). Using this method, one can obtain powder materials of controlled microstructure and chemical reactivity.
Many authors have investigated the processes accompanying the grinding of layered silicates such as kaolinite [5], montmorillonite [6, 7], illite [8] or pyrophyllite [9, 10]. On the other hand, there are not data available on the mechanical treatment of such substances as borates which have also a polymerized structural framework.

This paper presents the results of investigations of the effect of mechanical treatment on the processes of internal thermal dehydration and dehydroxylation and the accompanying structural changes of the chain structure of calcium borate, colemanite - Ca$_2$B$_6$O$_8$(OH)$_6$2H$_2$O.

**Experimental**

Selected, coarse-crystalline samples of colemanite from Turkey occurring in montmorillonized volcanic tuffs were studied. The mineral compositions of colemanite samples were determined by means of X-ray diffraction and FTIR methods. The samples proved to be pure colemanite.

Dry grinding was carried out in a laboratory vibration mill using different times of grinding from 1 to 90 h. The progress of amorphization of colemanite was followed by X-ray diffraction, FTIR spectroscopy and thermal examinations. X-ray diffraction powder patterns were obtained with a Dron-3 diffractometer, using CuK$_\alpha$ radiation. FTIR spectra were recorded by means of Bio-Rad Win-IR spectrometer and the samples were prepared as KBr discs.

![Fig. 1 Comparison of X-ray diffraction patterns of colemanite after different times of grinding](image)