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Dielectric relaxation of water in clay minerals

Vasilyeva M., Gusev Y., Shtyrlin V., Greenbaum Gutina A., Puzenko A., Ishai P., Feldman Y.
Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

The study of confined water dynamics in clay minerals is a very important topic in aluminosilicate-surface chemistry. Aluminosilicates are among the most technologically versatile materials in industry today. Dielectric spectroscopy is a very useful method for investigating the structure and dynamics of water adsorbed on solid matrix surfaces and water in the vicinity of ions in solutions. Use of this method for the study of clay minerals has been underutilized to date, however. The main goal of the present research was to understand the relaxation mechanisms of water molecules interacting with different hydration centers in clay minerals, with a view to eventually control this interaction. Two types of natural layered aluminosilicates (clay minerals) montmorillonite with exchangeable K+, Co2+, and Ni2+ cations and kaolinite with exchangeable K+ and Ba2+ cations were examined by means of dielectric spectroscopy over wide ranges of temperature (from -121°C to +300°C) and frequency (1 Hz-1 MHz). An analysis of the experimental data is provided in terms of four distributed relaxation processes. The low-temperature relaxation was observed only in montmorillonites and could be subdivided into two processes, each related to a specific hydration center. The cooperative behavior of water at the interface was observed in the intermediate temperature region, together with a proton percolation. The dielectric properties of ice-like and confined water structures in the layered clay minerals were compared with the dielectric response observed in porous glasses. The spatial fractal dimensions of the porous aluminosilicates were calculated by two separate methods - from an analysis of the fractality found in photomicrographs and from the dielectric response.

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Keywords

Adsorbed Water, Dielectric Spectroscopy, Exchangeable Cations, Fractal Dimension, Kaolinite, Montmorillonite