THERMAL ANALYSIS OF SELECTED ILLITE AND SMECTITE CLAY MINERALS. PART II.
SMECTITE CLAY MINERALS

C. M. Earnest

Department of Chemistry, Berry College
Rome, Georgia (USA)

Abstract

In this paper, the application of the techniques of differential thermal analysis (DTA), thermogravimetry (TG) and derivative thermogravimetry (DTG) to the characterization of smectite clay minerals is presented. Several specimens including both dioctahedral and trioctahedral types of smectite clay mineral are included here. The use of DTA to separate the mineral montmorillonite into two subtypes is demonstrated. A unique industrial example of the use of TG to follow the cleaning of a raw bentonite clay and its subsequent conversion into an organo-clay product is demonstrated. The thermal analysis of both raw and processed hectorite clay specimens which was originally performed by the author is reviewed.

Introduction

Montmorillonite Clay Minerals (Smectites)

The montmorillonite group (smectites) consists of a number of clay minerals composed of tetrahedral-octahedral-tetrahedral silicate layers of both dioctahedral and trioctahedral types. These belong to the group of minerals termed “argillaceous minerals” along with the micas. Argillaceous minerals are hydrated aluminum silicates which derive from the \([\text{Si}_2\text{O}_5]^{2-}\) anion. The dioctahedral members of the group are montmorillonite,
beidellite and nontronite. The trioctahedral members are hectorite and saponite.

Montmorillonite is the dominant clay mineral in bentonite (altered volcanic ash). Bentonite has the unusual property of expanding several times its original volume when placed in water. Due to this behavior, it has become industrially important as an oil drilling mud in which the montmorillonite is used to give the fluid a viscosity several times that of water. It is also used for stopping leaks in dams, soils and rocks. Another recent use is as a catalyst support material.

Unlike the kaolinite group of clay minerals, the smectites undergo extensive cation exchange or replacement in the crystal lattice. Thus, one will note that location of the origin of the clay is often listed with it. The degree of displacement and type of metal in the lattice can eventually govern the shape and position of many thermal analysis peaks.

Montmorillonite

Montmorillonite is by far the most abundant dioctahedral smectite. The theoretical formula is $\text{Al}_2(\text{Si}_4\text{O}_{10})(\text{OH})_2$. In montmorillonite, the silicate layer charge is due to the replacement of $\text{Al}^{3+}$ by $\text{Mg}^{2+}$ in the octahedral sheet. Most montmorillonite specimens have additional substitution of $\text{Si}^{4+}$ by $\text{Al}^{3+}$ in the tetrahedral sheet as well as substitution of $\text{Al}^{3+}$ by $\text{Fe}^{3+}$ in the octahedral sheet.

Because of this substitution, montmorillonite always differ from the theoretical formula. In the tetrahedral plane, the substitution may proceed up to about 15 percent, however, in the octahedral plane, it may extend to completion (Todor, 1976). This extensive substitution in the octahedral plane leads to a number of diverse minerals classified in this group.

Structurally montmorillonite is composed of units made of two silica tetrahedral sheets with a central alumina octahedral sheet. All of the tips of the