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ELECTROPHORETIC SEPARATION AND FRACTIONATION OF CLAY MIXTURES

ROBERT G. PARK, *College of Environmental Sciences, University of Wisconsin, Green Bay, Wisconsin 54300* AND GLENN C. LEWIS, *Department of Agricultural Biochemistry and Soils, University of Idaho, Moscow, Idaho, 83843.*

ABSTRACT

An electrophoretic continuous particle separator makes it possible to separate mixtures of bentonite-illite and bentonite-kaolinite clays. Separating bentonite and kaolinite from an artificial mixture requires an electrolyte of 0.001 M Na_2CO_3 adjusted to a pH of 4.5 with HCl. The concentration of clay in suspension was 0.2 mg/ml. The suspension contained 20×10^{-5} meq of Th^{4+} per ml. Separating bentonite and illite from an artificial mixture required the same conditions except that the clay suspension contained 30×10^{-5} meq of Th^{4+} per ml.

It is often desirable to study the mineralogical, chemical and physical characteristics of individual clay minerals found in a natural mixture of clay. These studies have been difficult due to the lack of a good method for a quantitative separation of the various clay mineral components. Electrophoretic methods have shown promise in performing these separations.

Beavers and Larson (1953) used a schlieren moving-boundary procedure to study the mobility of Putnam and Cisine subsoil clays and montmorillonite clay. When a mixture of Cisine and montmorillonite was subjected to electrophoresis, the clays retained their characteristic mobilities and the distance between bands indicated that a separation of the clays might have been accomplished.

McNeal and Young (1963) used a paper electrochromatographic technique to separate bentonite from a mixture containing bentonite, kaolinite and vermiculite. Disadvantages of the method included considerable adsorption of the clay onto the paper and the time required for separation (48 hours).

It appears theoretically possible, therefore, to separate various clays

electrophoretically if the mechanical difficulties of fractionating and collecting large quantities of solid material can be overcome.

Strickler, Kaplan and Vigh (1966) developed an electrophoretic cell which seems to overcome these mechanical difficulties. The cell utilizes a vertical free flowing film of electrolyte which serves as an electrophoretic medium. The sample is continuously injected at the top of the film and the electrophoretic fractions are continuously withdrawn at the bottom. The advantages of using a cell of this type are that the clay is not adsorbed on the medium and that continuous fractionation can be accomplished.

The purpose of the work reported herein was to determine if this type of cell can be used to separate mixtures of sodium-saturated illite-bentonite and kaolinite-bentonite.

The electrophoretic separation procedure requires an electrolyte which gives good dispersion of the particles. It also requires the concentration of this electrolyte which results in the greatest difference in mobility between mineral species. The greatest difference in mobilities was obtained using 0.001 M Na_2CO_3 at a pH of 4.5. However, when mixtures of the clays were subjected to electrophoresis there was not sufficient resolution between the bands of the different clay species to perform a separation.

Small amounts of ThCl_4 were added to the clay suspension to further alter the mobilities of the different clay species. The mobility of bentonite was not greatly affected by the Th^{4+} . However, the mobilities of kaolinite and illite were greatly altered (Fig. 1). It appears necessary to add small amounts of Th^{4+} to the electrolyte solution before separation can be accomplished.

Mixtures of clays having a concentration of 0.2 mg/ml were prepared using 20×10^{-5} milliequivalents Th^{4+} per ml clay suspension for the bentonite-kaolinite mixtures and 30×10^{-5} milliequivalents Th^{4+} per ml clay suspension for the bentonite-illite mixture. The electrolyte used in the electrophoretic cell was 0.001 M Na_2CO_3 at a pH of 4.5. The clay mixtures were introduced into the cell at a rate of 0.1 ml/min, with a curtain flow rate of 10 ml/min, and an electrode chamber flow of 40 ml/min. The mixture separated into bands corresponding to the characteristic mobilities of the pure clay species when a potential gradient of 60 V/cm was applied. There was approximately 2.5 mm distance between the bentonite and kaolinite bands (Fig. 2) and between the bentonite and illite bands (Figs. 2, 3). This distance was sufficient to perform a fractionation.

Samples of the individual bands were collected and analyzed by X-ray diffraction to determine the purity of the separates. The separates were uncontaminated by the other clay in the mixture.

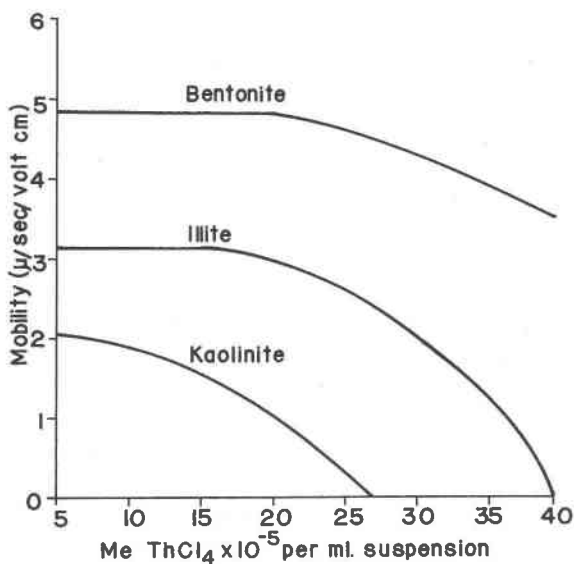


FIG. 1. The mobility of three different clays as a function of ThCl_4 in the clay suspension. The electrolyte solution was 0.001 M Na_2CO_3 at a pH of 4.5.

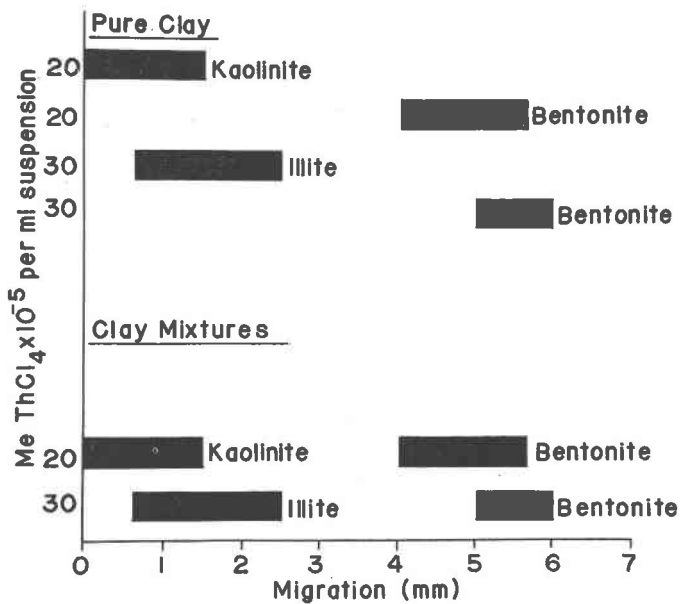


FIG. 2. The amount of migration and band width of pure clays and mixtures of these clays at the optimum ThCl_4 concentration. The electrolyte was 0.001 M Na_2CO_3 at pH 4.5.

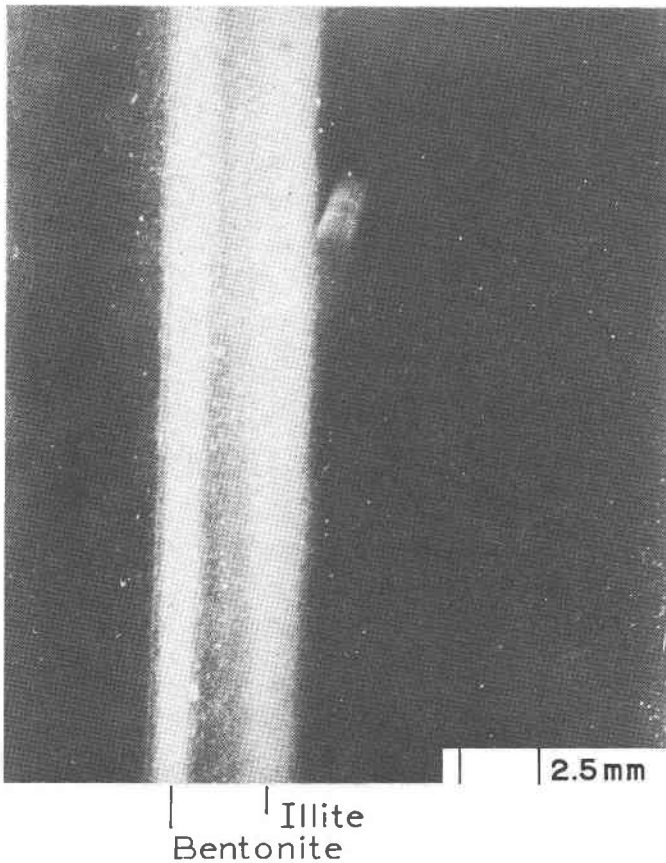


FIG. 3. Electrophoretic bands of Illite and Bentonite. Photograph taken 1 cm above sample pickup tube.

An electrophoretic cell of this type, under carefully controlled conditions, appears to have a great deal of promise for separating the mineral components found in naturally occurring clays.

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