RHEOLOGICAL PROPERTIES OF KAOLINS OF VARYING DEGREES OF CRYSTALLINITY

by

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EXTENDED ABSTRACT

THE degree of crystal perfection of kaolins is known to be related to certain properties of importance in the ceramic and paper-making industries. Such properties as viscosity, plasticity (Holdridge, 1956), and fired strength resulting from mullitization (Johns, 1953) may be closely related to the degree of crystal perfection. Recent work (Woodward, 1955; Murray and Lyons, 1956), in which a qualitative correlation between viscosity and degree of crystal perfection was indicated, is in contradistinction to earlier studies (Mitchell and Henry, 1943; Mitchell and Poulos, 1959) in which no consistent correlation was noted. In view of the somewhat clouded picture of the possible relation between viscosity and degree of crystal perfection, a detailed study was made of the flow properties of carefully sized fractions of different kaolins of varying degrees of crystallinity.

On the basis of previous work (Ormsby *et al.*, 1962), in which cation-exchange and surface area properties were found to parallel each other both among different clays and within fractions of a single clay, it was reasoned that changes in flow properties should parallel changes in surface-area (and cation-exchange) properties. In other words, when going from a well-crystallized to a poorly-crystallized clay or from coarse fractions to fine fractions of a single clay, one should get an increase in the viscosity, surface area, and cation-exchange capacity, irrespective of the crystallinity.

Each of several clays of varying degrees of crystallinity was fractionated into six fractions which were characterized with respect to mineral composition, surface area, and cation-exchange capacity. Crystallinity was evaluated using the methods described by Johns and Murray (1959) and Hinckley (1961). The pH's of the samples were controlled between 6.0 and 7.0.

The flow properties of aqueous systems of the various samples were determined using a recording Ferranti cone-plate viscometer (McKennell, 1956) equipped with truncated cones. This viscometer permitted the recording of shear stress (r) versus rate of shear (D) diagrams over a wide range of shear rates under uniform conditions of shear and temperature. Complete flow curves, i.e., up-and-down recording of D—r diagrams, were made in controlled times ranging from 20–80 sec. Shear rates were varied from 0–10,000 sec^{-1}, temperature was maintained constant at $25 \pm 0.2°C$, and the water content of the samples was varied between 40 and 60 weight per cent. Detailed studies were made at a nominal water content of 50 per cent.

Samples of the various fractions of the different clays at 50 weight per cent water exhibited flow curves which, depending largely on the particle size, could be classified as Newtonian (44–10, 10–5, 5–2 micron fractions), pseudoplastic (bulk and 1–0.5, 0.5–0.25 micron fractions) and dilatant (2–1 micron fraction). Dilatancy in the 2–1 micron fraction was especially pronounced at relatively low water contents (40–45

weight per cent) and the degree of dilatancy was found to increase with increasing degree of crystal perfection.

For purposes of comparison, the various flow curves were reduced to linearity by plotting log η or log τ/D versus log D. Any given curve could then be represented by the expression $\eta = kD^{N-1}$, where k and N were constants for the system in question. In this expression k is a measure of the consistency of the system and N indicates the type of behavior exhibited by the system, i.e., for $N = 1$, the system is Newtonian, for $N < 1$ the system is pseudoplastic and for $N > 1$ the system is dilatant. For non-dilatant systems, changes in "viscosity" of the different sized fractions of a single clay were found to parallel changes in surface area, cation-exchange capacity, and crystallinity. All three of these parameters were found to *increase* with *increasing* viscosity. Similar, but somewhat more poorly defined, correlations between viscosity and cation-exchange capacity (or surface area) were noted for bulk samples and fine particle-size fractions of different clays. In comparing the viscosities of fine fractions of different clays it was found that increases in viscosity generally parallel increases in cation-exchange capacity and surface area while, at the same time, crystallinity was decreasing. These results support the generally accepted thesis that flow properties are largely controlled by surface area (Platen and Winkler, 1958) and that, in studying factors affecting these properties, one should be especially careful to assess the role of variations in particle size (Rosenthal, 1962).

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