
Dielectric-Relaxation Spectroscopy of Kaolinite, Montmorillonite, Allophane, and Imogolite under Moist Conditions

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Abstract: The dielectric behavior of kaolinite, montmorillonite, allophane, and imogolite samples adjusted to a water potential of 33 kPa was examined using a time-domain reflectometry method over a wide frequency range of 10^3 – 10^{10} Hz. A dielectric relaxation peak owing to bound H₂O was observed. The observation of this peak required the precise determination of the contributions of dc conductivity. The peak is located at 10 MHz, indicating that the relaxation time of the bound H₂O is approximately ten times longer than the relaxation time of bound H₂O with organic polymers, such as an aqueous globular-protein solution. The structure of bound H₂O differs between phyllosilicates and amorphous phases, based on differences in relaxation strength and the pattern of distribution of the relaxation times. The dielectric process involving rotation of bulk H₂O molecules was also observed at 20 GHz. The relaxation strength of bulk H₂O increased with an increase in the water content. The interfacial polarization in the diffuse double layer occurred only in montmorillonite and kaolinite, indicating that mechanisms involving the Maxwell-Wagner and surface-polarization effects cannot be extended to include allophane and imogolite. Although these results suggest that additional work is required, a tentative conclusion is that a tangential migration of counter-ions along clay surfaces may be important.

Key Words: Allophane • Bound Water • Complex Permittivity • Dielectric-Relaxation Spectroscopy • Imogolite • Interfacial Polarization • Kaolinite • Montmorillonite • Time-Domain Reflectometry

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