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The Impact of Water Saturation on Hydrogen Adsorption in Clay-rich Caprocks

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Underground Hydrogen Storage (UHS) plays a pivotal role in the shift towards renewable energy resources, necessitating paramount attention to safety and efficiency. To maximize the recovery of stored hydrogen and ensure a reliable seal against leakage, it is crucial to comprehend the propensity for hydrogen migration through caprock. The migration may occur within the pore solution, where small H2 molecules can readily diffuse through pores and fractures of the seal. Accurate risk analysis requires a thorough assessment of hydrogen loss through the caprock, emphasizing the significance of hydrogen transport properties, including adsorption and diffusion. However, due to safety concerns surrounding hydrogen gas, comprehensive data on its interaction with various natural settings remains scarce. This study investigates the hydrogen adsorption of various natural and synthetic materials, including four shale samples from the Norwegian Continental Shelf and three standard clays. The samples underwent extensive characterization tests, such as X-ray Diffraction (XRD), X-ray Fluorescence (XRF), Scanning Electron Microscopy-Energy Dispersive Spectroscopy (SEM-EDS), and BET analysis. High-pressure gas adsorption analysis was conducted to measure hydrogen sorption isotherms. The experiments included dried and wet samples, with and without prior treatments. The results reveal that swelling clays, particularly those from the Smectite group, have a higher hydrogen uptake capacity. Additionally, when wet clay samples were examined, the presence of water resulted in competition between water and hydrogen for binding sites within the clay, leading to a decrease in hydrogen adsorption. The comprehensive testing and analysis conducted in this study provide valuable data for future risk assessments and enhance our understanding of geological hydrogen storage in various geological formations.

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