

Phospholipid influence on the water repellency of the clay montmorillonite

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Assembly of the lipid fraction of soil organic matter on mineral surfaces may stabilize lipids against microbial attack and the consequent redistribution of carbon. However, such assembly is a poorly understood phenomenon that reflects underlying lipid-lipid and lipid-substrate interactions, both of which are expected to be sensitive to hydration/dehydration cycles and have the potential for significant environmental impacts. For example, lipid-substrate interactions have been implicated in seasonal changes in soil water repellency. Therefore, it is desirable to build a molecular-scale understanding of lipid-mineral interactions. In order to build such an understanding, we have started with a simple model system of several phospholipids and the clay montmorillonite. We have conducted atomic force microscopy and fluorescence microscopy experiments to determine the microscale features of phospholipid-montmorillonite interactions, and compared these results to water repellency measurements of clay-lipid films. We have performed molecular dynamics simulations of phospholipid-montmorillonite interaction, to determine if lipid micelles interact with the mineral surface prior to or during drying.

We have found that the addition of very little lipid to montmorillonite causes a steep increase in hydrophobicity, and that this steep increase appears to coincide with the presence of lipids lining the edges of montmorillonite flakes. This behavior depends on the type of lipid. Saturated phosphoethanolamine and phosphoglycerol lipids prefer edges, while their unsaturated analogues do not have this preference. Likewise, contact angle data suggest that the lipid head-group chemistry changes the extent of induced hydrophobicity. Comparison of lipid behavior on an atomically flat mica surface as opposed to a defect-filled montmorillonite film indicates that the presence of edge sites and defects greatly changes lipid-surface interactions. Further study on increasingly complex model systems is warranted in order to fully understand the multifaceted nature of organic-mineral interactions.