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Superhydrophobic surfaces: A model approach to predict contact angle and surface energy of soil particles

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Summary
Wettability of soil affects a wide variety of processes including infiltration, preferential flow and surface runoff. The problem of determining contact angles and surface energy of powders, such as soil particles, remains unsolved. So far, several theories and approaches have been proposed, but formulation of surface and interfacial free energy, as regards its components, is still a very debatable issue. In the present study, the general problem of the interpretation of contact angles and surface free energy on chemically heterogeneous and rough soil particle surfaces are evaluated by a reformulation of the Cassie-Baxter equation assuming that the particles are attached on to a plane and rigid surface. Compared with common approaches, our model considers a roughness factor which depends on the Young's Law contact angle determined by the surface chemistry. Results of the model are discussed and compared with independent contact angle measurements using the Sessile Drop and the Wilhelmy Plate methods. Based on contact angle data, the critical surface tension of the grains were determined by the method proposed by Zisman. Experiments were made with glass beads and three soil materials ranging from sand to clay. Soil particles were coated with different loadings of dichlorodimethylsilane (DCDMS) to vary the wettability. Varying the solid surface tension using DCDMS treatments provided pure water wetting behaviours ranging from wettable to extremely hydrophobic with contact angles >150°. Results showed that the critical surface energy measured on grains with the highest DCDMS loadings was similar to the surface energy measured independently on ideal DCDMS -coated smooth glass plates, except for the clay soil. Contact angles measured on plane surfaces were related to contact angles measured on rough grain surfaces using the new model based on the combined Cassie-Baxter Wenzel equation which takes into account the particle packing density on the sample surface.