Unexpectedly Critical Role of Hydrophilic Surfaces on Nearby Water

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The impact of surfaces on the contiguous aqueous phase is generally thought to extend no more than a few water-molecule layers. We find, however, that colloidal and molecular solutes are profoundly excluded from the vicinity of various hydrophilic surfaces, to distances typically several hundred micrometers. Such large exclusion zones have been observed next to many surfaces, including hydrogels, biological tissues, hydrophilic polymers, monolayers, and ion-exchange beads. And, many diverse solutes are excluded. Hence, the exclusion phenomenon appears to be quite general.

Several methods have been applied to test whether the physical properties of the exclusion zone differ from those of bulk water. NMR, infrared, and birefringence imaging, as well as measurements of electrical potential, viscosity, and UV-VIS absorption spectra, reveal that the solute-free zone is a physically distinct, less mobile, ordered, phase of water that can co-exist essentially indefinitely with the contiguous solute-containing phase. Indeed, this unexpectedly extensive zone may be a candidate for the long-postulated "fourth phase" of water.

The energy responsible for building this charged, low entropy zone may come from sunlight. We found that incident radiant energy including all visible and near-infrared wavelengths induce exclusion-zone growth in a spectrally sensitive manner. IR is particularly effective. Ten-minute exposure to LED radiation at 3.1 μm (corresponding to OH stretch) causes exclusion-zone-width increase up to four times. Apparently, incident photons cause some change in bulk water that predisposes constituent molecules to reorganize and build the charged, ordered exclusion zone.

Photons from ordinary sunlight, then, may have an unexpectedly powerful effect that goes beyond mere heating. It may be that solar energy builds order and separates charge between the exclusion zones next to hydrophilic surfaces and the bulk waters beyond — each separation creating a battery. The resemblance to photosynthesis is evident. Indeed, this light-induced action would seem relevant not only for photosynthesis but also for all realms of nature involving water and interfaces. The implications are amply discussed in: http://uwtv.org/programs/displayevent.aspx?rID=22222 and will be presented.

Zheng, J.M. and Pollack, G. H.: Long range forces extending from polymer surfaces. Phys Rev E.: 68: 031408, 2003.

J.M Zheng, W.-C Chin, E. Khijniak, E. Khijniak, Jr, and G. H. Pollack: Surfaces and Interfacial Water: Evidence that hydrophilic surfaces have long-range impact. Adv. Coll. and Interface Sci, 127: 19-27, 2006.