

Long-Range Water Structuring at Interfaces

Jian-ming Zheng, Eugene Khijniak, Wei-Chun Chin, Hyok Yoo, and Gerald H. Pollack
Department of Bioengineering, University of Washington, Seattle WA 98195
ghp@u.washington.edu.

It is generally thought that the impact of surfaces on the contiguous aqueous phase extends to a distance of no more than a few water-molecule layers. Older studies, on the other hand, suggest a far more extensive impact. We report here that colloidal and molecular solutes in aqueous solution are profoundly and extensively excluded from the vicinity of various hydrophilic surfaces. The width of the solute-free zone is typically several hundred microns. Such large exclusion zones were observed in the vicinity of many types of surface including artificial and natural hydrogels, biological tissues, hydrophilic polymers, monolayers, and ion-exchange beads; and, many types of solutes are excluded. Hence, the exclusion phenomenon appears to be general.

Several methods have been applied to test whether the physical properties of the exclusion zone differ from those of bulk water. NMR and infrared imaging, as well as measurements of electrical potential, viscosity, and UV-Vis absorption spectra reveal that the solute-free zone is a physically distinct and less mobile phase of water, which can co-exist essentially indefinitely with the contiguous solute-containing phase. All of the above methods show that water in the solute-exclusion zone differs from water in the bulk.

The extensiveness of the solute-exclusion zone is impressive — typically 100 μm to 500 μm . Its presence carries implication for surface-molecule interactions in many realms, including cellular recognition, biomaterial-surface anti-fouling, bio-separation technologies, and areas of basic biology, physics and chemistry that involve water and solutes anywhere near (and not so near) to hydrophilic surfaces.