Water Structuring at Interfaces may be More Extensive than Generally Thought

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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 more extensive impact. We report here that in aqueous solution, colloidal and molecular solutes 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 surfaces including artificial and natural hydrogels, biological tissues, hydrophilic polymers, monolayers, and ion-exchange beads. Many types of solutes are excluded, over a broad size range. 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 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.

We found recently that radiant energy has a positive effect on exclusion-zone size. This energy includes all visible and near-infrared wavelengths, the latter having a particularly powerful effect. At 3.1 μm (corresponding to OH stretch), we have seen increases of exclusion-zone width up to four times. Apparently, photons cause some change in bulk water, which predisposes constituent water molecules to build the exclusion zone. The energy required for building this zone, in other words, may lie at least in part in ambient radiant energy.

The extensiveness of the solute-exclusion zone is impressive — typically 100 μm to 500 μm. Hence, this interfacial feature is considerably more dominant than previously thought. Its presence carries implication for realms of biology, physics, and chemistry that involve water and solutes anywhere near (and not so near) hydrophilic surfaces.

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