Spectroscopic investigation of water layers

J. Pokorný and A. Theodorou

Institute of Physics of the Academy of Sciences of the Czech Republic,
Na Slovance 2, 182 00 Prague 8, Czech Republic

e-mail: pokorny@fzu.cz

Despite water being the most accessible and most studied chemical compound, many of its anomalous properties remain poorly understood. At solid hydrophilic surfaces, water forms an interfacial layer up to ~ 500 µm thick [1]; the thickness depends on many factors such as composition of the solid material, surface treatment, or pH value of the liquid [2]. Compared to bulk water, the layer exhibits higher viscosity, higher refractive index as well as charge separation [3]. It is denoted as an ordered water layer, a clear zone, or an exclusion zone as suspended microparticles or solutes can be excluded from the layer. To a reasonable extent, macroscopic properties of such water layers have been experimentally studied and a number of theoretical approaches exist. However, clear experimental evidence of relevant microscopic phenomena such as structuring of water molecules and/or collective vibrational states is missing.

Precise characterization of the interfacial water may have high application potential e.g. in filtration techniques, cement setting control etc. It is reasonable to assume that in biological structures such as living cells stuffed with charged surfaces, most of the contained water exhibits interfacial properties. Understanding the processes mediated by water layers can provide deeper insight into fundamental phenomena in living systems as well as understanding of various pathologies such as degenerative brain disorders or cancer [4].

We have studied solid–water interfaces using infrared, Raman and fluorescent microscopy techniques. The experiments involved various solid materials such as glass, quartz, and Nafion in different geometries and under varying ambient conditions. We have observed a comparatively strong fluorescence emission localized around the solid/water interfaces confirmed by using multiple experimental techniques, involving various excitation wavelengths in the UV and visible regions. We believe that spectroscopic techniques may shed light on microscopic phenomena such as molecular dynamics in interfacial water layers.

Acknowledgment:

This work has been supported by the European Research Executive Agency, project 101130758.

References:

[1] J. M. Zheng, W. C. Chin, E. Khijniak, E. Khijniak Jr. and G. H. Pollack, *Adv. Colloid Interf. Sci.* **127**, 19 (2006).
[2] J. Zheng and G. H. Pollack, *Phys. Rev. E* **68**, 031408 (2003).
[3] J. Shen, A. Theodorou, Z. Li and G. H. Pollack, *Colloids Surf. A: Physicochem. Eng. Asp.* **691**, 133816 (2024).
[4] J. Pokorný, J. Pokorný, J. Kobilková, A. Jandová and R. Holaj, *Appl. Sci.* **10**, 1826 (2020).