Monitoring Uptake, Release and Reaction of Gases at the Liquid-Vapor Interface.

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Multiphase reactions are omnipresent in nature, industrial applications. The direct observation of reactions at the liquid-vapor interface requires spectroscopic techniques that are surface specific and chemically sensitive to detect low concentrations (~1 mM), e.g., photoelectron spectroscopy (XPS). Furthermore, the sample delivery method must allow sufficient time for an interface reaction to proceed. These complex challenges require individual approaches for each system of interest.

One example for a multiphase process is the reaction between liquid alkali metal (NaK) and water vapor, which is extremely fast (Fig. 1). We used a slow droplet train of NaK in a wet atmosphere and observed the formation of golden aqueous solutions with metallic properties with XPS.[1]

An example with relevance for atmospheric chemistry is the formation and the release of sulfur dioxide (SO_2) from aqueous sulfite solutions due to acidification. We demonstrated that dissolved gases can be detected with XPS even though their concentration is only about 1 mM.[2]

[1]P. Mason, C. Schewe, T. Buttersack, V. Kostal, M. Vitek, R. McMullen, H. Ali, F. Trinter, C. Lee, D. Neumark, S. Thürmer, R. Seidel, B. Winter, S. Bradforth, P. Jungwirth: "*Spectroscopic evidence for a gold-colored metallic water solution*", Nature 595, 673-676 (2021).

[2]T. Buttersack, I. Gladich, S. Gholami, C. Richter, R. Dupuy, C. Nicolas, F. Trinter, A. Trunschke, D. Delgado, P. Coral Arroyo, E. Parmentier, B. Winter, L. Iezzi, A. Roose, A. Boucly, L. Artiglia, M. Ammann, R. Signorell, H. Bluhm: "*Direct observation of the complex S(IV) equilibria at the liquid-vapor interface*", Nat. Commun. 15, 8987 (2024).

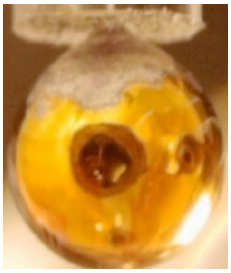

Figure 1. Gold colored metallic aqueous solution formed by the multiphase reaction between gaseous water and liquid alkali metal.