Superviscosity and electrovicous effects at an electrode/aqueous electrolyte interface: An atomic force microscope study

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Several authors observed in the past a larger than twofold increase of viscosity of organic liquids under the influence of an electric field of the order of $10^6$ V/m [1, 2]. This was called electro viscous effect (EVE). Significantly higher electric fields, of up to $10^8 – 10^9$ V/m, arise in the electric double layer in solutions close to an electrode. Therefore the viscosity can be expected to increase at strongly charged liquid-solid interfaces. In more recent years it was also observed that even in the absence of an externally controlled electric field the viscosity of water can be up to $10^7$ times higher close to a hydrophilic surface than in the bulk (“hydrophilic forces”) [4-6]. Here we present electrochemical atomic force microscopy (EC-AFM) measurements by which we can overcome the critical threshold of the electric field $H = 10^6$ V/m by the control of the potentials applied to both a conducting sample and a conducting tip immersed in solution. Using the EC-AFM we have investigated for the first time the EVE in an aqueous electrolyte [7]. We can show that by controlling the applied potential we can control the viscosity and the thickness of the super viscous liquid layer close to the solid interface. Using this technique we are further able to separate effects on viscosity induced by the hydrophilicity of the surfaces, by the strong nanoconfinement of the liquid between tip and surface, and by the applied electric field.

References