Water with excess electric charge

Telma R. D. Ducati, Leandra P. Santos, Lia B. S. Balestrin, Fernando Galembeck
Institute of Chemistry, University of Campinas, Campinas SP, Brazil

Every pure chemical substance under equilibrium has zero net electric charge, according to the electroneutrality principle. However, reports on the ability of water to store charge have been published, triggering strong debate.[i] This work shows that water with excess charge can be reproducibly obtained and stored, using two different methods.

Water dropped from a biased metal needle[ii] and kept within a Faraday cup contains net excess electric charge. Positive (negative) water is obtained from a positive (negative) needle and its charge largely exceeds the Rayleigh limit. Water drops are stretched forming water threads at V<-9.5 kV, even under field strengths well below those used in electrospray, electrowetting or electrospinning experiments described in the literature. Surface tension of electrified water decreases as the charge modulus increases. Water charging mechanism is the reduction of H+ ions when the needle is negative or the oxidation of OH- ions when the needle is positive.

Water drops falling through a biased non-contacting metal ring also acquire charge but its sign is opposite to the metal potential. This is understood considering that water in the atmosphere or adsorbed on surfaces under non-zero electric potential should always have excess concentration of H^+ (under V<0) or OH^- ions (under V>0), to satisfy the equilibrium condition expressed by the electrochemical potential equation,

$$\mu_i = \mu_i^0 + RT \ln a_i + z_i FV$$

where μ_i is the electrochemical potential of the ion i, μ_i^0 is the standard electrochemical potential of i, R is the gas constant, T is the temperature, a_i is the activity of i, z_i is the ion valence, F is Faraday's constant and V is the electric potential affecting i.

Falling water drops under a potential V acquire charge but while contacting only the atmosphere. This is only possible if there is charge exchange between water and the atmosphere, which is in turn assigned to the adsorption/desorption of water molecule cluster ions with excess H^+ or OH^- ions.

Thus, water charging experiments agree with a recent model for the electrification of insulators or isolated metals, according to which the atmosphere is a charge reservoir for insulators or isolated metals.

The present findings describe a new type of hygroelectricity phenomena and they can probably help us to understand hitherto unexplained atmospheric electricity build-up in thunderclouds and other electrostatic phenomena.

---

[i] M. S. Amin, T. F. Peterson and M. Zahn, "Advanced Faraday cage measurements of charge and open-circuit voltage using water dielectrics," *J. Electrostat.*, 64, 424-430, 2006. K. Ovchinnikova and G. H. Pollack, "Can water store charge?," *Langmuir*, 25, 542-547, 2009. H. R. Corti and A. J. Colussi, "Do concentration cells store charge in water? Comment on Can water store charge?," *Langmuir*, 25, 6587-6589, 2009.

[ii] L. P. Santos, T. R. D. Ducati, L. B. S. Balestrin and F. Galembeck, "Water with excess electric charge," *J. Phys. Chem. C* , *2011*, 115 (22), pp 11226–11232,