

Capillary rise of water in porous media: a thermo-dynamic process

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Significant and persistent decreases in temperature have been observed in very porous materials when they are partially immersed in water at room temperature. As the sample sizes were much smaller than the maximum height of the typical capillary rise, this represents a far-from-equilibrium system. We attribute this thermal decrease to two concurrent actions: (i) the highly porous property of the material used; and (ii) a transition-phase-like process of the water. Thus, the water not only cools down the material surface through evaporation at the sample–air interface, but it also expands within the material, causing a further internal decrease in temperature that cannot be explained solely through evaporation. This latter process is persistent enough to maintain the decrease in temperature over time. This unexpected characteristic of water and its persistence when diffusing inside an extremely porous medium are the most original results of this study. Our results seem in agreement with the recent model on the fourth phase of water by Pollack [1]. As a matter of fact, a large experimental survey has been performed on a very porous brick made up of cooked clay according to the *terracotta* process [2]. The experimental evidences show the water–brick system works as a thermal engine that exploits the water dissociation phenomenon (water dipole formation) occurring in hydrophilic materials, that is H_2O_n (the normal state of the water) passes to H_2O_{ez} (negatively charged in “exclusion zone”) and H_2O_p (positively charged in “protonated water”) water. This water state is not an equilibrium state and it needs a large amount of energy. The generated electric field can be fed by the environmental heat (of the medium) and, consequently, causes the cooling of the sample. For the experimental survey it seems that around 90% of the energy of the water passage from liquid state to vapor state, is spent for the passage from H_2O_n to $H_2O_{ez} + H_2O_p$ and only the remainder 10% is spent for the transition from polarized water to steam.

Finally, further experimental campaigns on both samples and in scale models are still needed to fully appreciate all the thermo-dynamic implications of this fourth state of water.

References

- [1] Pollack GH. (2013). *The Fourth Phase of Water*, Ebner & Sons Publishers, Seattle, Washington.
- [2] Signanini P., De Santis A., Di Fazio M., Greco P., Merla A., Monosi S., Piazza F, Rainone M.L., Fenzi F., Torrese P. (2014). *Unexpected thermal properties of water diffusion in very porous materials*, in press on *Journal of Water*.