Osmosis consumes and produces water? Simple experiment to test it

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The hypothesis that osmosis works by consuming and producing water can be tested by doing the experiment in an inert atmosphere. It can be produced using some inert gas like nitrogen, helium or carbon dioxide, or, even simpler, produced from ordinary air during the experiment. If the air supply to the endosmotic compartment is sealed, it should become nearly pure nitrogen gas as the oxygen gas is consumed, with a pressure of 4/5th of ordinary air.

What does it mean that osmosis consumes and produces water? Water pressure pushing against surfaces forces water into a solid phase, one that is more dense than water in contrast to ice that is less dense. This phase is denser than water because it is “compressed ice”, that has excluded the protons that link the molecular ice sheets vertically. The exclusion of protons gives the ice a molecular structure of $(H_3O_2^-)_n$, with a "cloud" of hydronium ions next to it from the ejected protons. This “ionized ice” has a net negative charge against the surface, and it is this charge asymmetry that provides the force for osmosis.

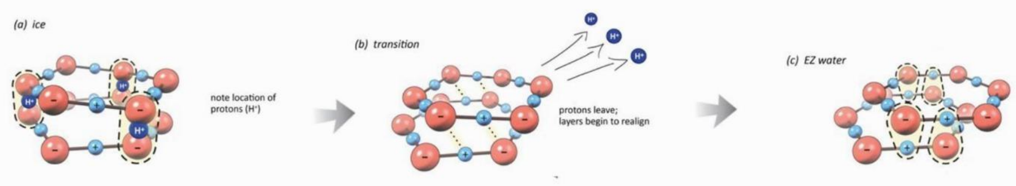

Fig. 12.5 *The effect of pressure on ice. The pressure squeezes out protons, which converts the ice to EZ water.*

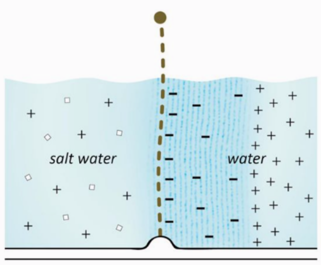

Fig. 11.5 *Standard osmosis experiment, with exclusion zones and protons distributed asymmetrically around the dividing membrane.*

Particles impair the formation of this solid phase at surfaces, in the same way they impair formation of ice in general. Asymmetry in this phase across a membrane causes a charge gradient that provides the force to transfer protons across the membrane.

The transfer of protons will destabilize the “surface phase” in the exosmotic compartment to release electrons, in the chemical reaction $4\ OH^- \rightarrow 2\ H_2O_2 + 4\ e^- \rightarrow 2\ H_2O + O_2 + 4e^-$. These electrons will transfer along the charge gradient, following the proton, and combine with external oxygen to form water, in the reaction $4\ H^+ + 4\ e^- + O_2 \rightarrow 2\ H_2O$.

The “surface phase” acts as a pump that provides the force to consume water on one side, and produce it on the other.

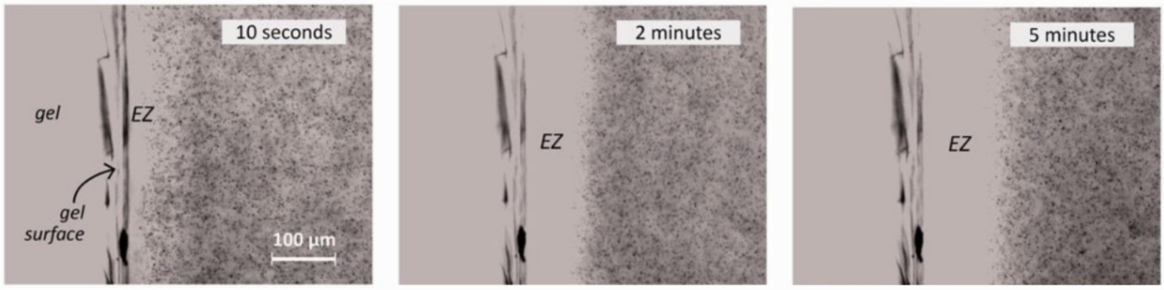

Fig. 3.4 *Microsphere-exclusion zone (EZ) next to a gel surface. The zone grows with time*

Materials and method

In the hyperosmotic compartment, leave air, and seal the container. The movement of water should stop once the O2 available in the compartment is used up. This should be enough to test the hypothesis.

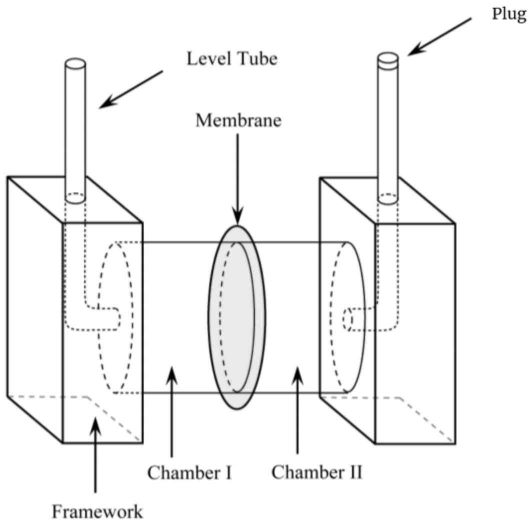

Figure 1. Experimental chamber. Drawing not to scale.

If the hypothesis is correct, and easily observed in such a simple and standard experiment, why has no one noticed that osmosis does not work without access to external atmospheric O2? People have missed things before, historically, neglected anomalies, failed to communicate them and to pay attention to them. People are very busy.

Overview of the experiment

Air contains roughly 0.01 mol oxygen gas per liter. This will turn into 0.02 mol water (0.4 ml) per liter air in the compartment. There is also 0.001 mol per liter oxygen gas dissolved in the water in the compartment, it will turn into 0.002 mol water (0.04 ml) per liter water in the compartment. The volume increase of water should be negligible, 0.4 ml per liter air and 0.04 ml per liter water, calculated from that water contains 55.5 mol per liter. The remaining air will be nearly pure nitrogen gas, assumed inert in the experiment. The air pressure will decrease with roughly 1/5th (the 21% O2 consumed.) The reduced air pressure impairs the surface phase of water at the membrane, an effect similar to increased osmolarity. This should not have a negative impact on the experiment.

If the hypothesis is correct, then the movement of water should stop early in this experiment, compared to when using non-sealed compartment that has free access to external O2 from the atmosphere.

Links

Zhao, Q., Ovchinnikova, K., Chai, B., Yoo, H., Magula, J., & Pollack, G. H. (2009). Role of Proton Gradients in the Mechanism of Osmosis. The Journal of Physical Chemistry B, 113(31), 10708–10714. https://doi.org/10.1021/jp9021568

Pollack, G., 2013. The Fourth Phase Of Water. Seattle: Ebner and Sons.