



±Water: Demonstration of Water Properties, Depending on its Electrical Potential

Yuri Pivovarenko

Research and Training Centre 'Physical and Chemical Materials Science' Under Kyiv Taras Shevchenko University and NAS of Ukraine, Kiev, Ukraine

Email address:

y.pivovarenko@gmail.com

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Abstract: The aim of this work is to demonstrate that the physicochemical properties of water depend on its electric charge (potential). It is also shown that the physico-chemical properties of aqueous solutions depend very much on the electric charge (potential) of the water on which these solutions are prepared.

Keywords: Water, Aqueous Solutions, UV Absorption Spectra, Electric Charge, Electric Potential, DNA

1. Introduction

Michaels and Hill found that the direction of reversible oxidation-reduction modifications of phenazines is determined by the electrical potential of the aqueous medium: in a medium with a positive electrical potential, the phenazines become oxidized, and in a medium with a negative electrical potential, into a reduced state [1, 2].

Consequently, when studying the interactions between phenazines and DNA, we had to use both water with different electrical potential and aqueous solutions prepared on water with different electrical potential [3]. As a result of this approach, it was found that many properties of water depend significantly on its electrical potential; It was also found that the properties of aqueous solutions depend on the electrical potential of the water used for their preparation. Here are examples of this relationship.

2. Material and Methods

First, it is necessary to define the terminology used. The term "uncharged water" is used to determine the water that was used as a control: it is assumed that the electric potential of this water is 0 mV.

Uncharged water was obtained during storage of distilled water in closed aluminum containers: It is considered that in such circumstances, the electric charges of water are concentrated on the outer surface of the container [4].

Water with a positive electrical potential was obtained in

two ways:

- (a) By passing through uncharged water of gaseous oxygen.
- (b) By filtration of uncharged water through the silica gel.

It is known that when in contact with water, oxygen gas exhibits the properties of a sorbent of aqueous electrons, and the silica gel exhibits the properties of a sorbent of aqueous hydroxyl ions [5].

Water with a negative electric potential was also obtained in two ways:

- (a) By passing through uncharged water of gaseous hydrogen.
- (b) By filtration of uncharged water through the activated carbon.

It is known that when in contact with water, hydrogen gas is the electron donor, and activated carbon exhibits the properties of a sorbent of aqueous hydrogen ions [5].

Water with the required electrical potential was obtained in two ways:

- (a) By varying the depth of the layer of sorbent through which filtered water is discharged.
- (b) Varying the time during which the gas passed through the uncharged water.

The electric potential of the charged water was measured with respect to uncharged water, the potential of which was conditionally assumed equal to 0 mV. In fact, the electric potential of charged water was measured as the flow potential or as the filtration potential [6].

Sodium salt of DNA was purchased from Fluka

(Switzerland).

Other reactive were purchased from Ukreachim (Ukraine).

To UV spectra recording Specord UV VIS (Carl Zeiss Jena, Germany) was used.

3. Results and Discussion

3.1. UV Absorbance of Electrified Water

First, it was found that the UV absorption of water depends on its electrical potential. So, it was found that UV absorption spectra of water with negative electric charge (potential) have sharp peaks with maximum in the range 190 – 200 nm (Figure 1, spectrum 2) and UV absorption spectra of water with positive electric charge (potential) have the wide peaks with maximum in the range 200 – 220 nm (Figure 1, spectrum 3) [7].

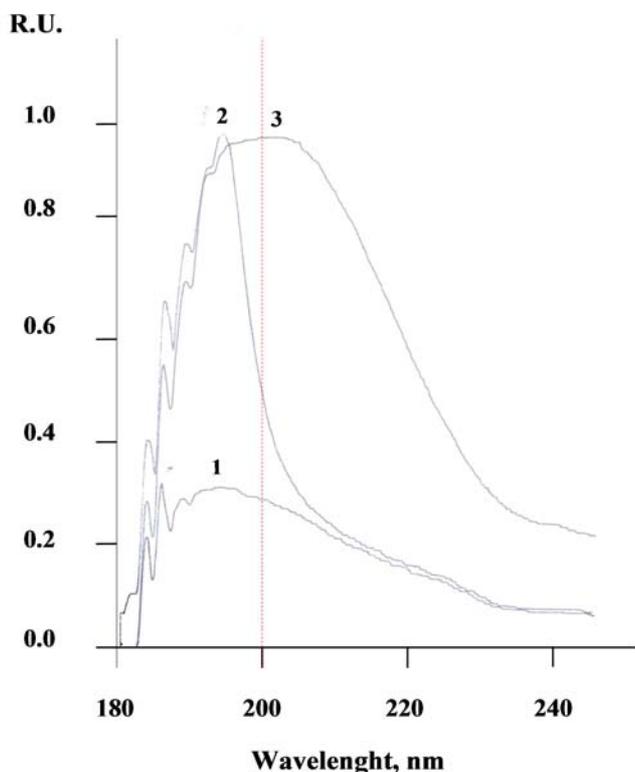


Figure 1. UV absorbance spectra of the water: 1 – fresh distilled water; 1 – negatively charged water; 2 – positively charged water. The spectra were not processed [7].

3.2. UV Absorbance of Water Solutions

It should also be noted an interesting regularity, found in the course of spectral studies of aqueous solutions of various substances. Thus, it turned out that the UV absorption spectra of aqueous solutions of surface-inactive substances have a maximum in the wavelength range of 190 – 200 nm (as in water with negative potential), and the UV absorption spectra of aqueous solutions of surfactants have a maximum in the wavelength range 200 – 220 nm (as in water with positive potential) [7].

3.3. Rotation of Electrified Water Flowing Through a Narrow Gap

Further studies have shown that the electric potential of water can determine not only its spectral properties. Thus, it was established that the electrical potential of water flowing from a narrow gap determines the direction of its rotation: the flow of negatively charged water rotates clockwise (Figure 2, left), and the flow of positively charged water is twisted counterclockwise (Figure 2, right) [8].

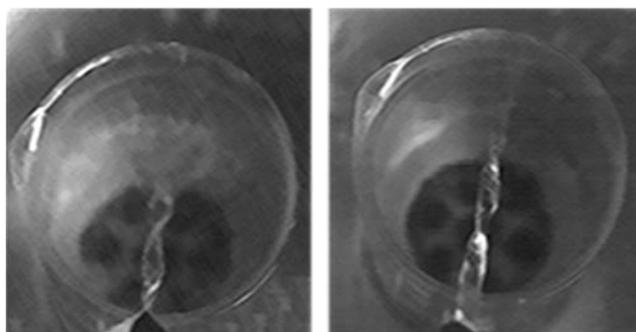


Figure 2. Left: When water with a negative charge flows through a narrow crack, it twisted clockwise. Right: When water with a positive charge flows through a narrow crack, it twisted counterclockwise [8].

It should be noted that this difference is observed in the Northern Hemisphere, where the vertical component of the geomagnetic field is directed downwards. It should be also recalled that a similar difference in the direction of rotation of charged particles moving along the magnetic field used in the mass spectrograph to determine the sign of the electric charge of the particles [4, 9].

3.4. Rotation of Aqueous Solutions Flowing Through a Narrow Gap

It should also be noted that when flowing out of a narrow gap, aqueous solutions of surface-inactive substances rotate clockwise (this is like water with a negative potential), and aqueous solutions of surfactants rotate counter-clockwise (this is like water with a positive potential). Such a difference in the rotation of aqueous solutions can be explained by the fact that during storage, surface-inactive substances sorb negative charges, and surfactants sorb positive charges.

3.5. UV Absorption of DNA Solutions Prepared on Water with Different Electrical Potential

In the course of further spectral studies it was found that the UV absorption of aqueous DNA is significantly dependent on the electric charge (potential) of the water used (Figure 3) [7].

The last result obviously allowed to assume that the electric charge (potential) of water affects not only the UV absorption of water DNA, but also its state. This assumption was decided to check in several ways. In particular, taking into account the salt nature of the DNA used, the state of dissolved salts in water with a different electric charge (potential).

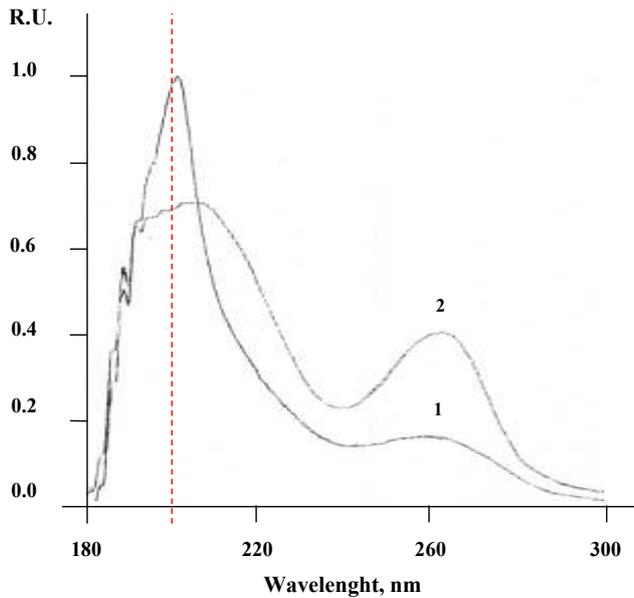


Figure 3. UV absorption spectra of the aqueous DNA: 1 – DNA solution prepared on negatively charged water; 2 – DNA solution prepared on positively charged water. The spectra were not processed [7].

3.6. Saline Solutions Prepared on Water with Different Electric Charge (Potential)

In a number of studies, it was found that the shape of the crystals that are formed when the salt solutions dry out is uniquely dependent on the electric charge (potential) of the water on which such solutions were prepared.

It has been particularly found that the evaporation of solutions with positive electric potential is accompanied by the formation of cubic crystals (Figure 4, left) and the evaporation of solutions with negative electric potential is accompanied by the formation of needle-like crystals (Figure 4, right) [10, 11].



Figure 4. KH_2PO_4 crystals. Left: the rhombic crystals formed upon drying of an aqueous solution of KH_2PO_4 prepared on the water with positive electric potential. Right: the needle-shaped crystals formed upon drying of an aqueous solution of KH_2PO_4 prepared on the water with negative electric potential [10, 11].

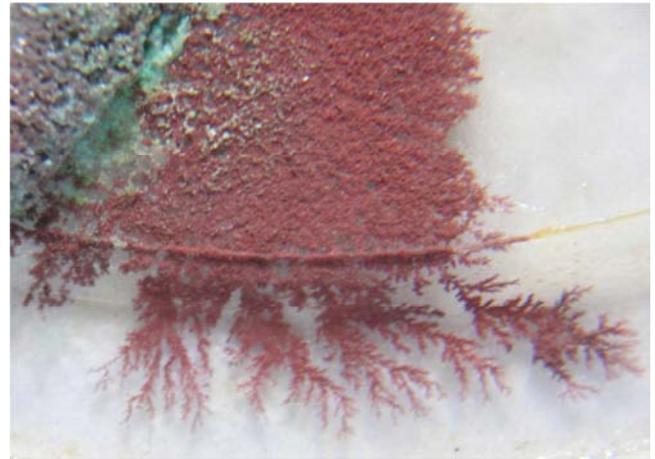


Figure 5. This is the powder of metallic copper at the boundary of aqueous solutions with positive (above) and negative (below) potentials.

It should be also noted that these dependences are observed not only for the salt crystals, but for some of the metals (Figure 5).

Based on the latest results, it can be assumed that the electric potential of water determines its internal structure, which can be manifested through the form of substances, both dissolved in water (Figure 4) and contacting it (Figure 5). It seems quite likely that different internal water structures are reflected in the type of spectra obtained, in particular – on the spectra of aqueous DNA (Figures 1, 3).

3.7. The Surface Tension of the Electrified Water

These results stimulated further studies aimed at elucidation of the properties of water and aqueous solutions, which depend on the electric potential. During these studies it was particularly found that the surface tension of the water clearly depends on its electrical potential: an increase in the positive electric potential of water is accompanied by an increase in its surface tension and increase the negative electrical potential of the water is accompanied by a decrease of its surface tension [11].

The existence of such dependencies can be demonstrated through some simple experiments. So, if to pour 5 ml of water (exactly!) with a negative potential in a standard Petri dish and mix, you can see that the water completely covers the bottom of a Petri dish (Figure 6, left). On the other hand, if to pour 5 ml of water (exactly!) with a positive potential in a standard Petri dish and mix, you can see that such water will not cover all the bottom of a Petri dish (Figure 6, right).

Such a distinction clearly demonstrates that the forces acting on the surface of the water depends on its electric potential. It can be explained by the fact that water with a positive potential has a greater surface tension than water with negative potential.



Figure 6. Left: 5 ml of water with an electric potential of -200 mV cover all the bottom of a Petri dish. Right: 5 ml of water with an electric potential of $+200$ mV do not cover the bottom of a Petri dish; the surface of such water decreases rapidly after mixing [11].

The noticed difference can be confirmed and visualized using additional experiments. For example, this difference can be easily visualized by means of a powder of starch deposited on the surface of charged water. By this simple test, it can be seen that the forces acting on the surface of positively charged water disperse powder starch on the surface of the water (Figure 7, left); such a distribution of powder of starch takes place over 1 – 2 seconds.

It can also be seen that the surface forces of negatively charged water do not distribute the starch powder across the water surface (Figure 7, right). Moreover, it can be observed that the starch powder sinks into negatively charged water. In our opinion, this experiment clearly demonstrates the difference in the surface tension of water with positive and negative potentials.

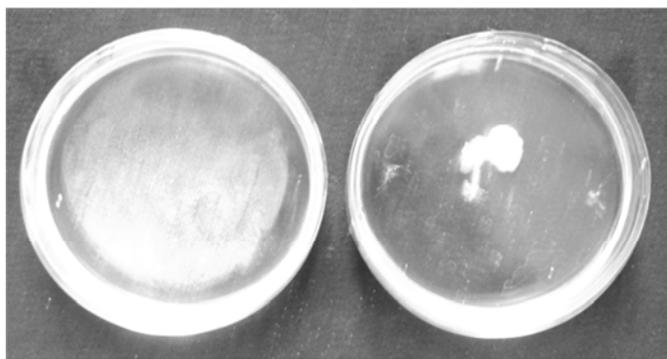


Figure 7. Left: the starch powder applied on the water surface with a potential of $+250$ mV forms a thin film that completely covers the water surface. Right: On the surface of water with a potential of -200 mV, the powdered starch remains at the application site and sinks.

Apparently, this distinction should be defined more precisely. The forces acting between molecules that reside on the surface of positively charged water are stronger than the forces acting between molecules that reside on the surface of negatively charged water. On the other hand, the interaction between the negatively charged molecules of water and the surface of the glass are stronger than the same interaction between the positively charged water and glass surface [11].

It should also be added that, due to the high surface

tension, positively charged water can keep on its surface steel needles (Figure 8), – in negatively charged water they immediately drown. (As is well known, the density of steel is much greater than the density of water [12].)

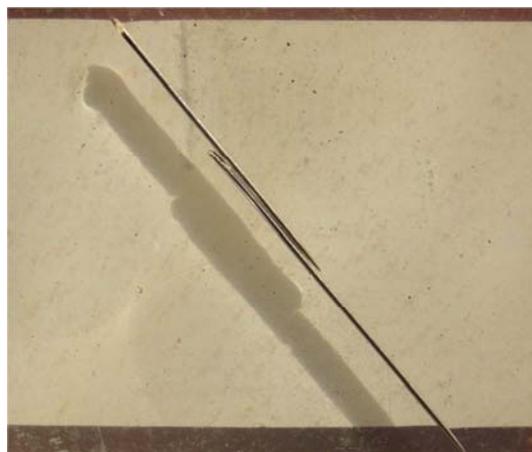


Figure 8. Steel needles can lie on the surface of positively charged water for 10 – 12 hours. At the same time, these same steel needles do not lie on the surface of negatively charged water for more than a few minutes.

Nevertheless, an acceptable explanation for this phenomenon can be given. For this one should take into account one feature of such a phenomenon: steel needles do not sink only in positively charged water, but drown in water that is negatively charged. Also one should take into account another experimental result: steel needles with a positive charge do not sink in uncharged water, but negatively charged steel needles drown in uncharged water.

3.8. The Ability of the Electrified Water to Hydrate the Biopolymers

It was also discovered that the electrical potential of the water determines its ability to hydrate some polymers of biological origin. In particular, it has been shown that water with a positive potential better hydrates biological polymers than water with a negative potential [11, 13].

Equally convincing is the result of the following experiment, in which powdered starch can also be used. One bottle was filled with water with a potential of $+500$ mV ($\sim 20^\circ\text{C}$), and the second vessel was filled with water with a potential of -500 mV ($\sim 20^\circ\text{C}$). After that, we introduced and stirred in both vessels of 100 mg of starch powder. Then we put both vessels in a place that was removed from heat sources and protected from direct sunlight. After 30 min. it was seen that the starch did not swell in a bottle containing water with negative potential (Figure 9, left), but swelled in a bottle filled with water with a positive potential (Figure 9, right).

3.9. The Penetrate Ability of the Electrified Water

When conducting the last experiment, it was observed another interesting property of water with positive potential. As you can see (Figure 9, right), this water is able to penetrate through the plastic and evaporate from a closed

polyethylene bottle. It should be noted that the increase in the permeability of polyethylene to water vapor is known: this phenomenon was observed earlier in the oxidation of polyethylene ROS induced by ionizing radiation [14].

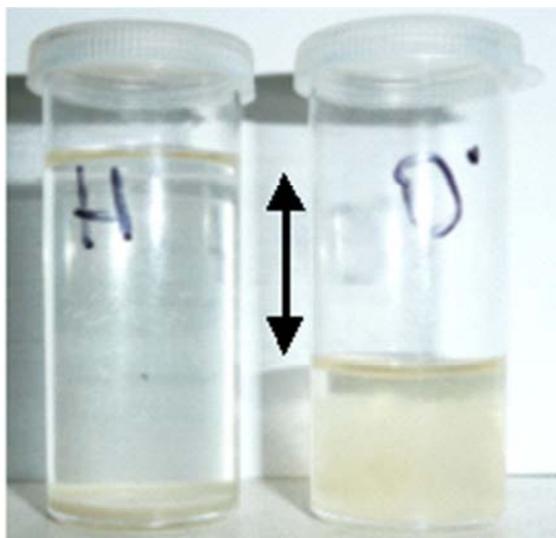


Figure 9. It is starch, mixed with water, having a different electrical potential. Starch does not swell in water with potential of -500 (left) and swells in water with a potential of $+500$ mV (right) [9, 10].

(Recently it gave a detailed analysis of the physical forces that cause this phenomenon [15]. In the earth's atmosphere the positive charges are moved up and the negative charges – down, generally [16-19]. For example, the water steam always has the positive charge [14].)

Anyway, the high penetration ability of the positively charged water is well correlated with its ability to hydrate the starch (Figure 9, right) and, as it was confirmed, other biopolymers [13].

3.10. Freezing Point of Electrified Water

It is recognized that pure water freezes at 0°C [5, 12]. But, it should be noted that this information, which is accepted as fact, is not complete. Water usually begins freezing by forming an ice crystal around a particle of dust or some other impurity, – without that starting point, water can stay liquid well below its freezing point, down to about -42°C . In other words, this freezing point can be recorded in the complete absence of charges, since all the impurities are charged. (It should be noted that initially uncharged particles can be charged in contact with uncharged water, – this occurs in accordance with the Keon rule [5].) Thus, the freezing point of pure water (-42°C) can actually be observed in a completely uncharged environment, that is, in an ideal world. Indeed, the real world is filled with electric charges. For this reason, it was necessary to study the effect of electric charges of water on its freezing.

Attractive results were obtained by scientists from Israel when freezing water droplets on surfaces that have electric charges of opposite signs. They found that on an uncharged surface the water freezes at -12.5°C , but on the positively

charged surface, water froze at a relatively balmy -7°C , and on a negatively charged surface, ice formed, on average, at a chilly -18°C . Thus, in spite of the fact that these results can cause surprise, they are experimental results.

In terms of these results, the following effect can also be analyzed: the water that is stored in the darkness freezes usually after water that is stored under the action of diffused visible light. Taking into account that lighting leads to positive electrification, it can be concluded that positively electrified water is more sensitive to freezing than uncharged water. Apparently, this needs to be explained in more detail.

As is known, the positive charges are moving in the direction of the light, which is defined by the Pointing vector, – at the same time, the negative charges move against the Pointing vector, i.e., against the direction of light [20]. Thus, using visible light, it is possible to create water with a positive charge (potential). An obvious advantage of this method is that it excludes the ingress of impurities into the water.

So, proceeding from the described results, it can be assumed that negatively charged water has a higher heat capacity than positively charged water. Also, it can be assumed that positively charged water has a greater thermal conductivity than negatively charged water.

4. Conclusion

Some practically important physicochemical properties of water depend on its electrical potential (charge). It is particularly important that this dependence is established for such indicators as UV absorption and surface tension of water.

There is no doubt that the demonstrated dependence can represent not only theoretical, but also practical interest for scientists of different specialties, in particular for biophysicists. In any case, this dependence will help explain a number of properties of water, which are now called "mysterious."

References

- [1] Elderfield R. K. (1960) Hetero-cyclic compounds, 6. Moscow: Edition of the Strain Literature. In Russian.
- [2] Michaelis L. Hill E. S. (1933) Potentiometric Studies on Semiquinones. *J. Am. Chem. Soc.*, 55 (4), 1481-1494.
- [3] Pivovarenko Y. V., Shablykin O. V., Vasiljev O. M. (2012) Nature of interaction between cation-gene phenazines and DNA. *Medical Chemistry*, 3, 20-24. In Ukrainian.
- [4] Purcell E. (1971) Electricity and magnetism. BPC, 2. Moscow: Nauka. In Russian.
- [5] Nekrasov B. V. (1974) General chemistry, 1. Moscow: Chemistry. In Russian.
- [6] Fridrichsberg D. A. (1974) Course of colloid chemistry. Leningrad: Chemistry. In Russian.
- [7] Pivovarenko Y. V. (2015) UV Absorbance of Aqueous DNA. *European Journal of Biophysics*, 3 (3), 19-22. doi: 10.11648/j.ejb.20150303.11.

- [8] Yuri Pivovarenko (2017) The Electrical Polarization of the Earth in Its Orbital Motion. *World Journal of Applied Physics*, 2 (4), 97-100. doi: 10.11648/j.wjap.20170204.11.
- [9] Shpolsky E. V. (1974) *Atomic physics 1*, Moscow: Nauka. In Russian.
- [10] Pivovarenko Yu. V. (2016) Nature of the polymorphism of salt crystals in the aspect of arborization diagnostic method. *Morphologia*, 10 (1), 72-6.
- [11] Yuri Pivovarenko (2017) Potential-Dependent Changes of the Surface Tension of Water. *Fluid Mechanics*, 3 (4), 29-32. doi: 10.11648/j.fm.20170304.11.
- [12] Kuchling, H. (1980) *Physik*. Leipzig: VEB Fachbuchverlag. In German.
- [13] Yuri Pivovarenko (2017) The Electric Potential of the Tissue Fluids of Living Organisms as a Possible Epigenetic Factor. *Chemical and Biomolecular Engineering*, 2 (3), 159-164. doi: 10.11648/j.cbe.20170203.15.
- [14] Spangenberg J. E., and Vennemann T. W. (2008) The stable hydrogen and oxygen isotope variation of water stored in polyethylene terephthalate (PET) bottles. *Rapid Commun. Mass Spectrom*, 22, 672-676.
- [15] Pivovarenko, Y. (2015) A Charge Distribution in the Earth's Atmosphere. *American Journal of Physics and Applications*, 3 (3), 67-68. doi: 10.11648/j.ajpa.20150303.11.
- [16] Feinman R., Leiton R., Sands M. (1965) *FLP*, 5, Moscow: Mir. In Russian.
- [17] Krasnogorskaja N. V. (1984) Electromagnetic fields in the earth's atmosphere and their biological significance 1, Moscow: Nauka. In Russian.
- [18] Pivovarenko, Y. (2016) Diamagnetism Flame. *Faraday Mystery. GJSFR* 16 (1), 53-55.
- [19] Fialkov, A. B. (1997) Investigation on Ions in Flames. *Prog. Energy Combust. Sci.* 23, 399-528.
- [20] Grawford F. (1974) *Waves*. BPC, 3. Moscow: Nauka. In Russian.