

On Magnetic Properties of Water

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Introduction

Water is the chemical substance with chemical formula H_2O , one molecule of water has two hydrogen atoms covalently bonded to a single oxygen atom. The molecules of water have extensive hydrogen bonds resulting in unusual properties in the condensed form. This also leads to high melting and boiling points. As compared to other liquids, water has a higher specific heat, thermal conductivity, surface tension, dipole moment, etc. These properties form the reason for its significance in the biosphere. Water is an excellent solvent and therefore it helps in the transportation of ions and molecules required for metabolism. It has a high latent heat of vaporization which helps in the regulation of body temperature. Water has diamagnetic properties (the coefficient of its magnetic permeability $\mu = 0.999991$). However we can talk about “magnetic water” – water in which the structure is ordered under the influence of a magnetic field. Salts and trace elements line up identically to water from a natural source.

The fact that the magnetic field somehow changes the properties of water was known as early as the 13th century. But only in the twentieth century physicists and biologists began to pay attention to this phenomenon. Magnetic water treatment has proven to be very effective against scale. The water was preliminarily subjected to magnetic treatment, as a result of which the scale was sharply reduced. Magnetic treatment not only helps to prevent the precipitation of inorganic salts from the water, but also significantly reduces the deposition of organic matter, such as paraffins. This treatment turns out to be useful in the production and pumping of highly paraffinic oil, and it has been noticed that the field effect increases if the oil is hydrated. [1,2].

The effect of accelerating crystallization and reducing the size of crystals falling out of magnetic water is also used in other areas, for example, in the construction industry. Greater efficiency of the use of magnetized water is observed in the production of concrete, the hardening of which is accelerated, and the strength increases by an average of 45%. [3].

To remove difficult-to-settle thin suspensions (turbidity) from water, another property of magnetic water is used - its ability to accelerate the coagulation of particles with the subsequent formation of large flocs. Magnetization is successfully applied at waterworks with significant turbidity of natural waters; similar treatment of industrial effluents allows for the rapid precipitation of finely dispersed contaminants. Also, the ability of magnetic water to improve the wetting of hard surfaces is used to extract valuable metals from ores during their flotation beneficiation [4,5].

Magnetic water slows down aging. The benefits of magnetic water are that it increases the permeability of cell membranes, cleans blood vessels and the liver from cholesterol and foreign

proteins, enhances the process of cell renewal, normalizes metabolism, increasing the overall tone of the body and the standard of living.

Theoretical and Experimental Studies

Several experimental works of magnetization of water and its specific heat measuring by DSC (Differential Scanning Calorimetry), as well as measurement of evaporation amount and boiling point by the ebulliometric method of vapour-pressure measurement, have shown that, that magnetic field have changed some physical properties of water, including specific heat, evaporation amount and boiling point [6-8]. The evaporation amount results are consistent with reports in literature that the evaporation amount of water increase after MF treatment. Studies explored the effect of MF on specific heat and boiling point of water, and the decrease of specific heat and boiling point have been observed. Despite of the experimental fact, that the optimal result in all experiments are achieved maximum value some studies which have been carried out to investigate the effect of MF on properties of pure water or high-level purified water, have shown that in general, the changes are similar to the tap water, and therefore, it can be inferred that dissolved solids and ions have a very limited influence on magnetization effect [9,10]. So hypothesis that the hydrogen bonds among water molecules are probably effected by MF can be and should be considered.

Reducing the formation of scale and other salt deposits remains the most widespread field of application for magnetic processing. If dissociating salts (real water) are present in water, several processes take place during magnetic treatment: displacement of equilibrium fields between the structural components of water by electromagnetic forces; the physicochemical mechanism of the increase in crystallization centers in the volume of the liquid after its magnetic treatment, as well as the change in the rate of coagulation (adhesion and coarsening) of dispersed particles in the liquid flow.

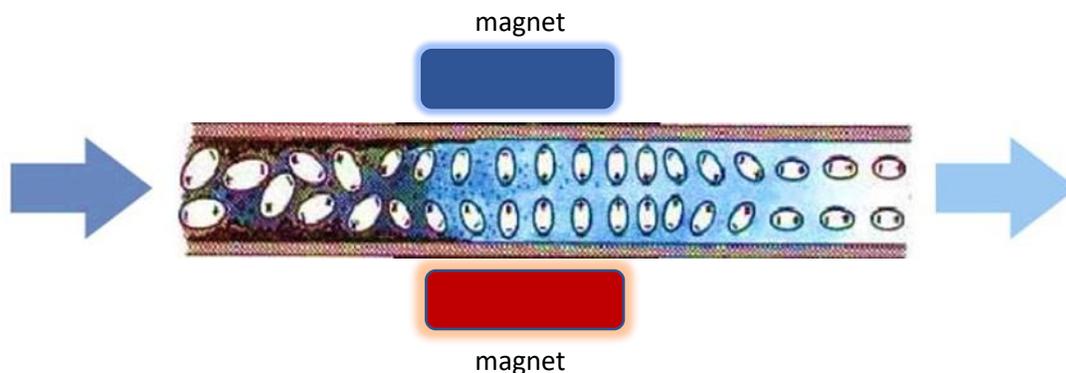


Fig. 1. Water purification from high concentration of impurities by magnetic field.

Among the main changes observed in natural water, which necessarily flows in a magnetic field it is possible to underline: acceleration of coagulation and adhesion of solid particles suspended in water; the formation of salt crystals during evaporation not on the walls, but in volume; changes in the wettability of hard surfaces; acceleration and enhancement of adsorption;

acceleration of dissolution of solids; change in the concentration of dissolved gases; an increase in the adhesion of mineral particles by 2-4 times.

Let's try to figure out what will happen if a constant magnetic field is applied to a certain cubic volume of water. In this case, all water molecules, which are small charged dipoles, will line up along the magnetic field lines, that is, along the X axis [11]. When a dipole water molecule moves perpendicularly to the magnetic field lines, along the Y axis, a moment of forces F1, F2 (force Lorentz) trying to unfold the molecule in the horizontal plane. When the molecule moves in a horizontal plane, along the Z axis, a moment of forces will arise in the vertical plane. But the poles of a magnet will always prevent the rotation of the molecule, and, therefore, slow down any movement of the molecule perpendicular to the lines of the magnetic field. In a water molecule, placed between two poles of a magnet, there is only one degree of freedom - this is oscillation along the X-axis - the lines of force of the applied magnetic field. For all other coordinates, the movement of water molecules will be slowed down. Thus, the water molecule becomes, as it were, "sandwiched" between the poles of the magnet, making only oscillatory movements relative to the X axis. For all other coordinates, the movement of water molecules will be slowed down. Thus, the water molecule becomes, as it were, "sandwiched" between the poles of the magnet, performing only oscillatory movements relative to the X axis. A certain position of the dipoles of water molecules in the magnetic field along the field lines will be maintained, making the water more structured and ordered.

Following to this we can look at the structure of water using fractal dynamics model, which represents linear dynamic approach, space and time dimensions. It is expected that linear phenomenon observes the conservation law. However, the nonlinear phenomena does not consider space and time identification via the linear orientation [12,] but remark conservation law (as an example, no temperature increase of water in the glass on the table in the room fixed conditions). Reviewing the fundamentals with a glass of water on the table at room condition example will be easier to understand. According to the law, energy types in a system convert to each other, but the whole is constant (equation 1). Generally, particles movement categorized into three majors:

- 1- Ev: Vibrational
- 2- Er: Rotational
- 3- Et: Transmission

$$E_i = \sum (E_v + E_r + E_t) \quad (1)$$

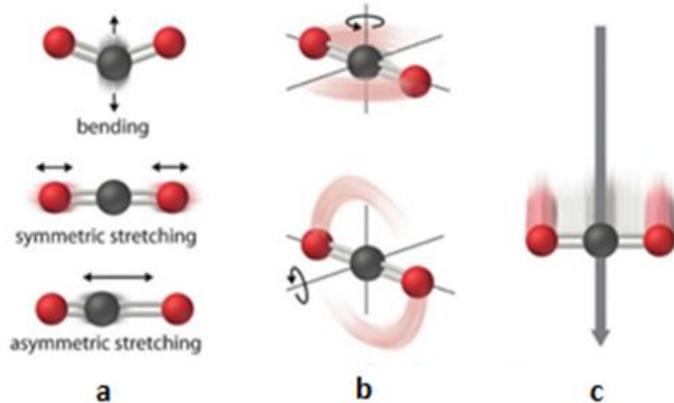


Fig.2. Nanoparticles momentum possibilities. vibrational motion in a, rotational motion in b, translational motion in c. (Example of Water).

Energy conservation and then no spontaneous temperature rising in the glass of water under constant conditions represent there must be a harmonic motion between particles, because the water temperature is known as molecules motion indicator. In other words, particles in a glass of water sense each other movement and maintain balance in the whole system in the way of conservation law.

Therefore, system balance as the result of conservation law is possible only by the harmony of the particles as a unique system. Self-Control Closed Loop concept not only represents frequent repeat procedures but also shows that any time batch will be a new approach to the system. In short, in this doctrine particle position prediction in space-time is meaningless. But refer to energy conservation law observation, harmony and balance should be the investigation key. According to particle identification by space-time, particle dynamic is the key in a linear system, and then balance correlates to symmetry. On the other hand, its symmetry depends on the physical symmetry reference as a center or an axis but in a nonlinear system it is meaningless; because if dynamic coordination was predictable, it would be linear. [13].

Dynamic Fractal doctrine is based on quantitated time. Hence, balance in a nonlinear system correlates to time batch. In accordance, nature is always in unbalancing and balancing batch time to batch time. Every batch time treats previous unbalancing, but it would be in balance by the next batch time regards to the Self-Control Closed Loop. However, Self-Control Closed Loop and quantitated time approach define the quality of the Dynamic Fractal doctrine, but the quantity study is inevitable. Quantity investigation could be explained by Dynamic-Topologic space on Clusters and Knots as the Dynamic Fractal foundation. Balance is possible via a systematic approach as Self-Control Closed Loop by quantitated time mentality in a nonlinear phenomenon instead of symmetry in the linear systems. Then, particles space-time identification is not necessary. Refer to concepts, Set theory and Topology are the mathematical foundation of Dynamic Fractal doctrine. Also, it turns out particles in a matter are not fragments but members of fractals. Knots and Clusters shape lattice and then clarified particles nonstop and nonchaotic motion reason.

Hydrogen atoms have a slight positive charge, attracting them to slightly negatively charged oxygen atoms in water.

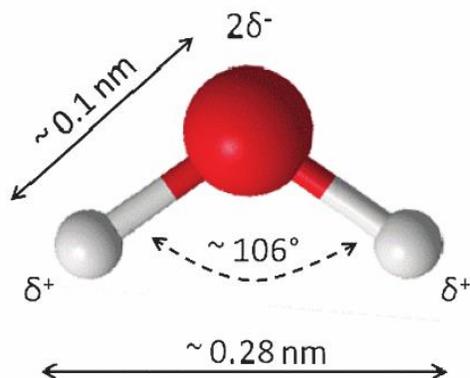


Fig. 3. The geometry of a single water molecule. (The molecule tends to form a tetrahedral structure once hydrogen bonded in ice crystals).

This so-called nuclear quantum effect has been hypothesized to be at the heart of many of water's strange properties and the question is: if this quantum effect could be the missing link in theoretical models describing the anomalous properties of water.

It is well known that a water molecule is made up of one oxygen atom (O) and two hydrogen atoms (H). It is the interactions between different HOH molecules – intramolecular forces called hydrogen bonds – that give water its bizarre properties. Positively charged hydrogen atoms in one molecule are attracted to more negatively charged oxygen atoms in another. This web of hydrogen bonds holds groups of water molecules together.

Observing these hydrogen bonds is key to understanding how water molecules interact with their neighbours – but it's a hard process to see, because the hydrogen bonds are small and ephemeral.

For understanding the hydrogen bond network it is very suitable to use the spectrometry technics, which is helpful to achieve sustainable production of hydrogen (H_2) through water splitting and establishing efficient and earth-abundant electrocatalysts. A combination of control experiments and density functional theory (DFT) investigations indicates that the exceptional H_2 evolution performance is attributed to the abundant sharp edge sites of the advanced frameworks, which are responsible for promoting the adsorption and reduction of protons [14].

To begin with, the team set up a microscopically thin jet of liquid water (1,000 times thinner than the width of a human hair) and used infrared laser light to make the water molecules vibrate. They then scattered electrons off the molecules to generate high-resolution snapshots of the molecular movements. This allowed them to build up a stop-motion movie of how the molecules responded to the light. Another interesting structural properties of water, which can somehow explained its dependence from magnetic field recently was investigated by the colleagues from Oak Ridge National Laboratory of US [15]. During chemistry experiments carried out on the beryl crystal, it was discovered that water molecules under extreme physical or special geological conditions arrange themselves into ultra-small hexagonal shape around a ring and

enter a "quantum tunneling" state. This phenomenon goes beyond the known liquid, solid or gaseous states and, in this case, water behaves quite differently than what we are accustomed to since it is capable of quantum motion. In this state, for example, water particles pass through solid walls, which, according to the rules of classical physics, is absolutely impossible. During the experiment it was found that when the water is "trapped" in an enclosed area (e.g. Inside crystals), the oxygen and hydrogen atoms of water molecules "delocalize" (they separate from each other) and this is when the quantum tunneling mechanism is created.

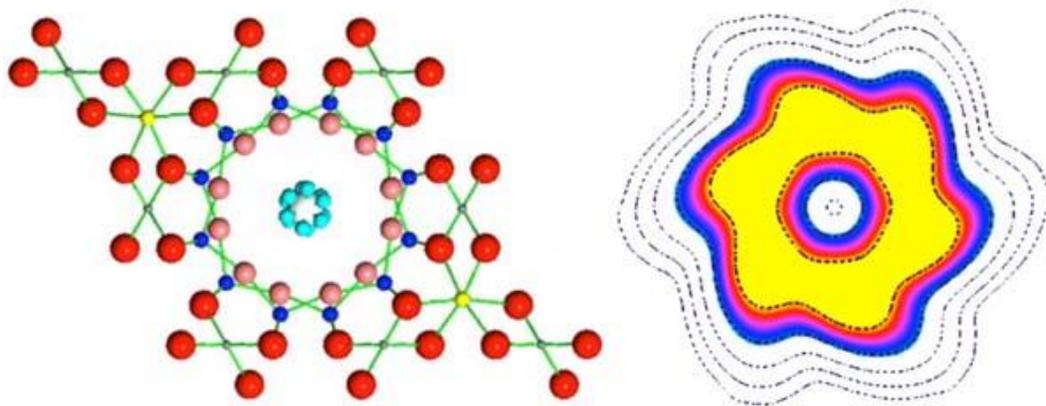


Fig.4. Scheme of water atoms localization in the six symmetrical positions: the oxygen and hydrogen atoms of the water molecule are 'delocalized' and therefore simultaneously present in all six symmetrically equivalent positions in the channel at the same time [15].

The discovery of water's 'quantum tunneling' state could even be scientific evidence to – Everett's multi-world theory, in which he argues that opportunities allowed by quantum mechanics appear all together in a multiverse, which consists of many independent, universes existing in parallel. It was also discovered water's hologram-like properties, which is very important for water molecules participation in the process of storing and transferring the information. So it means that water is capable of relaying the information of the history of universe through the inorganic and organic substances, including living organisms. An international team of researchers has used a high-speed electron camera to observe the atomic motion of liquid water for the first time [16].

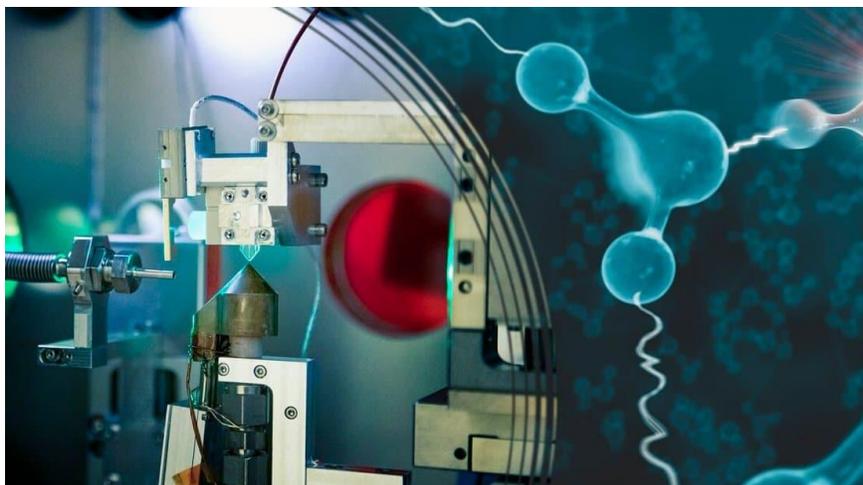


Fig.5. Installation for observation of quantum nature of atoms interacting in molecule of water [17,18].

These observations – which reveal the quantum nature of how hydrogen atoms interact – is very important for understanding the weird and wacky properties of water, like its unusually high surface tension, its large capacity to store heat, and the way it is densest just above freezing point (instead of getting denser as it gets colder, like other liquids).

As a water molecule began to vibrate, its hydrogen atom pulled oxygen atoms from a neighbouring molecule closer – then shoved them away again to expand the space between molecules. This is quantum wave-like behaviour – likely heightened by the low mass of the hydrogen atoms: the response of the hydrogen bond network to an impulse of energy depends critically on the quantum mechanical nature of how the hydrogen atoms are spaced out.

Instead of Conclusions

Water molecules have a quantum nature which is key for understanding many chemical and biological processes connected with water.

Water molecule with its hydrogen bonds properties is behaving as nonlinear system and following that it could be described by the Dynamic Fractal model.

Magnetic properties of water molecules are showing their possibilities to have the magnetic memory and abilities to store and transfer the information.

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