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MRET Treatment Effect on Diffusion Coefficient of Water

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ABSTRACT

The confined water case displaying both decreased viscosity and decreased diffusion coefficient (relative to bulk water) typically occurs under strong hydrophilic confinement (e.g., in narrow pores of silica, clays, oxidized carbon nanotubes). Confined water in biology refers to water molecules trapped within nano-scale spaces—such as protein cavities, lipid bilayers, or hydrated DNA—where they display significantly different physical properties than bulk water. The experiments conducted to verify the effect of MRET (Molecular Resonance Effect Technology, US Patent # 6022479) treated bulk water on (D) diffusion coefficient behavior yield for the conclusion that MRET water can be considered as a special case of nanoconfined water. MRET treated water has strong tendency of displaying both anomalous decreased viscosity and decreased diffusion coefficient (relative to bulk water).

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Introduction

The correlation between ionic activity and the diffusion coefficient (D) in water is primarily governed by the thermodynamic non-ideality of the solution, where the activity coefficient (γ) accounts for departures from ideal behavior (concentration ≈ activity). Generally, as ionic strength increases, the activity coefficient decreases (per Debye-Hückel theory), which impacts the thermodynamic driving force for diffusion and can lead to a decrease in the diffusion coefficient due to increased of ion-pairing.

The true driving force for diffusion is the gradient in chemical potential (μ), not just concentration. The diffusion coefficient is proportional to the **thermodynamic factor** ($1 + d\ \ln\gamma/d\ln c$), which corrects for changes in activity coefficients along the diffusion path. The hydration shell surrounding an ion moves with it. The diffusion coefficient of water (D_w) is influenced by the concentration of ions, with strong electrolytes reducing (D_w) by tying up water molecules in the solvation shell.

When ions transport in confined nanochannels, however, their hydration behavior deviates markedly from the above bulk-like picture. Several assumptions underlying continuum models begin to break down. As an example, ion mobility under a continuum framework is well described by the Stokes–Einstein relation [1].

Stokes-Einstein Equation defines diffusion in fluids, showing D depends on T and η^{-1};

$$D = k_B\ T\ /\ 6\pi\eta r\ ,\ (1)$$

where D is a diffusion coefficient, k_B – Boltzman constant, T -temperature, η – solvent viscosity and r -radius of ion;
The equation (1) yields for the conclusion that diffusion coefficient of bulk water at room temperature decreases when viscosity of water is increased considering that in this case Boltzman parameter, temperature and radius of ion are constant.

While some confined systems show *enhanced* transport (low viscosity/high diffusion) due to slip on hydrophobic surfaces, strong interactions with hydrophilic surfaces generally suppress water dynamics, making them slower than bulk water. The confined water case displaying both **decreased viscosity** and **decreased diffusion coefficient** (relative to bulk water) typically occurs under **strong hydrophilic confinement** (e.g., in narrow pores of silica, clays, oxidized carbon nanotubes). Confined water in biology refers to water molecules trapped within nano-scale spaces—such as protein cavities, lipid bilayers, or hydrated DNA—where they display significantly different physical properties than bulk water. This "biological water" acts differently due to its restriction, showing increased hydrogen bonding, lower mobility (glassy behavior), and lowered freezing temperatures. Confined water generally shows two types of regimes: a more ordered interfacial layer and a core that may behave slightly more like, but still distinct from, bulk water.

The experiments conducted to verify the effect of MRET (Molecular Resonance Effect Technology, US Patent # 6022479) treated bulk water on (D) diffusion coefficient behavior yield for the conclusion that MRET water can be considered as a special case of nanoconfined water. MRET treated water has strong tendency of displaying both anomalous **decreased viscosity** and **decreased diffusion coefficient** (relative to bulk water).

Key Mechanisms for Simultaneous Reduction in Mobility

- **Hydrogen Bond Interaction:** Hydrophilic surfaces (containing hydroxyl groups or polar sites) form strong hydrogen bonds with water molecules, restricting their movement.
- **Structural Changes:** Confinement forces water into ordered structures (monolayers or bilayers), reducing molecular freedom.
- **Low Temperature/High Pressure:** Combined with low temperature (supercooled) or high pressure, confined water experiences a slowing of dynamics.

Specific Cases and Findings

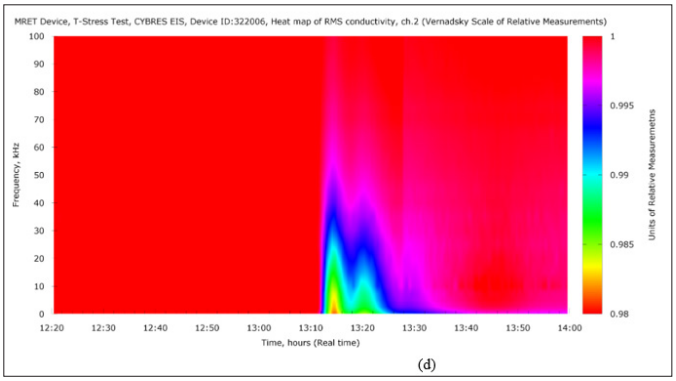
- **Hydrophilic Nanopores (e.g., Vycor surface):** Studies show a significant "slowing down" of dynamics, with diffusion coefficients at protein or silica surfaces found to be up to 10 times lower than that of bulk water.
- **Water in Clay Nanopores (e.g., C-S-H):** Water in cement-based materials shows lower diffusion coefficients compared to bulk, especially in narrow pores, due to increased structure and surface interactions.
- **Supercooled Confined Water:** In small confinements (e.g., 1.4 nm Carbon Nanotubes), water dynamics show an Arrhenius behavior, indicating slower, more restricted movement compared to the non-Arrhenius behavior of bulk water.

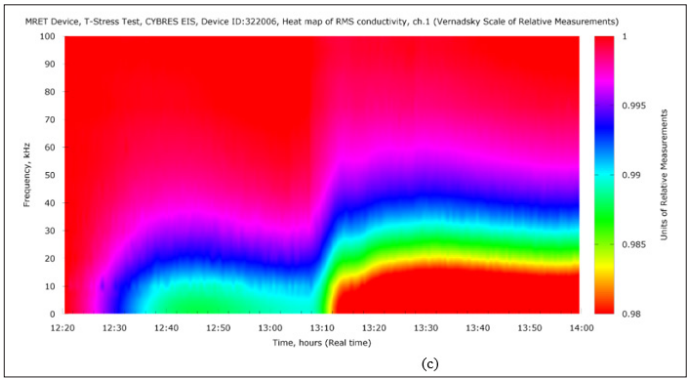
Discussion

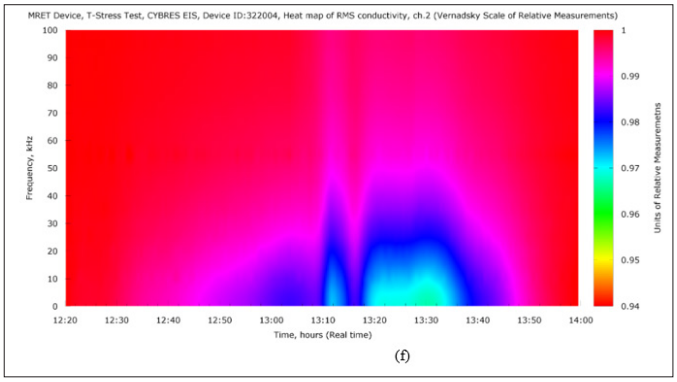
Experiment was conducted at Research Center of Advanced Robotics and Environmental Science "Cybertronica Research", Germany. Research of last 30 years identified electrochemical measurements of water and aqueous solutions (pH, DC/AC conductivity, impedance spectroscopy) as a useful tool for detecting and characterizing various effects of 'weak emissions' and non-chemical treatment of water. The measuring equipment should satisfy specific requirements such as differential measurements, thermo-stabilization of samples and electronic components, high resolution of the system (up to 10^{-5}-10^{-6} pH and 10^{-8}-10^{-11} µS/cm resolution) [2].

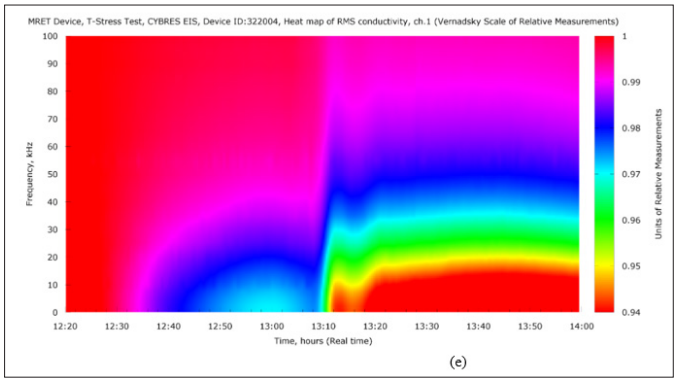
Results

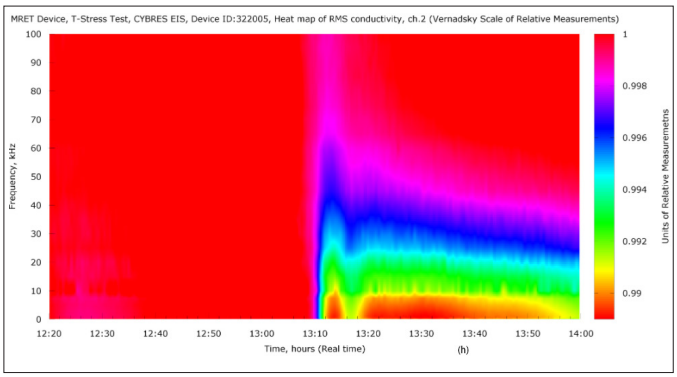
EIS measurements (t-stress test) of MRET activated water were conducted on 23.10.17 with three independent EIS systems (ID: 322004, 322005, 322006). Different EIS patterns around the thermal transition point of MRET activated and non-activated water are well visible (with equal EIS ranges for control and experimental channels).

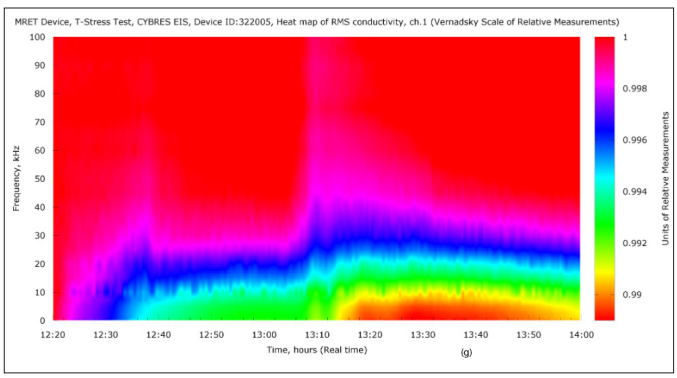












1. EIS data from control containers (3 diagrams, d, f, h):

2. EIS data from experimental containers (3 diagrams, c, e, g):

All three samples of MRET activated water demonstrate larger dynamic range of the ionic activity before and after the transition point compared to the control samples (Fig.1). It is well known that ion mobility (μ_i), directly relates to the diffusion coefficient via the Einstein relation: $D = \mu_i k_B T$, [2].
where kB – Boltzman constant and T-temperature), and it is influenced by the same ionic interactions that dictate the activity coefficient. The chemical potential (μ_i) of an ion in water is directly proportional to the natural logarithm of its activity (a_i), defined by:
$\mu_i = \mu_i^0 + RT \ln(a_i)$, (3)
where μ_i^0 is the standard chemical potential, R is the gas constant, and is T temperature. Activity represents the "effective concentration" and is linked to molarity (m_i) via the activity coefficient (γ) as $a_i = m_i \gamma$, (4).
Generally, as ionic strength increases (μ_i), the activity coefficient (γ) decreases (per Debye-Hückel theory), which impacts the thermodynamic driving force for diffusion and can lead to a **decrease** in the diffusion coefficient (D) due to increased of ion-pairing.

These experimental findings quite well correlate with the data received from the study conducted at Moscow State University, Russia. The experiments had a purpose to measure diffusion coefficients of different types of water before and after MRET treatment. The experiments were carried out on the basis of four different samples of the initial water:

- Natural Mineral Water "AVIAN" (produced in France);
- Fresh Water Life "JINBO/Seok Su" (produced in the Republic of Korea);
- Natural Mineral Water "HAITAI/Gangwondo/Pyeong Chang" (produced in the Republic of Korea);
- Natural Mineral Water "JEJU/Sa Da Soo" (produced in Iceland).

As a quantitative characteristic, we used the integral index of the molecular dynamics of water (W) which is inversely proportional to the coefficient of diffusion (D) of the scattering objects. It includes the normalizing factor (in order to make W dimensionless), and is directly related to the parameters of the auto correlation function. An increase of the index (W) corresponds to a decrease of the coefficient of diffusion and characterizes uniquely the increase of the mass and size of a stiffly bound molecular complex which is present in the water bulk and scatters the laser emission. We applied the following procedure and the sequence of studies, whose total duration was equal to 71 h.

Firstly, we carried out three measurements of the index (W) for 3 h for each of the studied types of water. The purpose of these measurements was related to the determination of the stability of a measuring unit. The results of this "testing period" correspond to the first three points on all the plots presented in Fig. 2. It is obvious that the differences of the indexes of molecular dynamics (W) for different types of water prior to the activation are related to a great extent to the differences of their salt composition.

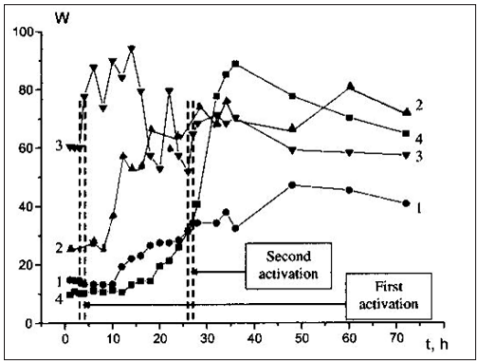


Figure 2: Integral index W of the molecular dynamics of activated water of different types versus time. The numbers stand for the types of water given in the text above.

We then performed the activation of water of each type for one hour. Immediately after the completion of the activation, we carried out the next study. From Fig. 2, it is seen that the index (W) was changed comparatively slightly (except for water 3) for the time of this first activation. Thereafter for 24 h (with an interval of two hours), we measured the index (W) for all types of water. It is seen that, for this time interval, there occurred a systematic increase of the index (W) for all types of water except for water 3. In this case, a change in (W) was accompanied by very strong oscillations for the water samples 2 and 3. At the same time, the index (W) for all the remaining types of water was changed as a monotonously increasing function of time. In 24 h after the first activation, we performed the second activation of water with the same duration of one hour. The results of this activation also turned out ambiguous.

Results

After the activation, we observed a very sharp increase of the index (W) for water sample 4. At the same time, this index was practically constant for the remaining samples of water. The measurements after the second activation were performed for 42 h (firstly, we carried out three measurements with an interval of two hour and then the other three measurements with an interval of 12 h). After the completion of the whole cycle of measurements, the values of the index (W) for all samples of water (except for water specimen 3) turned out on a level somewhat exceeding the initial value (W_0) (prior to the first activation). The characteristics of water specimen 3 after the completion of all actions and all measurements turned out to be equal to the initial values of the index (W_0) which were determined prior to the beginning of the cycle of measurements and were anomalously great. Based on the results of the analysis of the performed cycle of measurements, we can made some conclusions.

First of all, it should be noted that, upon the activation of water, there occur both a very significant increase of the degree of correlation of the scattered emission and a decrease of the coefficient of diffusion of scattering complexes in water, which testifies unambiguously to the formation of very large and stable clusters in water after the activation.

The second important conclusion consists in that the processes of formation and change of these clusters do not cease after the termination of the activation but continue for many hours and days. Such an effect can occur in the case where the activation of water induces such a change of the properties of separate water molecules and strongly-bound molecular groups, at which their further joining in great clusters becomes energy-gained.

The third conclusion is related to the unambiguous confirmation of the assumption about the presence of the stable water memory, the duration of existence of which can be equal to many hours and days, by the correlation analysis of the scattered laser emission. This memory can be interpreted as the existence of stable super molecular clusters in the volume of water. One more conclusion consists in that the process of formation of stable clusters in the volume of water depends significantly on the salt composition of water. In this case, different types of mineral water are characterized by different dependencies of the parameter (W) on the time interval after the activation [3].

At higher concentrations (lower activity coefficients), the diffusion coefficient usually decreases due to increased ion-ion interaction, which limits the mobility of ions compared to their state at infinite dilution.

Therefore, the diffusion coefficient of ions is primarily determined by their effective hydration size. In contrast, when ions are held in molecular-scale confinement, the restricted geometry alters both the static structure and dynamic stability of the hydration shell; water molecules may experience longer residence times near the ion or, conversely, undergo partial dehydration as the confinement approaches the dimension of hydration shells. Moreover, the reorganization of water within nanochannels—often forming layered or quasi-two-dimensional arrangements—contrasts sharply with the isotropic hydrogen bond network of bulk water. These structural transformations lead to distinct mechanisms of nanoconfined ion transport, where the interplay between hydration distortion and confined water ordering governs ionic mobility and selectivity [1].

Key Characteristics and Biological Roles of Nanoconfined Water

- **Interfacial Water Behavior:** Water molecules directly contacting biological surfaces (interfacial water) act like supercooled bulk water, forming more hydrogen bonds and behaving like a solid even at room temperature.
- **Protein Dynamics:** Confined water molecules within protein structures contribute to their structural flexibility, stability, and functional folding.
- **Ion Transport (Aquaporins):** In membranes, water passes through narrow channels (aquaporins) in a constrained state. This confinement enables specific transport mechanisms and can alter how water screens electric fields, influencing channel conductivity.
- **Biological Function (Cold Activity):** Because it does not crystallize easily even below, confined water allows biological molecules to maintain flexibility and function in subzero environments.
- **Binding Force:** Recently, it has been discovered that this high-energy confined water can actively influence surrounding molecules, promoting stronger binding and influencing molecular interactions.

Conclusion

MRET treated water has strong tendency of displaying both anomalous decreased viscosity and decreased diffusion coefficient (relative to bulk water). It allows to consider MRET water as a special case of nanoconfined water. The anomalous physical properties like extremely low viscosity, reduced dielectric permittivity, electrical conductivity and diffusion coefficient of bulk water after MRET treatment leads to conclusion of the direct correlation between MRET treated and nanoconfined water. Whereas the anomalous physical characteristics of nanoconfined water can be achieved by introducing bulk water to the nanoscale confinements, the production of MRET water does not require nanoscale environment. In this case the regular bulk water can be transformed into nanoconfined type of water under normal room temperature, atmospheric pressure, and avoiding any requirements of the volume confinements.

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