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AUTOTHIXOTROPY OF WATER AND ITS POSSIBLE IMPORTANCE FOR THE PHYSICS-CHEMICAL THEORY IN ENVIRONMENT

AUTOTIKSOTROPIA WODY I JEJ ZNACZENIE DLA CHEMOFIZYKALNEJ TEORII ŚRODOWISKA

Abstract: It is well known that water is the source of all life and therefore it is an important factor for the chemical-physics theory in environment. The article deals with phenomenon in water that was called „autothixotropy of water". A history of the discovery of the phenomenon is connected with very fine gravimetric experiments which have been made by the author between the years 1978 and 1986. The independent phenomenon of autothixotropy of water was qualitatively explored in the period from 1991 to 1992 and quantitatively in period from 2003 to 2011. From the physical point of view the autothixotropy of water is a very weak macroscopic phenomenon that is observed in water that has remained at rest for a certain time (in about tens of hours or days) *ie* 'standing' water. For the experiments distilled water was used, re-boiled before use. Physically the phenomenon manifests itself by force (mechanical resistance) acting on a body immersed in 'standing' water in the direction of the tendency to change its position. The fundamental method of research of phenomenon is static method; it uses a moment of force that is necessary for a very distinctive turn of a stainless steel plate hung up on a very thin filament and immersed in examined water. With a certain angular torsion of the filament a certain moment of force is achieved when a state of stress reaches a critical value in 'standing' water. It is demonstrated with an expressive changing of angular position of the plate. When the direction of moment of force in 'standing' water is changed, it is reflected in a different angle rotation of the plate (the phenomenon of hysteresis was observed). The phenomenon of autothixotropy disappears for a certain time (in tens of minutes or hours), if 'standing' water is mechanically vigorous shaking or re-boiled. It is significant that the phenomenon of the autothixotropy is not present in deionised distilled 'standing' water. From the chemical-physics microscopic point of view the autothixotropy of water can be explained by a hypothesis of a cluster formation by H_2O molecules in 'standing' water. As the phenomenon of autothixotropy is not present in 'standing' deionised water, it may be primarily caused by a presence of ions in water, as it was demonstrated in the experiment with a salt solution (NaCl). Environment and biophysical applications of the autothixotropy of water remain still open. Some possible applications of the phenomenon are outlined.

Keywords: standing water, autothixotropy of water, deionised water, salt solution, super clusters

Autothixotropy of water is a very weak macroscopic phenomenon in water that has remained at rest for a certain time (in about tens of hours or days) ie 'standing' water. For experiments distilled water was used, re-boiled before use. The phenomenon is manifested by very small force (mechanical resistance) acting against a body immersed in water and arising when it should change its position. If standing water is vigorously mixed or re-boiled again, the phenomenon disappears and appears again in a matter of about tens of minutes or hours (or days). Macroscopically therefore standing water acts as a very weak gel, which has approximately thixotropical properties. Because it arises spontaneously a phenomenon was called '*the autothixotropy of water*'.

The history of discovery of this phenomenon in water is connected with very fine gravimetric measurements which I made in the years 1978 till 1986 [1]. The experiments

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were not successful: during the experiments unknown molecular properties of water were shown disturbingly and superimposed the expected gravitation of the phenomena very strongly. After a period longer than about ten hours it was not possible to control the torsion pendulum with a rotation of the filament hanging - molecular forces of unknown origin took effect against small gravitational forces. In 1986 I decided to use the dynamic method which an influence of phenomenon of autothixotropy was excluded. The results of qualitative analysis of autothixotropy of water were published [2].

Method and experimental

The fundamental method of research of phenomenon is a static method. The apparatus for measurements with the method is shown in Figure 1. The method uses a moment of force that is necessary for a very distinctive turn of a stainless steel plate hung up on a very thin filament and immersed in examined water. With a certain angular torsion (angle φ_u) of the filament a certain moment of force is achieved when a state of stress reaches a critical value in 'standing' water. It is demonstrated with an expressive changing of angular position of the plate (angle φ_d).

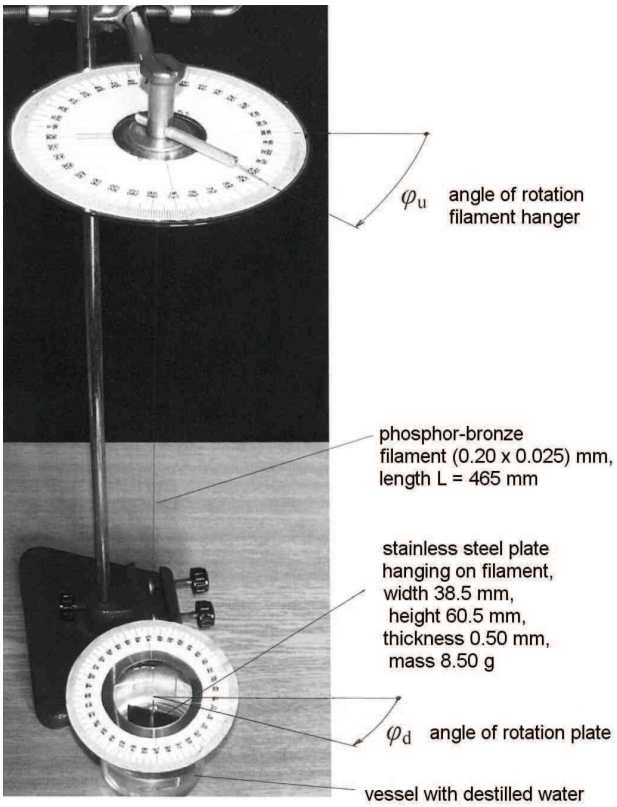

Fig. 1. Photo of apparatus for measurements of autothixotropy of water

Ideal fluid model of water: Then, if we turn the upper end of the filament by angle φ_u, we expect that the plate will follow the rotation of upper, so that approximately is[2] $\varphi_d = \varphi_u$, where φ_d being angle of rotation of the plate (this equality is true for i.e. 'fresh' water).

Basic observations: According to our experiments with 'standing' water, equality $\varphi_d = \varphi_u$ was not achieved. In the experiment, a series of increasing values of angle φ_d is observed, following a very slow - 'step by step' - change of angle φ_u. We measured function $\varphi_d = f(\varphi_u)$. If angle φ_u reaches a critical value $(\varphi_u)_{crit.}$, the rotation of the plate (ie $\dot{\varphi}_d$) becomes relatively quick.

Phenomenon of hysteresis: When the direction of moment of force is changed, it is reflected in the different rotation of the hanged plate - the phenomenon of hysteresis is observed [3]. Measurements for a cyclic change of angle φ_u were carried out.

Experiments were made for this case:

1. distilled water (re-boiled before use),
2. deionised distilled water (re-boiled before use),
3. salt solution (concentration of 1 per mille NaCl in deionised distilled water, re-boiled before use).

Results and discussion

1. *Distilled water.* Typically experimental functions $\varphi_d = f(\varphi_u)$ are on Figure 2; loop **a** is relevant for the experiment with the plate totally immersed in water, while loop **b** is related to the experiment with the plate only half-immersed. The effect is clearly more pronounced for the half-immersed plate than for the completely immersed one. When the direction of moment of force is changed, it is reflected in the different rotation of the hanged plate - *the phenomenon of hysteresis* was observed [3].
2. *Deionised distilled water.* Neither the existence of critical angles $(\varphi_u)_{crit.}$, nor the phenomenon of hysteresis, were found. From the performed experiment [3] we arrived at the important conclusion that the autothixotropy of water, characterized by a non-zero critical angle, and hysteresis, *is caused by the presence of ions in the water.*
3. *Salt solution.* For a period of 7 days no autothixotropy appeared, more to the contrary for angles inequality $\varphi_d > \varphi_u$ was valid (see the curve **a** in the Figure 3). Thus the angle φ_d of turning of plate is bigger than the angle φ_u of a primal turning of the upper hanging of filament. It is a remarkable finding because the plate shows a certain additional automotoric movement. The phenomenon of autothixotropy appeared after 7 days from a preparation of the solution. Afterwards, on the contrary, the measurement results $\varphi_d < \varphi_u$. After the critical angle $\varphi_u = (\varphi_u)_{crit.1} = 70°$ is achieved, the angle φ_d of plate turning starts increasing, even if φ_u, is invariable how it is evident from the Figure 3, loop **b**.

The autothixotropy of water can be explained by a hypothesis [5] of a (super) cluster formation by H_2O molecules in 'standing' water. As the phenomenon of autothixotropy is not present in *deionised* water, it may be primarily caused by a presence of ions in water [2, 3]. In case of the experiment with salt solution NaCl in deionised distilled water dissociation happens (the molecule NaCl breaks up to ions Na^+, Cl^-). Around ions Na^+, Cl^- the clusters of molecule H_2O are formed.

[2] See too Figure 3 (the curve **a**).

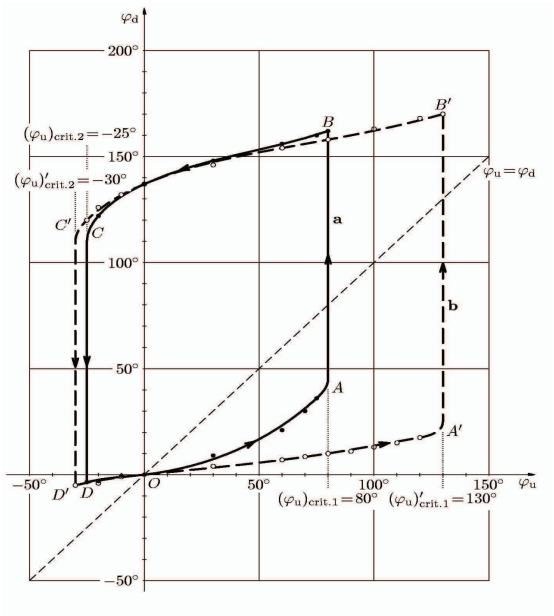

Fig. 2. Autothixotropy in distilled water: loops of hysteresis - the changes of angle $\varphi_d = f(\varphi_u)$): with the completely immersed plate (loop **a**) and with the half-immersed plate (loop **b**) [3]

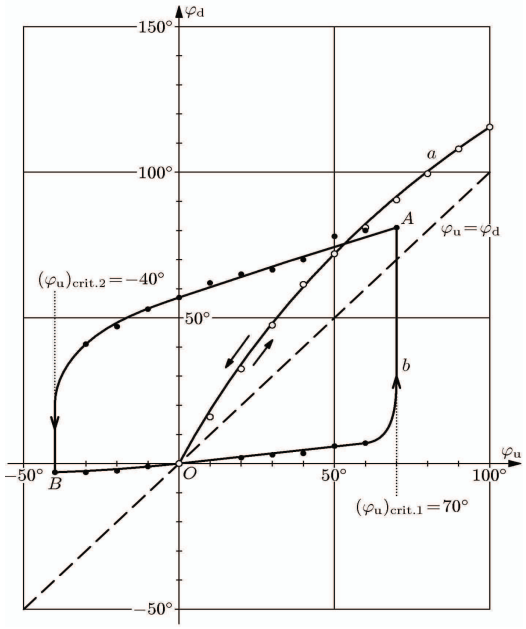

Fig. 3. The results of experiments with salt solution (with the plate totally immersed in solution). The curve **a** describes a dependence $\varphi_d = f(\varphi_u)$ of a fresh salt solution. The curve **b** describes a dependence $\varphi_d = f(\varphi_u)$ after arising of autothixotropy. Evidently a phenomenon of hysteresis appeared

From Figure 2 we see that the loop ***b*** describes the phenomenon of autothixotropy of water more intensive than loop **a**, although the plate was immersed only by half of its area. However, in this case, the plate cut through the surface of water. This suggests that at the surface of the water the network of H_2O super clusters molecules is denser.

Conclusions

- A state of autothixotropy of water is macroscopically demonstrated with very weak mechanical properties analogous to the properties of *solid substances*, such as a certain internal static friction, elasticity and strength.
- Water slightly deviates from an ideal Newtonian viscous fluid, because the autothixotropy appears in the form of a certain internal static friction, although very weak.
- Existence of autothixotropy *is probably caused by super clusters* that are created in standing water after a certain time and evidently fill up the whole vessel with the exploring water (with greater density at the surface level). The kernels of these macroscopic clusters *can be ions* present in water.
- The time interval during which the autothixotropy arises (in case of fresh water or after its re-boiling or vigorous shaking) has not been definitely determined yet. Obviously it depends on the structure and amount of ions contained in water.
- Environment and biophysical applications of the autothixotropy of water remain still open [6, 7]. The autothixotropy can have a considerable significance for biophysics because with the aid of autothixotropy *the rigidity of cytoskeleton* of living cell could be explained. Time depended self-organisation of water molecules into super clusters may play a significant role in the mechanical and electrical stability of this clusters system.

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AUTOTIKSOTROPIA WODY I JEJ ZNACZENIE DLA CHEMOFIZYKALNEJ TEORII ŚRODOWISKA

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Abstrakt: Woda jest źródłem życia i dlatego jest ona ważnym obiektem badań fizyki chemicznej środowiska. W artykule przedstawiono zjawisko zachodzące w wodzie, nazywane „autotiksotropią wody". Historia jego odkrycia wiąże się z bardzo precyzyjnymi eksperymentami grawimetrycznymi, które zostały wykonane przez autora w latach 1978 i 1986. Ponadto zjawisko autotiksotropii wody zostało jakościowo zbadane w latach 1991/92 oraz ilościowo od 2003 do 2011 roku. Z fizykalnego punktu widzenia autotiksotropia wody jest bardzo subtelnym zjawiskiem makroskopowym, które obserwuje się w wodzie, pozostającej przez pewien czas w spoczynku (około kilkudziesięciu godzin), czyli wodzie „stojącej". Zjawisko to przejawia się przez oporność mechaniczną działającą na ciało zanurzone w wodzie „stojącej". Podstawę badania stanowi metoda statyczna, wykorzystująca moment siły, która umożliwia pomiar kąta skręcenia nierdzewnej blachy stalowej zawieszonej w badanej wodzie. Kiedy kierunek momentu siły w „stojącej" wodzie się zmienia, znajduje to odzwierciedlenie w różnych kątach obrotu tej płyty (zaobserwowano zjawisko histerezy). Zjawisko autotiksotropii znika po pewnym czasie (w kilkadziesiąt minut lub godzin), jeśli „stojąca" woda jest mieszana mechanicznie lub ogrzewana do wrzenia. Znamienne jest, że zjawisko autotiksotropii nie występuje w „stojącej" zdejonizowanej wodzie destylowanej. Zjawisko to może być wyjaśnione przez hipotezę powstawania „w wodzie stojącej" klastrów molekuł H_2O. Zjawisko autotiksotropii nie jest obecne w zdejonizowanej wodzie „stojącej", co może być spowodowane obecnością jonów w wodzie, jak to wykazano w eksperymencie z roztworem soli kuchennej (NaCl). Środowiskowe i biofizyczne wykorzystanie autotiksotropii wody nadal pozostają otwarte. Niektóre z możliwych zastosowań tego zjawiska są już opisane.

Słowa kluczowe: wody stojące, autotiksotropia wody, dejonizowane wody, roztwory soli, superklastry