Some peculiarities of convective and diffusion processes at interfacial layers of water.

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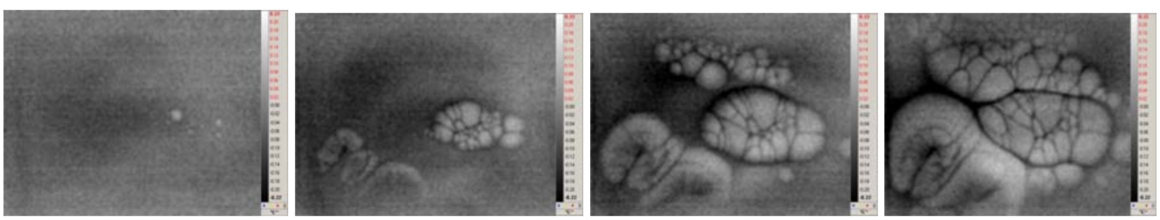
Most of the differences between bulk (free) water and interfacial (bounded) water are associated with the peculiarities of convective and diffusion processes at the interfacial layers of water. Practically all water in biological systems should be considered as interfacial water. It is quite difficult to study diffusion and convective processes in thin layers of interfacial water and water solutions (for example of those in contact with biological cells or blood vessels). Especially difficult is performing experimental study of the processes of concentration-capillary convection. Such processes are usually studied on board of space vehicles in the absence of gravity. Using the method of real-time infrared imaging we have demonstrated the possibility to perform experimental study of concentration-capillary convection at the thin interfacial layer of water.

High sensitivity focal plane array (FPA) infrared (IR) camera with 3-5 micron spectral window of sensitivity was used in our studies. Temperature sensitivity of IR camera was better than 10 mK at 200 frames per second acquisition rate and the sensitivity could be improved up to 1 mK using the method of averaging and IR image processing. Such method makes it possible to visualize the difference between free and bounded water and to observe the dynamics of thermo-clusters formation in superficial layers of water and multi-component water solutions. Such thermo-clusters are invisible in visual spectral range and the mechanism of their formation is associated with concentration-capillary type of convection in thin interfacial layers of water. Examples of thermo-clusters formation in a thin superficial layer of 10 % ethanol-water solution obtained using the method of real-time infrared imaging is presented below. Time interval between IR pictures is 0.1 second and the size of each IR picture is 3x4 centimeters.



The speed of the temperature front propagation can reach velocity up to 1 meter per second. It is important to note that the shape of thermo-cluster remains unchanged during the process of its evolution.

Such thermo-clusters may be considered in principle as a new type of dissipative structures because the collision of two temperature fronts of two thermo-clusters does not lead to their annihilation and the temperature in the area of two thermo-clusters colliding is $0.5\ ^{o}C$ lower than it should be according to a diffusion mechanism. Special experiments performed using ethanol vapor show that such high speed of temperature front propagation corresponds to the propagation of a molecular layer of ethanol on the surface of the water and the mechanism of this effect is associated with the concentration-capillary type of convection. Moreover, cylindrical type vortex is formed in the area of temperature front together with the changes of surface tension and these two effects are responsible for the absence of temperature front annihilation. The presence of extremely low level external sources of energy (such as ultrasound or microwave) could lead to the appearance of regular temperature oscillation in thin interfacial layers of water.

Obtained results make it possible to consider the process of spontaneous thermo-cluster formation as an example of a self-organization process in interfacial layers of water.