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To date, research has told us cesium chloride hydrates should not exist at all. However, scientists from the Institute of Scientific Instruments of the Czech Academy of Sciences, in cooperation with experts from the University of Innsbruck, have now demonstrated their existence. The key to their preparation involves a special freezing procedure. This strategy could serve as a new pathway for synthesizing unstable molecules, potentially leading to novel pharmaceuticals and a better understanding of chemical reactions in space.

On Earth, only one type of ice occurs naturally – so-called hexagonal ice. Whether it be tiny snowflakes, massive glaciers, frozen surfaces of rivers and ponds, or ice cubes in drinks – all share the same hexagonal crystal structure.

However, many more forms of ice exist. To date, at least 20 different types of crystalline ice and several amorphous forms (lacking regular structure) have been prepared and characterized in laboratories. Their formation typically requires very low temperatures, high pressures, and extremely rapid cooling – conditions that are generally unattainable in nature.

The "nonexistent" compound in frozen salt solutions

This seemingly ordinary state of water remains, in many respects, a mystery to experts. Scientists from Vilém Neděla's research team at the Institute of Scientific Instruments of the Czech Academy of Sciences (CAS), working together with Thomas Loerting from the University of Innsbruck, investigated the properties of salty glassy water – i.e., ices lacking a regular crystal structure – prepared from a solution containing cesium chloride.

This type of ice is formed by the extremely rapid cooling of microscopic droplets of the saline solution to -196°C or by compressing "regular" ice under the pressure of 1.6 GPa at the same temperature. "With such significant cooling, no ice crystals form in the water, leaving the water frozen in a disordered state typical of a liquid. Upon subsequent heating of the glassy solution, the molecules rearrange, and only then do tiny ice crystals form," describes Ľubica Vetráková, a researcher from the Institute of Scientific Instruments of the CAS. This crystallization from the glassy water state at low temperatures differs significantly from the usual freezing of liquid water.

This property has allowed scientists to discover molecules in such specially prepared ice that, according to previous experimental results and computational models, should not exist at all. That is because cesium chloride is one of the salts that, due to the instability of its hydrates, does not form any hydrates – it does not bind water.

Nevertheless, the team of scientists from Brno and Innsbruck discovered several types of these hydrates in the specially prepared ice. They demonstrated their existence using a combination of differential scanning calorimetry, X-ray diffraction, and advanced environmental scanning electron microscopy (A-ESEM), a unique imaging method that Neděla's team from the Institute of Scientific Instruments of the CAS introduced to the world about five years ago. "Thanks to cutting-edge A-ESEM technology, which recently enabled the unique imaging of the nanostructure of the surface layer of chromosomes, it was possible for the very first time to image the 'nonexistent' hydrates. For this purpose, the microscope was newly equipped with the first test version of a unique cryo-holder, developed at the Institute of Scientific Instruments of the CAS for use in environmentally compatible conditions of relatively high gas pressures," Neděla explains.

The scientific team's discovery was published in *ACS Physical Chemistry Au*. The research was co-financed by the new CAS Strategy AV21 program The Power of Objects: Materiality Between Past and