Spectra Suggest Anomalous Water is a Stable Polymer of H_2O

Anomalous water, first discovered by Boris V. Deryagin and coworkers at the Karpov Institute of Physical Chemistry in Moscow, is a polymer, according to a group from the National Bureau of Standards and the University of Maryland. The experimenters, Ellis Lippincott, Robert Stromberg, Warren Grant and Gerald Cessac, believe[1] that the substance they have produced in capillaries from distilled water is not H_2O but rather a polymer whose formula is $(H_2O)_n$.

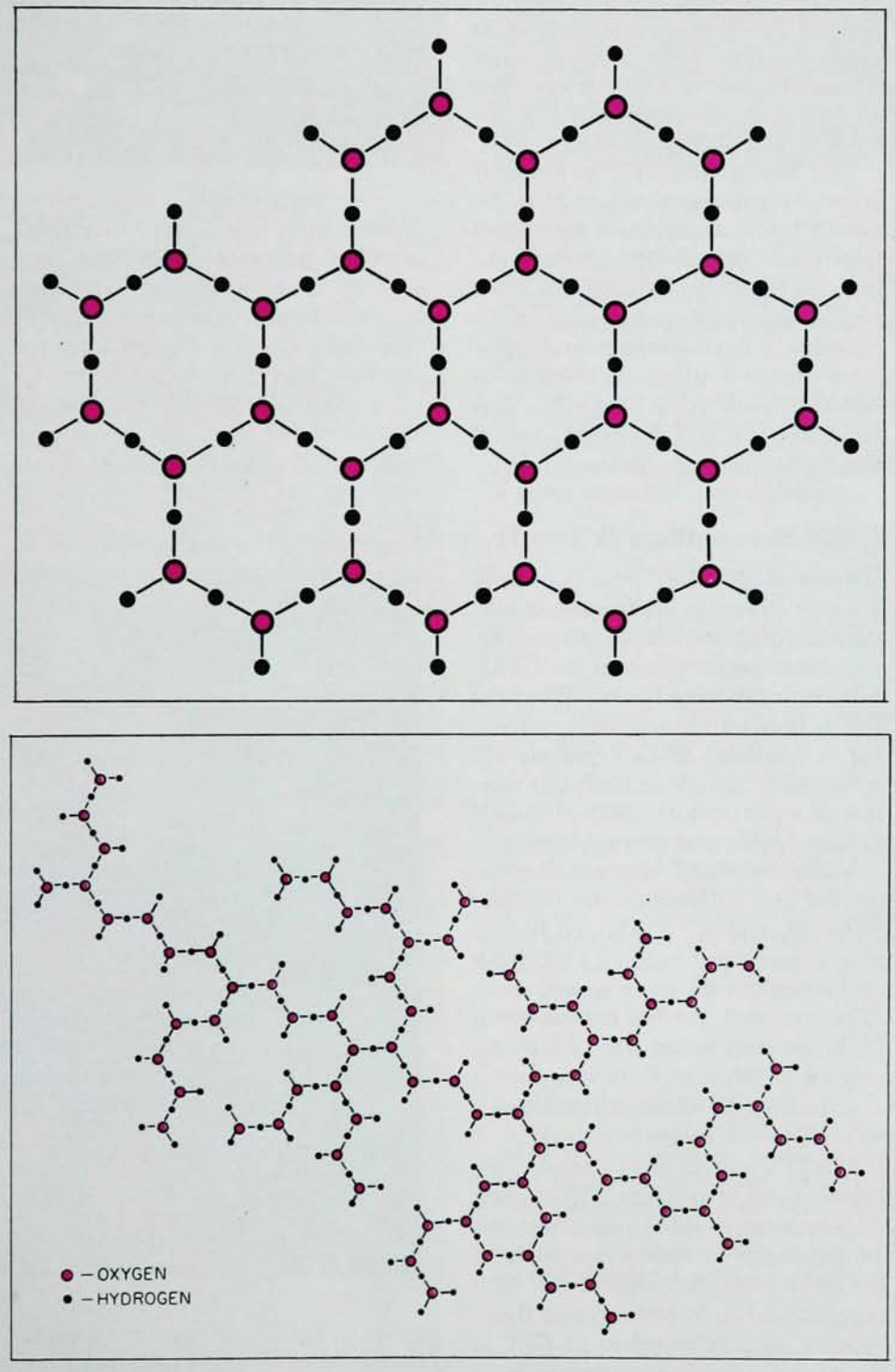
Deryagin's group reported a form of water with properties very different from those of normal water:[2] low vapor pressure, high density (1.01–1.4 gm/cm^3), solidification at a maximum of −40°C to a glassy form with a much lower expansion than that of ordinary water when it forms ice, and stability to 500°C.

Their results were met with skepticism because the samples obtained were microscopic and were not shown to retain their unusual properties when removed from the containers in which they had been prepared. It seemed unlikely that a form of the most thoroughly studied compound could exist and yet remain undiscovered until now. Many experimenters have been trying to duplicate the Deryagin results.[3,4]

Results include spectra. Lippincott and his coworkers prepared many samples of anomalous water in both quartz and Pyrex capillaries. They obtained infrared spectra of the products both in and out of these tubes and Raman spectra only within the tubes. These spectra differ markedly from those of normal water (for example, the combination bands near 6950 cm^{-1} and 5100 cm^{-1} disappeared in many cases) and show no evidence of H_2O_2, silica gel, silicic acids, oils or greases.

Spectrochemical analyses (laser probe and copper spark) showed no impurities. Microprobe tests showed no significant silicon and only traces of sodium. By matching liquids of known refractive indices, the experimenters determined the polywater index to be 1.48; using this result and assuming equal molar refractivity for water and polywater, they estimated the density as 1.39 gm/cm^3. The group noted that portions of the material were birefringent, with a lower refractive index.

Because the spectra of anomalous water are similar to those of hydrogen-bond systems such as KHF_2 and $HCrO_2$, and because O-H-O has the same number of electrons as FHF^-, the group proposed that the structural



POLYWATER STRUCTURE is either layers of hexagons (top) or highly branched polymer chains (bottom). Colored dots represent oxygen and black ones hydrogen. The polywater layer in the top figure has a total charge of −8.

unit of "polywater" is a very strong (60–100 kilocalories/mole) three-center O-H-O bond. The distance between oxygen atoms is estimated as 0.23 nanometers and the O-H distance as approximately 0.115 nm. Normal water has a hydrogen-bond energy of 4 kcal/mole and an oxygen–oxygen distance of 0.28 nm.

Two structures are proposed for polywater, both held together by delocalized three-center bonds (in which the electron wave function is spread over three atoms). One of the structures is a planar or puckered layer of hexagons. Each layer is negatively charged and is held to adjoining layers by protons or cations or hydronium ions (H_3O^+).

The second structure is a highly branched polymer chain; a high degree of branching accounts for the relatively few normal OH groups. The experimenters also considered a tetrahedral structure because quartz is tetrahedral. But according to Lippincott's group, if polywater were tetrahedral it would form from either normal water or one of the dense forms of ice; no one has ever observed this.

POLYWATER MAGNIFIED 80 times shows birefringence (white areas). Dark spots are voids in the material, which was dropped onto a surface from a capillary. (Lines are from the microscope eyepiece).

Although one crystallographer considers polywater work "the most exciting since noble-gas compounds were produced," others are reserving their judgment. A leading chemical physicist who has studied water for many years told PHYSICS TODAY he was not convinced that the group was studying pure water; he felt silicate impurities might have been absorbed in preparation. Although the spectra did not show such impurities, he noted that it is difficult to obtain spectra of amorphous substances. Two groups that have been trying to prepare anomalous water criticized the lack of details reported on the preparation. Both thought that because no capillary had been used to prepare more than one sample of water, this suggested that the capillary surface gave up something to the water. When we asked Lippincott about this objection, he replied that the procedure in question had been experimentally convenient and that he saw no reason why a given capillary could not be used repeatedly. —MSR

References

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CERN Storage Rings in Two Years: Experimenters are Making Plans

"Physics at 1500 GeV" was the title of a recent Princeton conference; it considered possibilities for American participation in experiments at the CERN Intersecting Storage Rings. When the ISR is finished (in mid-1971, according to schedule) 28-GeV protons will collide with 28-GeV protons; this reaction is equivalent to 1500–1700-GeV protons hitting a stationary target.

Victor Weisskopf, who was director-general at CERN when the ISR was proposed, said in his talk that he had trouble pushing the ISR at CERN because Brookhaven was opposed to it. "The fact that the US did not do it [build an ISR] is just what the doctor ordered for Western European physics . . .The mistake of Brookhaven was a tremendous advantage to Europe."

The ISR consists of two nearly concentric rings of magnets (300 meters in diameter), which intersect at 15-deg angles in eight places; two of the eight interaction regions will have experimental halls built around them. Protons are accelerated to 28 GeV in the proton synchrotron, ejected by a fast-ejection system into a transfer channel and guided toward the ISR,

DETAIL OF RING CONSTRUCTION. Experimental Hall II is in background; it has flexible shielding arrangements that can be readily adapted to different requirements. Inside width of the ring tunnel is 15 meters; inside height is 6.5 meters. Some of the 1 million tons of rock and soil removed during the year-long excavation of the ring will cover it with about 4 meters of shielding.