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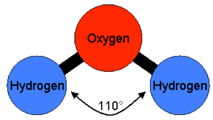
Thermal Water Dissociation

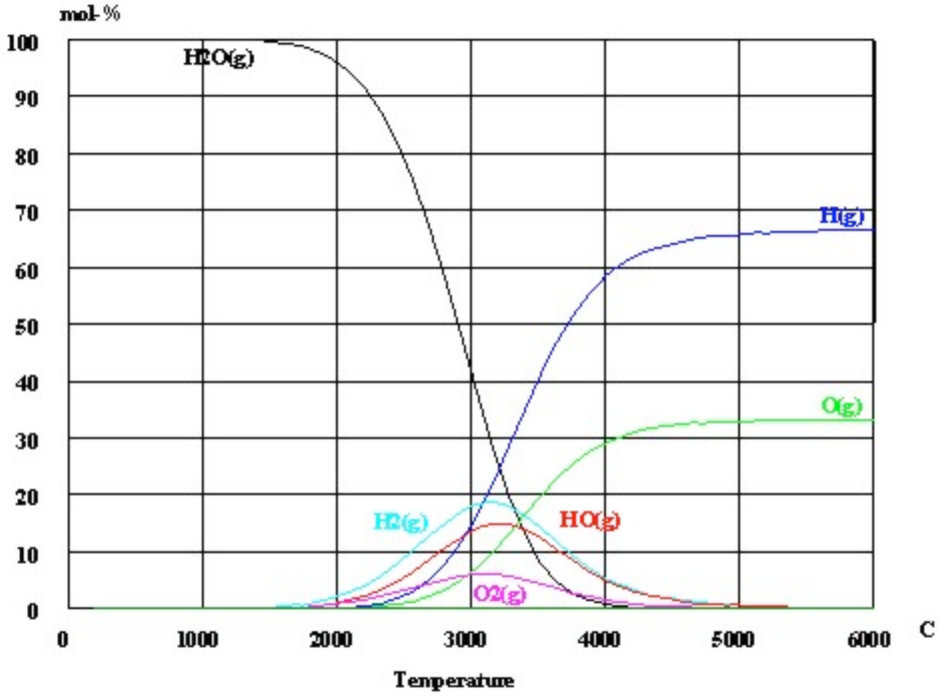
Water is one of the most abundant materials on our planet. There are about 1'350 million cubic kilometres of salt water mostly in the oceans and 33,6 million cubic kilometres of sweet water, three quarters of which are contained in snow and ice and one fifth in underground reservoirs.

Water is the liquid state of the water molecule. The water molecule (chemical formula H_2O) is composed of one oxygen atom (O) and two hydrogen atoms (H). The oxygen sits between the two hydrogen atoms and together they form a triangle with an opening angle of 104.5 degrees. When condensating, several such molecules, usally 5 to 7, combine into chains making the liquid.



The atoms in the water molecule are strongly bound together with an energy of 242 KJ/mol or 3.73 KWh/Kg in the gaseous state (steam) and 286 KJ/mol or 4.37 KWh/Kg in the liquid state (water). Of course, to separate the atoms in the molecule this energy has to be invested, which can be done by different means. In electrolysis it is done using electricity, in thermolysis (thermal water splitting) it is done with heat.

At elevated temperatures water molecules split into their atomic components hydrogen and oxygen. For example at 2200°C and 0.1 MPa about eight percent of all H2O molecules are split into various combinations of hydrogen and oxygen atoms, mostly H, H_2, O, O_2 and OH. Other reaction products like H_2O_2 or HO_2 remain spurious. At the very high temperature of 3000°C more than half of the water molecules are decomposed, but at ambient temperatures only one molecule in 100 trillion dissociates by the effect of heat. However, catalysts can accelerate the dissociation of the molecules.



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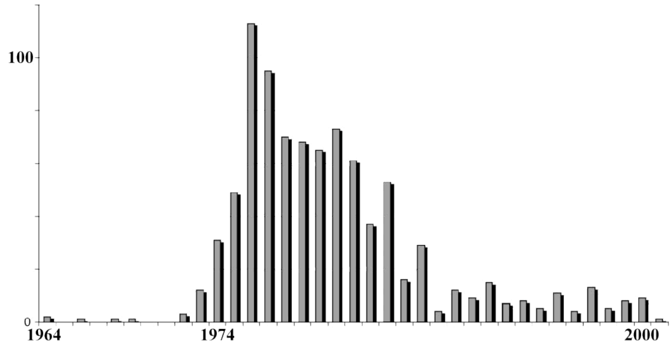
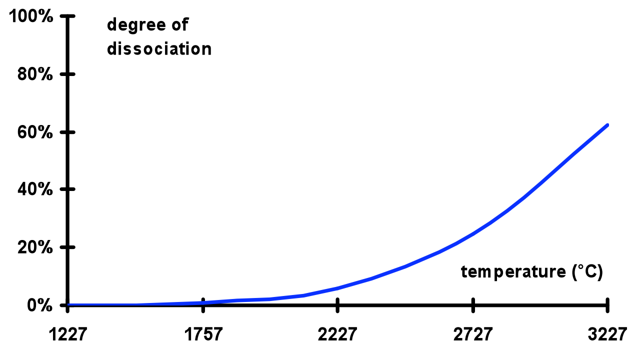


Research on water splitting started in the 1960s in an attempt to increase the efficiency of hydrogen production processes. The figure to the right shows the number of publications by year from 1964 until today (Int J Hydrogen Energy 26 (2001) 185). Research got a strong boost during the oil crisis in the 1970s. However, the then available gas separation techniques and materials pushed research in the direction of multi-step processes, to overcome the need for very high temperatures and simultaneous gas extraction. Their efficiency is low and they do not appear economically interesting. This fact and that cheap oil and natural gas was again available, led to a world-wide decrease in interest and thus funding for thermal water splitting from the 1980s. A recent overview is given by Prof. Aldo Steinfeld in "*Solar thermochemical production of hydrogen–a review*", Solar Energy, Vol.78/5(May 2005)603-615.

H2P

Our technology is based on high temperature thermal water dissociation. In thermal dissociation water vapour is heated until the supplied energy is enough to split large amounts of the molecules. For pure water, sizeable dissociation occurs above 1800°C. The number of dissociated molecules increases with temperature. However, if the temperature is lowered, the components recombine very quickly. At 2500K and 0.68 MPa, it takes 5.97 KWh to split one kilogram of water and to separate the hydrogen and oxygen produced in the thermal water splitting.



The main challenge is to separate the hydrogen when it is there. **H2P uses selective membrane filters for effective gas separation**. Such membranes are available for temperatures up to 1000°C and research groups in Israel and Japan have recently studied their use for thermal water splitting. However, we prodcue our own high temeprature membrane fitlers.

Thermal water splitting requires very high temperatures and imposes constraints on the materials. The degree of dissociation, which is samll at temperatures below 2000°C, can be increased by use of catalysts.