High Temperature Co-electrolysis (HTCE)

Ceramatec has been actively developing planar SOFC (solid oxide fuel cells) systems for over 20 years. In the early 1990's, Ceramatec used its SOFC materials for dry electrolysis of CO_2. These experiments indicated that the electro-kinetics of dry CO_2 conversion to CO were an order of magnitude slower than the same cell exhibited with a conversion of steam to hydrogen.

In late 2006, a HTSE unit was operated in the steam electrolysis mode for 1000 hours. The stack was then switched to a feed of steam and CO_2 and operated for an additional 1000 hours producing syngas by co-electrolysis of steam and CO_2. By September, 2007 a Ceramatec HTSE stack located at INL was producing 1.5 nm^3/hr of hydrogen. The mechanism for the electrolysis of steam and carbon dioxide is shown in Figure 1 below.

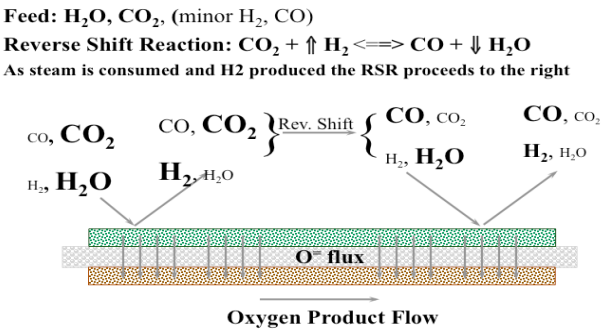

Figure 1: HTCE mechanism

The preference for the cell is to extract the oxygen from the steam (i.e. $H_2O \rightarrow H_2$) with the oxygen being transported to the other side of the cell by the electrochemical process. As the steam is reduced and hydrogen generated, the reverse water gas shift reaction is forced by the equation equilibrium. There is some conversion of the CO_2 to CO by the cell transfer of oxygen but most is believed to occur through the reverse water gas shift.

The Ceramatec co-electrolysis cell uses a zirconia based electrolyte "stabilized" in the cubic phase by doping with a trivalent ion supplied as an oxide, typically yttria (YSZ – yttria stabilized zirconia) or scandia. The HTCE cathode (anode in SOFC operation) is a micro-porous metal-ceramic composite (cermet) commonly composed of micron scale particles of nickel and YSZ. The oxygen evolution electrode (the cathode in SOFC operation) is a micro-porous Perovskite ceramic such as a lanthanum manganite ($LaMnO_3$). Ceramatec uses a proprietary composition for their nickel cermet hydrogen electrode and Perovskite oxygen electrode system that has shown better performance in co-electrolysis mode than the conventional materials set. There are no precious metals required for the cell or stack assembly as it is implemented by Ceramatec.

Recently, Ceramatec produced a ~ 18 kWe HTCE system that was operated at the Idaho National Laboratory. The unit is pictured below.

Ceramatec, Incorporated
2425 South 900 West
Salt Lake City, UT 84119
Telephone: 801 972-2455
www.ceramatec.com

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