Pressurized HxCyOz Cells at ca. 250 °C: Potential and Challenges

The increasing need for easy and affordable storage of intermittent renewable energy has encouraged us to explore the possibilities of pressurized electrolysis and fuel cells operating in the temperature range of 200 – 300 °C and pressure from a few bar up to 50 bar and above. Most electrochemical rate limiting processes are strongly thermal activated. Also, increased pressure may increase the electrode reaction rates. High pressure means increase energy density in gaseous products. Furthermore, as hydrocarbons, alcohols or ethers - in common denoted HxCyOz - are very convenient fuels, we have focus on cells that may have a potential of forming or using HxCyOz in electrolysis or fuel cell mode, respectively. Examples of HxCyOz are hydrogen with (x,y,z) = (2,0,0), carbon monoxide with (x,y,z) = (0,1,1), methane with (x,y,z) = (4,1,0), gasoline with approximately (x,y,z) = (18,8,0), methanol with (x,y,z) = (4,1,1), and dimethyl ether (DME) with (x,y,z) = (6,2,1). The temperature about 200 – 300 °C is of particular interest because if the direct electrochemical reduction products from electrolysis of H2O and CO2 mixtures are H2 and CO (syngas) then this temperature together with increased pressure makes it potentially possible to convert the syngas into HxCyOz inside the cathode compartment using suitable catalysts, because such conditions are very similar to the commercial catalysis technology used by chemical industry.

A brief review of some literature behind this strategic thinking is given, followed by examples of results from our own laboratory. So far the concept of high temperature and pressure electrolysis has proven successful on small scale using button cell with KOH(aq.) electrolyte immobilized in a porous ceramic layer. Also cells using immobilized K2CO3(aq.), CsH2PO4 solid acid, and BaZr1-u-vCe0.5+YvO3-δ proton conducting electrolytes have been constructed and tested. Reduction of CO2 seems significantly more difficult than reduction of H2O. This and many other challenges appear from our work.

The apparent challenges and the potential benefits that make it worthwhile to overcome the challenges are discussed and some main arguments in favor of continuing this strategy are presented.