ELECTROCHEMICALLY-MEDIATED ADSORPTIVE PROCESSES FOR CO_2 CAPTURE

T. Alan Hatton, MIT
tahatton@mit.edu
Sahag Voskian, MIT

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The capture of anthropogenic carbon dioxide CO_2 from industrial and power generation sources, where the concentration of CO_2 is relatively high, is an important component in an overall portfolio of low carbon energy sources for climate change mitigation. The US Department of Energy (DOE) acknowledges, for instance, that for the foreseeable future coal will continue to play a critical role in the national and global electricity generation, and that innovations in the field of carbon capture from high concentration sources such as coal combustion and coal gasification units are crucial. In addition, on-board carbon capture for reduced emission from vehicles and other mobile sources, which account for almost 30% of all emissions in the US, has garnered interest over the last few years by the automotive, and gas and oil industries. Other sources of much lower CO_2 concentration collectively represent a large volume of carbon emissions, and there is thus a growing interest on the part of the DOE and private industries in capture technologies that operate over a wide range of CO_2 concentrations, especially at concentrations below 1%. There is also a significant benefit to innovations in the removal of CO_2 from enclosed spaces such as in buildings, aircraft, spacecraft and submarines, where the concentration of CO_2 is in the 1,000-10,000 ppm range, and the small spaces available limit the types of capture technologies that can be used. The removal of CO_2 from buildings to reduce its overall concentration to acceptable levels for human activity will obviate the need for frequent air exchanges and thereby reduce the energy needs for conditioning of fresh air brought into the buildings; this in turn results in fewer CO_2 emissions from power plants.

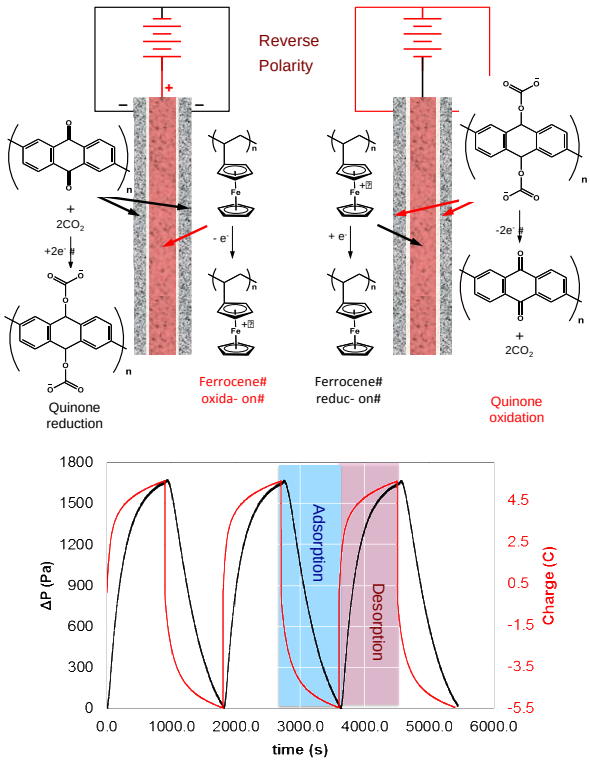

Figure 1 - Principle of electro-swing adsorption for controlled CO_2 capture and release. Experimental results show changes in pressure in a sealed electrode chamber as the potential is switched from oxidizing to reducing conditions (charge transfer is positive or negative)

We have developed asymmetric supercapacitor assemblies of novel architecture for the electrosorption and subsequent release of carbon dioxide over a wide range of feed concentrations. The electrodes rely on Faradaic pseudocapacitance in which the gas uptake and release are regulated by changes in the redox state of a functional group and hence its affinity for CO_2. We will discuss the preparation of the electrodes, including their chemical synthesis and assembly into the working cell; the electrochemical characterization of the electrode assembly; and the dynamic uptake and release of the targeted compounds under a range of different operating condiditons, including both batch and cyclic continuous flow systems. experimental results from a bench-scale prototype show up to 80% capture of CO_2 from inlet streams of CO_2 concentrations as low as 0.5% (5000 ppm) at a Faradaic efficiency of >70% and work of 30-100 kJ per mole of CO_2 captured. The talk will conclude with an evaluation of the concept for a number of different applications, a discussion on the dynamics and energetics of the process, and an assessment of enhancements that can be made in the process.