Oxygen Generation from Carbon Dioxide for Advanced Life Support

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The partial electrochemical reduction of CO_2 using ceramic oxygen generators (COGs) is well known and has been studied. Conventional COGs use yttria-stabilized zirconia (YSZ) electrolytes and operate at temperatures greater than 700°C (1, 2). Operating at a lower temperature has the advantage of reducing the mass of the ancillary components such as insulation. Moreover, complete reduction of metabolically produced CO_2 (into carbon and oxygen) has the potential of reducing oxygen storage weight if the oxygen can be recovered.

Recently, the University of Florida developed ceramic oxygen generators employing a bilayer electrolyte of gadolinia-doped ceria and erbia-stabilized bismuth oxide (ESB) for NASA's future exploration of Mars (3). The results showed that oxygen could be reliably produced from CO_2 at temperatures as low as 400°C. These results indicate that this technology could be adapted to CO_2 removal from a spacesuit and other applications in which CO_2 removal is an issue.

This strategy for CO_2 removal in advanced life support systems employs a catalytic layer combined with a COG so that the CO_2 is reduced completely to solid carbon and oxygen. First, to reduce the COG operating temperature, a thin, bilayer electrolyte was employed. Second, to promote full CO_2 reduction while avoiding the problem of carbon deposition on the COG cathode, a catalytic carbon deposition layer was designed and the cathode utilized materials shown to be coke resistant. Third, a composite anode was used consisting of bismuth ruthenate (BRO) and ESB that has been shown to have high performance (4).

The inset of figure 1 shows the conceptual design of the tubular COG and the rest of the figure shows schematically the test apparatus. Figure 2 shows the microstructure of a COG tube prior to testing. During testing, current is applied across the cell and initally CuO is reduced to copper metal by electrochemical pumping. Then the oxygen source becomes the CO/CO_2. This presentation details the results of testing the COG.

ACKNOWLEDGEMENTS

NASA Contract # NNJ06HB01C and the Major Analytical Instrumentation Center (MAIC) at the University of Florida

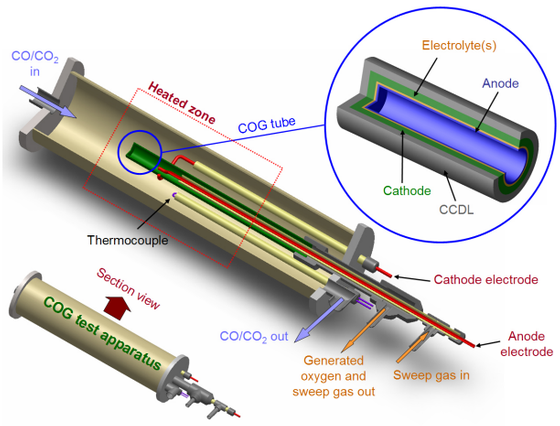

Figure 1: Schematic of COG tube in test apparatus.

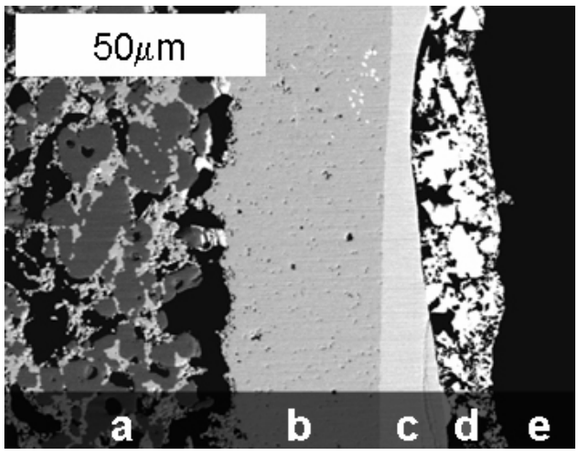

Figure 2: SEM image of COG tube microstructure. a) CuO/GDC cathode support, b) GDC electrolyte, c) ESB electrolyte, d) BRO/ESB composite anode, and e) epoxy sample mount.

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