Electrocatalytical Membrane Cell Processes for Removal of NO and SO_2 from Power Plant Flue Gases.

S.B. Rasmussen, K.M. Eriksen and R. Fehrmann

ICAT (Interdisciplinary Research Center for Catalysis)
and Department of Chemistry, Technical University of
Denmark, DK-2800 Kgs. Lyngby, Denmark

Flue gas cleaning by use of electro-catalytic molten salt membrane cells might be attractive alternatives to the traditional wet scrubber desulfurization process ($deSO_X$) producing waste products and the denitrification by the SCR process ($deNO_X$) where the widely used V_2O_5/TiO_2 catalyst experiences rapid deactivation in potassium containing off gases from e.g. biomass or combined biomass/fossil fuel fired power plants.

The cell design[1,2] is shown as a principal sketch in Figure 1 for the $deSO_X$ process. The porous Li_XNiO electrodes are separated by a $V_2O_5/M_2S_2O_7$ (M = alkali) molten salt membrane supported on a porous YSZ matrix. The cell operates at 350-450°C where the electrolyte is molten and the oxidation process SO2 + ½O2 → SO3 can take place catalyzed by the vanadium(V) oxosulfato complexes formed in the melt.[3] The electrode processes are $SO_3 + ½O_2 + 2e^- \Leftrightarrow SO_4^{2-}$ where sulfate ions are formed at the cathodic flue gas side and the reverse process liberating SO_3 and O_2 takes place on the anodic product side. Here the final product could be sulfuric acid or oleum of commercial grade.

The cell has been operating at 90% SO_2 removal at a current density of around 5 mA/cm^2, but a current density of 20-25 mA/cm^2 is considered economical viable. In order to reach this goal the cell performance might be improved through utilization of a thinner membrane, optimization of electrode porosity and further development of the molten electrolyte.

A similar cell design is under development for the $deNO_X$ process where the electrolyte is a MNO_3 (M = alkali) melt at 300-400°C. At the cathodic flue gas side NO is transformed to NO_2^- by the reaction $NO + NO_3^- + e^- \rightarrow 2NO_2^-$ and the reverse reaction liberating NO as a concentrated gas takes place at the anodic product gas side. The final product could be nitric acid of commercial grade after catalytic oxidation of the product gas. Our recent results concerning physico chemical properties of possible electrolyte candidates like the $M_2S_2O_7$-$MHSO_4$-V_2O_5 and MNO_3-MNO_2 (M = alkali) molten systems as well as the catalytic and electrochemical processes taking place during cell operation will be presented together with the latest results concerning the performance of the prototype cells prepared so far.

References:

1. D.J. McHenry and J. Winnick, Aiche J., 40 (1994) 143.

2. S.B. Rasmussen, K.M. Eriksen, R. Fehrmann and J.Winnick, J. Appl. Electrochem., 32 (2002) 19.

3. O.B. Lapina, B.S. Bal'zhinimaev, S. Boghosian, K.M. Eriksen, R. Fehrmann, Catal. Today, 51 (1999) 469.

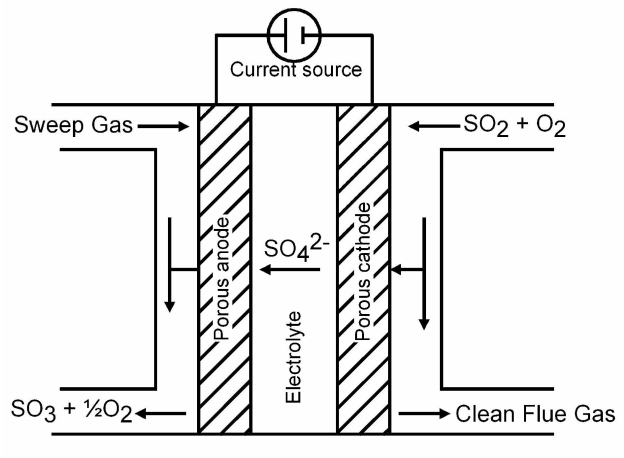

Fig. 1: Principal drawing of the electrochemical membrane cell for SO_2 removal.

Cathode: $NO + NO_3^- + e^- \rightarrow 2NO_2^-$

NO_2^- - transport

Anode: $2NO_2^- \rightarrow NO + NO_3^- + e^-$

Fig. 2: Proposed electrode reactions for an electrochemical membrane cell for NO removal.