A Small Closed-Cycle Combined Electrolysis and Catalytic Exchange Test System for Water Detritiation

H. Boniface*[a], S. Suppiah[a], K. Krishnaswamy[a], L. Rodrigo[a], J. Robinson[b] and P. Kwon[b]

[a]*Atomic Energy of Canada Limited, Chalk River Laboratories, Chalk River, Ontario, Canada, K0J 1J0*
[b]*Tyne Engineering Inc., Oakville, Ontario, Canada, L6L 6L4*

AECL has been actively involved in exploring advanced electrolysis technologies for its Combined Electrolysis and Catalytic Exchange (CECE) technology for water detritiation, which relies on electrolysis for deuterium gas return to the Liquid Phase Catalytic Exchange (LPCE) system for hydrogen isotope exchange. A mini-CECE system has been built and operated at AECL to explore its operation as a closed-cycle system with a Proton-Exchange Membrane (PEM) type electrolysis cell. Following the successful demonstration of its operation, a number of proton-exchange membranes are being tested for their suitability for tritium service. In parallel, a similar mini-CECE system suitable for service with tritium concentrations up to 1000 Ci/kg(water) has been assembled, in collaboration with Tyne Engineering, for installation in a glovebox in AECL's Tritium Facility. The proton-exchange membranes selected from the currently operational mini-CECE system will be used in the tritium-service cell to determine their performance with high tritium concentrations and verify their suitability for full-scale commercialization. Results obtained from this program will be used to design a large-scale PEM-type cell at Tyne Engineering for applications involving tritium service.

Nafion-112 membrane samples placed in water were exposed to gamma and beta irradiation to determine their suitability for use in the above CECE system. Gamma or beta dose to the samples ranged up to 1250 or 200 kGy, respectively. The physical integrity was characterized by visual inspection and Scanning Electron Microscopic and Fourier Transform Infrared analyses before and after irradiation. When possible, irradiated membrane samples were used to prepare Membrane Electrode Assemblies and tested in a single fuel cell to determine any change in the proton exchange capacity of the membrane due to irradiation. Visual observations showed that gamma irradiation at doses as low as 380 kGy (equivalent to one year of exposure to tritiated water at 750 $Ci \cdot kg^{-1}$) produced severe damage to the membrane while no significant damage was observed for samples exposed to tritiated water (200 kGy dose). However, membranes exposed to tritiated water showed 20-25% decrease in cathode mass activities in the fuel cell tests.

This paper will discuss the latest results from the mini-CECE systems and the studies conducted with the membranes.