PROGRESS IN ELECTRON BEAM INDUCED GRAFTING FOR DEVELOPMENT OF ION CONDUCTING MEMBRANES FOR POLYMER ELECTROLYTE FUEL CELLS IN MALAYSIA

MOHAMED MAHMOUD NASEF[a,b*]

[a]*Chemical and Environmental Engineering Department, Malaysia-Japan International Institute of Technology,Universiti Teknologi Malaysia, Jalan Sultan Yahya Petra, 54100 Kuala Lumpur, Malaysia*

[b]*Center of Hydrogen Energy, Institute of Future Energy, Universiti Teknologi Malaysia, Jalan Sultan Yahya Petra, 54100 Kuala Lumpur, Malaysia*

Ion conducting membranes (ICM) are playing a crucial role in electrochemical energy systems by supporting the desired migration from the dependence on fossil fuels to renewable energy. Radiation-induced graft copolymerization (RIGC) technique is a distinctive means for development of alternative ion conducting membranes for energy conversion devices to overcome low fuel barrier, low conductivity or high cost associated with widely used commercial membranes. The use of electron beam (EB) accelerator in irradiating polymer film provides essential advantages to speed up the IEM preparation procedure, reduce the monomer consumption (if simultaneous irradiation grafting is used), facilitate the IEM preparation upscaling process and improve the overall process economy and greenness. The objective of this talk is to review the latest developments in applying EB for preparation of ICMs for fuel cells in Malaysia. This includes proton conducting composite membranes for proton exchange membrane fuel cells (PEMFC), direct method fuel cell (DMFC) and high temperature PEMFC. The EB was also used to prepare a novel composite anion exchange membranes for alkaline electrolyte membrane fuel cell (AEMFC). The preparation of proton exchange membrane for PEMFC started by RIGC of 4-vinylpyridine (4-VP) with EB onto polypropylene (PP) nanofibrous sheet followed by immobilization of phosphotungstenic acid (H3PW12O40, PTA) and subsequent casting of 2 thin layers of Nafion solutions leading to composite membrane with high conductivity and less water dependence. Similar membrane based on electrospun nylon-6 fibrous sheet demonstrated superior barrier properties compared to Nafion 115 especially at higher methanol concentrations when tested in DMFC. The membrane for high temperature PEMFC was prepared by grafting a binary mixture of 4-VP/1-vinylimidazole onto EB-irradiated poly(ethylene-co-tetrafluoroethylene) followed by doping with phosphoric acid (PA) under controlled conditions. The incorporation of two basic monomers was highly effective in enhancing PA doping level, proton conductivity and the overall performance of the membrane in fuel cell operation at 120°C. The anion exchange membrane for AEMFC was prepared by incorporation of imidazolium head group to EB irradiated nanofibrous substrates such as syn-PP grafted with vinylbenzyl chloride and crosslinked by 1,8-octanediamine and functionalized with OH^- group. The obtained membranes displayed not only high ion exchange capacity and ionic conductivity, but also reasonable alkaline stability and hight ionic conductivity (130 mS cm^{-1} at 80°C). The membrane showed a high-power density reaching 440 mW cm^{-2} at a current density of 910 mA cm^{-2} when combined with electrodes using diamine crosslinked quaternised polysulfone binder at 80°C with 90% humidified H2 and O2 gases making it a promising candidate for application in AEMFC. It can be concluded that EB is highly effective in development of membranes for fuel cells and more work is sought to expand its use for other applications including emerging batteries, water electrolysers, and antifouling membrane systems.