An Overview of Proton Exchange Membrane Development in Fuel Cell Research

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Fuel cells have been in a state of development for over 150 years, ever since their invention in the year 1839[1] by William Robert Grove in Great Britain. The significant advances in fuel cell technology made during this period have taken it from its beginning as a laboratory observation to its position as one of the leading current areas of research.

Arguably, the most important component of a fuel cell is the electrolyte. For a fuel cell to exhibit good performance, an electrolyte that exhibits good chemical, electrochemical, thermal and mechanical stability over a given range of operating conditions, while enabling rapid electrode kinetics, is of the essence. Over the years, the advances made in fuel cell performance have been frequently associated with advances in electrolyte technology. Indeed, the different classes of fuel cells (such as PAFCs, SOFCs etc.) extant today are defined primarily by the type of electrolyte used and the operating conditions under which they are stable.

One of the more recent, and perhaps one of the most important, advances in fuel cell technology came about with the introduction of the Proton Exchange Membrane (PEM) as the fuel cell electrolyte. PEM fuel cells have since been projected for a variety of applications including stationary power generation, transportation (fuel cell cars), military (alternate to batteries for mobile units) and portable power (power source for cellular phones and notebooks). These diverse potential applications have provided the incentive for PEM research and development.

PEM technology was used by Thomas Grubb and Leonard Niedrach at GE during the early 1960s[2]. The first operational PEMFC was the 1 KW power plant in the Gemini spacecraft, which used a poly (styrene sulfonic acid) membrane. The performance of this membrane and subsequent hydrocarbon membranes was poor due to degradation problems. The advent of du Pont's Nafion®, a perfluorosulfonicacid (PFSA) membrane, in the late 1960s gave a boost to the PEM industry and gave rise to a membrane with improved performance and lifetime – a rare combination. However, these membranes were (and still remain) expensive. The three decades since then have seen the introduction of several different classes of PEMs, each designed to increase performance and lifetime by overcoming the limitations of the existing membranes, while keeping costs reasonable.

This paper traces the development of PEM technology through the years, from its inception to date. In addition to providing a historical perspective, the paper profiles different PEMs, from the traditional PFSA based membranes, to the more recent and more exotic membranes including various hydrocarbon backbone membranes[3], organic / inorganic nanocomposite membranes[4], and composite membranes specifically designed for high temperature and direct methanol applications. Also discussed are comparisons between the various membranes based on critical parameters such as protonic conductivity and power density and future trends in PEM technology both from a materials and an applications point of view.

<u>References</u>:

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