Combinatorial Study of Blended Membranes for PEM Fuel Cells

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Among fuel cell technologies, polymer electrolyte membrane fuel cells (PEMFCs) have gained momentum at a strong pace in small to medium scale energy generation (e.g., mobile applications, transportation, etc). Historically, the development of polymer electrolytes has gone through several stages: from ionic polymers of poly(ethylene oxide)-salt complexes, polystyrene sulfonate polymers, to perfluorinated sulfonated ionomer copolymers (PFSI) that constitute the base of current PEMFC technologies. However, it is clear that current membranes do not meet cost and durability requirements for large-scale implementation in automobiles. Thus, the search for lower-cost formulations continues.

Exploratory research comprising de novo material syntheses for PEMs, however, involves extensive variable spaces that encompass both material intrinsic characteristics and processing conditions. To effectively map such parameter space we have developed combinatorial libraries with continuous single and two-dimensional orthogonal property gradients that permit the exploration of multiple dissimilar properties within a single sample (library), while reducing experimental variance. Our group has previously reported the successful implementation of this approach in other study fields; namely, polymer mechanical characterization (HTMECH) and biomaterial screening, proving it as a streamlined way to efficiently address large number of parameters. In addition, due to the multivariate nature of combinatorial PEM libraries, overwhelming to standard screening methodologies, we have designed and developed a novel high throughput 4 electrode AC impedance conductivity characterization device (HTC) tailored specifically to heterogeneous PEM library samples.

We will discuss recent innovations in novel screening methodologies for polymer electrolyte membrane. The use of custom developed high throughput screening tools for comprehensive characterization of new PEM materials will be illustrated in detail, emphasizing the generation of high-dimensional discrete data spaces that can be utilized for further material optimization, when coupled with appropriate data mining and statistical analysis tools.