Abstract
As with other polymeric materials, the mechanical properties of proton exchange membranes are highly dependent on temperature and testing rates. The hydrophilic nature makes them dependent on absorbed moisture as well. Viscoelastic characterization has proven useful for measuring the constitutive properties of the membranes. These viscoelastic properties may prove useful for predicting the stress state that results with a constrained membrane is subjected to thermal and moisture variations anticipated in operating fuel cells. Master curves and shift factors for several commercial membranes have been obtained from stress relaxation tests conducted in a dynamic mechanical analyzer outfitted with a humidity control chamber. Nonlinear behavior is evident at relatively small strain levels, and may complicate the analysis. Of particular interest is the observation that viscoelastic shift factors obtained from stress relaxation tests are consistent with time dependent durability data obtained from two other mechanical property measurements. A knife slitting test has been used to draw the membrane past a microtome blade that is mounted to a small load cell. Fracture energies obtained with the knife blade are nearly two orders of magnitude smaller than obtained from traditional tear tests. In a separate series of tests, circular blister specimens have been subjected to an increasing pressure level to induce biaxial stress states that may mimic the stresses resulting within constrained membranes in a fuel cell. The rate and temperature dependence for these fracture energies and times to burst are both consistent with the rate, temperature, and moisture dependence of the relaxation modulus, suggesting the usefulness of a viscoelastic framework for examining and modeling fuel cell membrane durability.

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