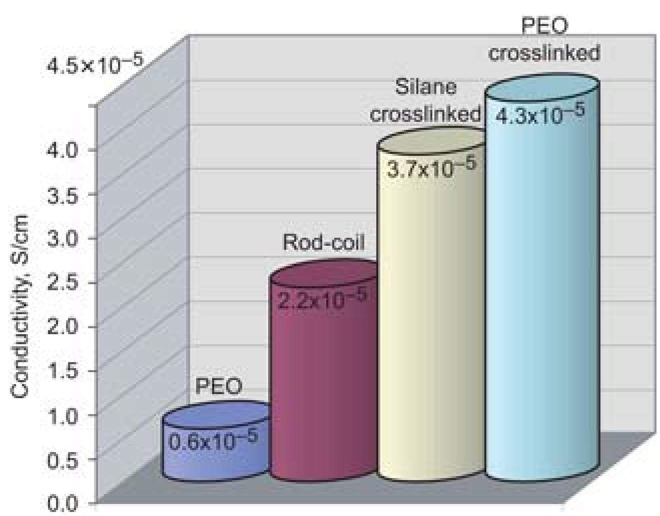
Novel Elastomeric Membranes Developed for Polymer Electrolytes in Lithium Batteries

Lithium-based polymer batteries for aerospace applications need to be highly conductive from -70 to 70 °C. State-of-the-art polymer electrolytes are based on polyethylene oxide (PEO) because of the ability of its ether linkages to solvate lithium ions. Unfortunately, PEO has a tendency to form crystalline regions below 60 °C, dramatically lowering conductivity below this temperature. PEO has acceptable ionic conductivities (10^{-4} to 10^{-3} S/cm) above 60 °C, but it is not mechanically strong. The room-temperature conductivity of PEO can be increased by adding solvent or plasticizers, but this comes at the expense of thermal and mechanical stability. One of NASA Glenn Research Center's objectives in the Polymer Rechargeable System program (PERS) is to develop novel polymer electrolytes that are highly conductive at and below room temperature without added solvents or plasticizers.

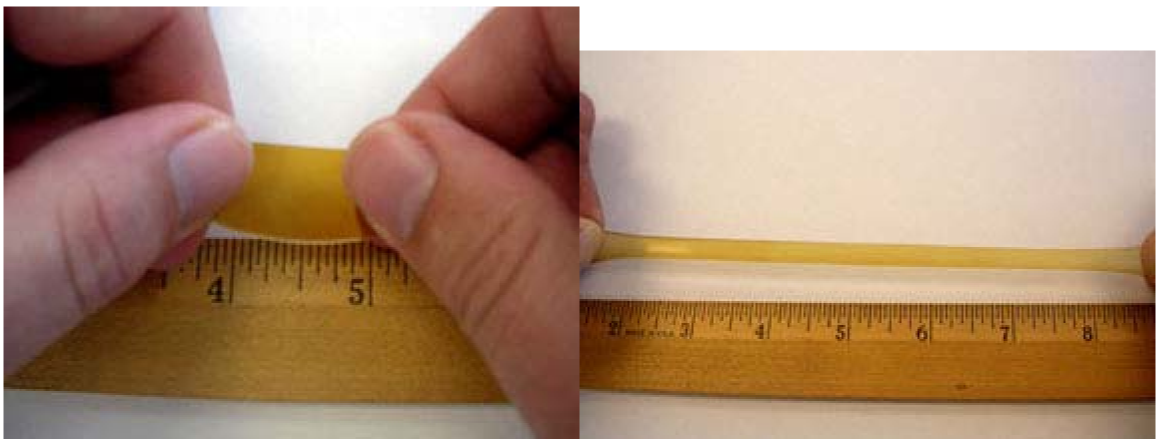
Glenn previously produced a series of rod-coil block copolymers made from polyimide rods alternating with short PEO segments. When doped with lithium salts, these polymers were strong, flexible, thermally and mechanically stable up to high temperatures, and completely amorphous over the required temperature range. Furthermore, these polymers demonstrated room-temperature conductivities as high as 2.3×10^{-5} S/cm, in comparison to 6.0×10^{-6} S/cm for state-of-the-art PEO measured in-house.



Room-temperature conductivity of state-of-the-art PEO and previous rod-coil polyimides compared with new elastomeric polymers.

Long description of figure 1. Bar chart of conductivity in siemens divided by centimeters for PEO (6×10^{-5}, rod-coil (2.2×10^{-5}, silane cross-linked (3.7×10^{-5}), and PEO cross-linked (4.3×10^{-5}).

Recently, Glenn researchers made new block copolymers that improve upon the conductivity of the rod-coil polymer systems while maintaining dimensional stability. In the new systems, the polyimide segment is replaced by a triazine molecule with three reactive sites toward primary amines. The third reactive position provides a site for both branching to increase conductivity and crosslinking to provide mechanical strength. Films have been cross-linked by silicon-oxygen bridges to provide a partial inorganic network. The most conductive films in this series have a room-temperature conductivity of 3.7×10^{-5} S/cm when doped with lithium salts. Films also have been cross-linked with PEO molecules that are terminated with primary amines at both ends. The highest conductivity obtained so far for these films is 4.3×10^{-5} S/cm. These new polymers are readily cast into rubbery freestanding films when cured at 160 °C. The polymer films are stable to over 300 °C and can be stretched to over 7 times their original length.



Silane cross- linked elastomer before and after stretching.

Find out more about this research at
http://www.grc.nasa.gov/WWW/MDWeb/5150/Polymers.html

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