

# Rod/Coil Block Copolyimides for Ion-Conducting Membranes

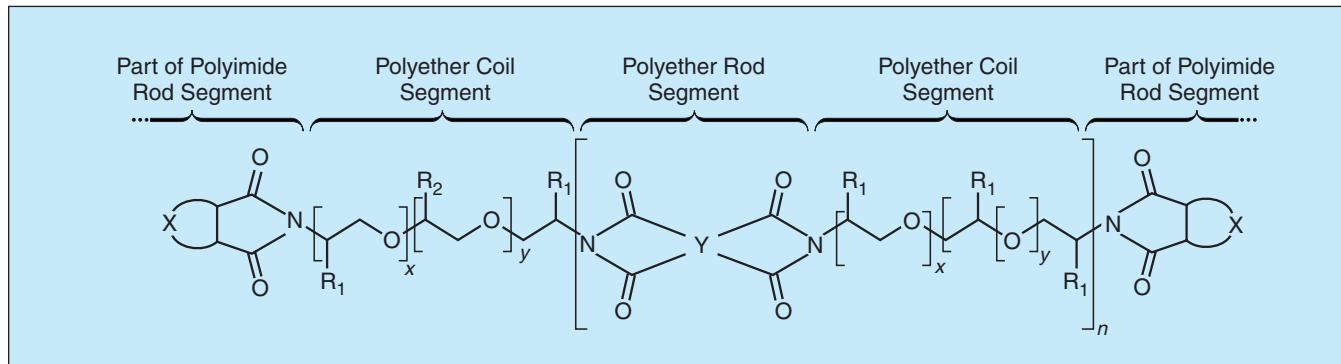
Lithium cells and fuel cells could function over wider temperature ranges.

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Rod/coil block copolyimides that exhibit high levels of ionic conduction can be made into diverse products, including dimensionally stable solid electrolyte membranes that function well over wide temperature ranges in fuel cells and in lithium-ion electrochemical cells. These

with increasing temperature above 80 °C because of loss of water from within the membrane. The loss of water has been attributed to the hydrophobic nature of the polymer backbone. In addition, perfluorosulfonic polymers are expensive and are not sufficiently stable for long-term use.

synthesized and processed easily (e.g., by solution casting) to make membranes. These polymers are expected to cost less than perfluorosulfonic polymers. Suitable functionality can be introduced into the rods and/or coils to produce or enhance (1) retention of



A **Rod/Coil Block Copolyimide** molecule comprises polyether coil segments and polyimide rod segments.  $R_1$  denotes a hydrogen, alkyl, or alkoxy radical;  $R_2$  denotes hydrogen or an alkyl or alkoxy group and may be the same as, or different from,  $R_1$ ;  $X$  denotes an aromatic or aliphatic group;  $Y$  denotes any of a variety of straight or branched polyimide segments;  $x$  and  $y$  are zero or greater; and  $n$  is 1 or greater.

rod/coil block copolyimides were invented to overcome the limitations of polymers now used to make such membranes. They could also be useful in other electrochemical and perhaps some optical applications, as described below.

The membranes of amorphous polyethylene oxide (PEO) now used in lithium-ion cells have acceptably large ionic conductivities only at temperatures above 60 °C, precluding use in what would otherwise be many potential applications at lower temperatures. PEO is difficult to process, and, except at the highest molecular weights it is not very dimensionally stable.

It would be desirable to operate fuel cells at temperatures above 80 °C to take advantage of better kinetics of redox reactions and to reduce contamination of catalysts. Unfortunately, proton-conduction performance of a typical perfluorosulfonic polymer membrane now used as a solid electrolyte in a fuel cell decreases

Rod/coil block copolyimides are so named because each molecule of such a polymer comprises short polyimide rod segments alternating with flexible polyether coil segments (see figure). The rods and coils can be linear, branched, or mixtures of linear and branched. A unique feature of these polymers is that the rods and coils are highly incompatible, giving rise to a phase separation with a high degree of ordering that creates nanoscale channels in which ions can travel freely. The conduction of ions can occur in the coil phase, the rod phase, or both phases. The rod phase also imparts dimensional and mechanical stability to the polymer. In the case of a rod/coil block copolyimide synthesized for use in a fuel cell, the incorporation of the polyether coils enables the polymer to hold water at higher temperatures than it could in the absence of these coils.

Rod/coil block copolyimides can be

water; (2) the transport of lithium ions in a lithium-ion cell; (3) the transport of protons for use in a fuel cell; (4) the transport of the aforementioned or other ions for use in chemical sensors, ion sensors, water-purification devices, and other electrochemical devices; and/or (5) optical properties for use in optical waveguides.

*This work was done by Mary Ann B. Meador and James D. Kinder of Glenn Research Center. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17299.*