

order by using gas tight syringes. After stirring for 3 days, the reaction was quenched with methanol. The polymer was fractionated by dissolving in diethyl ether and then precipitated with hexane. After the removal of solvent, the polymer was then dissolved in 30 mL HPLC water and extracted with CH_2Cl_2 /diethyl ether (v/v=3) twice in order to remove the residue base. The organic phase was condensed with a rotavapor and then dried at 65° C. under vacuum for 3 days. About 8.5 g of polymer was obtained (yield, 85.5%), it was a viscous liquid with molecular weight Mw around 20K (measured by GPC). NMR spectrum confirmed the random structure and desired composition. NMR (CDCl_3 , selected): 5.95(m, 1, $\text{CH}_2\text{-CH}=\text{CH}_2$), 5.30(q, 2, $\text{CH}_2\text{-CH}=\text{CH}_2$), 4.07(d, 2, $\text{CH}_2\text{-CH}=\text{CH}_2$), 3.37(s, 15, CH_3).

Example 4

The preparation of a single-ion conductor is prepared as follows. The comb-branch copolymers were grafted with lithium salt 3 (of FIG. 3) by a hydrosilylation reaction under the platinum catalyst retained in the salt. The equivalent amount of salt and copolymer were dissolved in THF and refluxed for 3 days when about 75% of allyl groups were consumed. Diethyl ether was then added to precipitate the catalyst. After removal of diethyl ether, the slightly yellowish polymer was recovered and then dried. The polymer was finally subjected to dialysis using a membrane with a molecular weight cut-off of 6K–8K for 8 days. The solution was then concentrated under a rotary evaporator and was cast on Teflon coated substrates. The films were then transferred into a drying piston with P_2O_5 as a drying agent and dried under vacuum (50 mtorr) at 65° C. for 3 days. Transparent free-standing films were obtained.

Measurements and characterization. All ^1H spectra were obtained from a Bruker AMX-400 NMR spectrometer. DSC and TGA scans were performed on Perkin-Elmer DSC-7 differential scanning calorimeter and TGA-7 thermogravimetric analyzer, respectively, at a heating rate of 10° C./min. Molecular weight and distribution of polymers were measured on a Rainin Dynamax HPLC modified GPC, using a minimix-B PL gel column. Ionic conductivity of the single-ion conductors was determined from complex impedance spectra measured with stainless steel blocking electrodes using a Solartron 1286 Frequency Response Analyzer. The cells were maintained at different temperatures for 0.5–1 hr until thermally stabilized, prior to measurement. The polymer films were examined by DSC and conductivity measurements (FIGS. 5 and 6, respectively). The results are consistent with expectations for a single-ion conductor material. Conductivities of the SIC-45 material are excellent as a value of 10^{-5} S/cm is obtained above 60° C. FIG. 7 shows the polarization behavior of the SIC-85 material at 85° C. where a current density of 0.05 mA/cm² is imposed on a symmetrical Li/polymer/Li cell. Both cells are cycled galvanostatically at 0.05 mA/cm². SIC-80 is the electrolyte shown in FIGS. 5 & 6 with a glass transition temperature of -51° C. and a conductivity of 10^{-5} S/cm at 85° C. The PVBE polymer is a cross-linked polyvinylbenzyle ether with a side chain length of 12 EO units. The behavior is contrasted with the behavior of a polymer electrolyte containing a lithium salt under similar current conditions. The invariant voltage behavior of SIC-85 is characteristic of a polyelectrolyte where the anion is covalently fixed to the polymer and only the Li^+ . The cycle involved the passage of >7.2 coulombs/cm² of charge. The reverse cycle shows some drift in the voltage which may be due to reaction of the polyelectrolyte with lithium. After two cycles the cell fails due to reaction at the lithium metal. While not wishing to be bound by any particular theory, it is possible that this reaction may be due to the use of the disiloxane to graft the anion to the polymer. The stability will be improved by use of silanes instead

which will not contain the labile Si—O—Si groups. Otherwise, the instability is most probably due to impurities which can be removed by more rigorous dialysis and drying procedures.

These results illustrate several points about the invention. The silane or siloxane reaction may be used to graft groups on to pre-polymers that are designed with a reactive allyl group. The graft reaction can be carried out in a manner that is quite clean and which can be improved by further purification of the polymer. The grafting reaction is very controllable and involves no other groups than the introduced allyl groups, though the instant invention is not so limited. Attachment of the anion to a longer chain leads to higher conductivities. Comparison with polyelectrolytes prepared with the same anion that was bound to a much shorter side chain shows that the conductivity is higher for the longer side-chain polymer. Variation of the concentration of the anion in the polyelectrolyte leads to an optimum conductivity. Direct comparison of the low lattice energy anion, $(\text{CF}_3\text{SO}_2)_2\text{C}-\text{Si}-$ with a sulfonate anion bound in a similar fashion is inconclusive. The conductivities of the two polyelectrolytes are similar.

It will be appreciated that conductive compositions formulated with the novel electrolyte materials of the invention are also useful in the fabrication of fuel cells, sensors, supercapacitors, electrochromic devices, and the like, using manufacturing techniques well known to those skilled in the art, or readily available in the relevant literature.

Although the foregoing invention has been described in some detail for purposes of clarity of understanding, those skilled in the art will appreciate that various adaptations and modifications of the just described preferred embodiments can be configured without departing from the scope and spirit of the invention. Therefore, the described embodiments should be taken as illustrative and not restrictive, and the invention should not be limited to the details given herein but should be defined by the following claims and their full scope of equivalents. Further, it is to be understood that all references and patents cited herein are expressly incorporated herein by reference.

We claim:

1. An interpenetrating polymer network comprising a comb-branch polymer having unconjugated side chains, said side chains being capped with solvating moieties such that the solvating moieties are capable of solvating a cation, and wherein
 - 1,3 propanediol units or a mixture of 1,3 propanediol and ethylene oxide units, and there are substantially no Si—O—C linkages.
2. The interpenetrating polymer network of claim 1, wherein the solvating moieties are not all identical.
3. The interpenetrating polymer network of claim 1, wherein the solvating moieties are selected from the group consisting of imidazoles, hydroxyls, methoxy, pyridines, pyrazines, oxazoles, phosphates, acrylates, carbonates.
4. The interpenetrating polymer network of claim 1, wherein the side chain may be branched or unbranched and is chosen from the group consisting of alkyl, lower alkyl, allyl, alkyl ethers, lower alkyl ethers, allyl ethers, alkylated poly(ethylene glycols).
5. The interpenetrating polymer network of claim 1, wherein the solvating moieties comprise imidazoles and oxazoles.
6. The interpenetrating polymer network of claim 5, wherein the solvating moiety comprises imidazoles.
7. The interpenetrating polymer network of claim 4, wherein the side chain comprises a branched or unbranched ether.
8. The interpenetrating polymer network of claim 1, wherein the cation is chosen from the group consisting of an