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19. ABSTRACT (Continue on reverse if necessary and identify by block number) The present study investigated solid state secondary lithium cell systems, especially Li/PEO, LiCF ₃ SO ₃ /V ₆ O ₁₃ . The material necessary to fabricate thin film (100-200 ^{micron} nm) cells were characterized and the behavior of the cells was investigated as a function of cycle number, humidity, overcharge, temperature and rate. Cell performance looked promising with continued cycling. Results were reported in twenty-one technical publications.				
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The investigation of polymeric solid electrolyte cells, carried out during a nominal three-year period, focused on the rechargeable lithium battery,



where polyethylene oxide (PEO) and the lithium salt form an ionically conductive complex. The objective was to characterize thin, solid state electrochemical cells and identify those problems that may impact scale-up of the cells and their ultimate usefulness.

The results of the investigation were reported in scientific journals and presented at various conferences, as summarized by the listing in Table 1. The individuals who participated in the research are the following:

Dr. R. Gopaliengar
Tom Hayes
John David Locatus
Gonzalo Mortinez
Dr. M. Zafar A. Munshi

Son Nguyen
Dr. Boone B. Owens
P. Van Sickle
Dr. Paul Skarstad
Oanh Vo

The accomplishments of this program included the following:

- (1) New materials properties were reported for lithium polymer electrolytes.
- (2) A process was developed for the preparation of polymeric composite cathode structures containing solid cathodes (V_6O_{13}), carbon and polymer electrolytes.
- (3) Rechargeable lithium cell performance was investigated as a function of cycle number, humidity, overcharge, temperature and rate.
- (4) Morphological changes at the electrode/electrolyte interfaces were assessed after cycling. The uniformity of the electrode surface indicated no problems with long-term cycling in these electrodes with very low loadings and the low current densities that are inherent in the design.

The cells look promising for additional development. Further studies should assess modelling of performance as a function of design, scale up, behavior of multi-cell designs and hardware designs that will maintain adequate mechanical constraints on the cells. Overcharge stable designs are an important objective. A major goal should be to incorporate room temperature polymer electrolytes into the designs to permit wider applications.

Table 1. ONR Technical Reports, Contract N00014-85-K-0634

Technical Report #	Title and Reference
1	"Solid State Batteries", M.Z.A. Munshi & B.B. Owens, Proc. of the Symp. on Electrochem. and Solid State Science Education at the Graduate and Undergraduate level, Ed. W.H. Smyrl and F. McLarnon, Proceeding Volume 87-3, The Electrochemical Society, p. 116 (1987).
2	"Phase Diagrams for the PEO-LiX Electrolyte System," M.Z.A. Munshi & B.B. Owens, Applied Physics Communications, Vol 6(4), p. 279 (1986-1987).
3	"A Study into the Effect of Humidity on (PEO) ₂ •LiCF ₃ SO ₃ Solid Polymer Electrolyte," M.Z.A. Munshi & B.B. Owens, Applied Physics Communications, Vol 6(4), p. 299 (1986-1987).
4	"Solid State Lithium/Polyacetylene Battery," B. Scrosati & B.B. Owens, Solid State Ionics, <u>23</u> , 275 (1987).
5	"History of Solid State Batteries," B.B. Owens & M.Z.A. Munshi, Proc. of the Symp. on History of Battery Technology, Ed. A.J. Salkind, Proc. Vol. 87-14, p. 199 (1987).
6	"Rechargeable High Energy Density Solid State Polymer Electrolyte Batteries," M.Z.A. Munshi, B.B. Owens, R. Gopaliengar, P.M. Skarstad, Penny Van Sickle, & G. Martinez, presented at ASM Conference on Materials Processes and Corrosion in Microelectronics, April 28, 1987.
7	"Solid State Batteries," M.Z.A. Munshi & B.B. Owens, invited chapter in "Superionic Solids and Solid Electrolytes--Recent Trends," Eds. A.L. Lasker and S. Chandra, Academic Press, (1988).



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8	"Applications of Multivalent Ionic Conductors to Polymeric Electrolyte Batteries," J.Y. Cherng, B.B. Owens, W.H. Smyrl, & M.Z.A. Munshi, Proceedings of the 6th International Meeting on Solid State Ionics, Garmisch - Partenkirchen, W. Germany, Sept. 6-11, 1987; Solid State Ionics, 28-30, p. 857 (1988).
9	"Ionically Conductive Polymers: Application to Solid State Batteries," B.B. Owens, M.Z.A. Munshi & Paul M. Skarstad, 38th Meeting of Int. Soc. of Electrochemistry, Poster + Extended Abstract, Maastricht, The Netherlands, September 14-18 (1987).
10	"Optimization and Scale-Up Performances of Polymer Electrolyte Batteries," M.Z.A. Munshi & B.B. Owens, Proc. of the Symp. on Primary and Secondary Ambient Temperature Lithium Batteries, Eds., J.P. Gabano, Z. Takehara and P. Bro, Proc. Vol. 88-6, The Electrochem. Soc., p. 737, (1988).
11	The Overcharge and Overdischarge Behavior of Polymer Electrolyte Cells, R. Gopaliengar, M.Z.A. Munshi & B.B. Owens, Extended Abstracts of 172nd Meeting of Electrochemistry, p. 121, 1987.
12	"Applications of Multivalent Ionic Conductors to Polymeric Electrolyte Batteries," J.Y. Cherng, M.Z.A. Munshi, B.B. Owens, & W.H. Smyrl, 38th Meeting of Int. Soc. of Electrochemistry, Poster + Extended Abstract, Maastricht, The Netherlands, September 14-18 (1987).
13	"Optimization and Scale-Up Performance of Polymer Electrolyte Batteries," M.Z.A. Munshi & B.B. Owens, Eds., J.P. Gabano, Z. Takehara and P. Bro, Proc. Vol. 88-6, The Electrochem. Soc., p. 737, (1988).
14	"The Overcharge Behavior of Polymer Electrolyte Cells," R. Gopaliengar, M.Z.A. Munshi, & B.B. Owens, Eds., J.P. Gabano, Z. Takehara and P. Bro, Proc. Vol. 88-6, The Electrochem. Soc., p. 726 (1988).
15	"Performance of Polymer Electrolyte Cells at +25 to +100°C," M.Z.A. Munshi & B.B. Owens, Solid State Ionics, 26(1), (1988) 41.
16	Measurement of Li ⁺ Ion Transport Numbers in PEO-LiX Complexes, M.Z.A. Munshi, B.B. Owens & S. Nguyen, Polymer Journal, 20(7) p. 597, (1988).
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18	Morphological Changes in Polymer Electrolyte Cells, M.Z.A. Munshi & B.B. Owens, Solids State Ionics, 27, p. 251, (1988).
19	Corrosion Phenomena During Overcharge in Polymer Electrolyte Cells, M.Z.A. Munshi, R. Gopaliengar, & B.B. Owens, Solid State Ionics, 27, p. 259 (1988).

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- 20 Lithium Secondary Batteries: Role of Polymer Cathode Morphology, Katsuhiko Naoi, Tetsuya Osaka, & B.B. Owens, Proceedings of Symposium on Materials and Processes for Lithium Batteries, Eds. K.M. Abraham and B.B. Owens, Fall Meeting, The Electrochemical Society, Chicago, 1988, (to be published in 1989).
 - 21 Intercalation Reactions of Monovalent and Divalent Cations in V_6O_{13} Single Crystals, M.Z.A. Munshi, A. Gilmour, B.B. Owens, & W.H. Smyrl, Proceedings of Symposium on Materials and Processes for Lithium Batteries, Eds. K.M. Abraham and B.B. Owens, Fall Meeting, The Electrochemical Society, Chicago, 1988, (to be published in 1989).
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