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BEHAVIOR OF POLYMER ELECTROLYTE BATTERIES AT 80 - 100 °C AND NEAR ROOM TEMPERATURE

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A joint R&D project (ACEP Project) between SNEA, IREQ and ANVAR (Agence Nationale de Valorisation de la Recherche) acting for LEE has been under way since 1980 to develop thin-film, solid-state batteries based on polyether complexes. The starting point for this project was Armand's pioneering work [1], which suggested the use of polymer electrolytes for high-energy-density batteries. Albeit only slightly conducting, these materials can be obtained in a high surface-to-thickness ratio and can also maintain good contact with the electrode materials. The main interest of SNEA and IREQ in this joint project is to develop a battery for electric vehicle (EV) application. Consequently, the project was organized along the lines of the main technical tasks identified as being essential to its success (Fig. 1). In addition, in order to meet the power density requirement for EV application (>80 W/kg sustained power) with polyethylene oxide (POE 5M) based electrolytes, the operating temperature was fixed at 80 - 100 °C for most of the tests.

Usually, POE electrolytes have very limited performances at temperatures lower than 40 °C, but recently a first family of polyether electrolytes was developed as a result of the ACEP Project research activities. These new electrolytes are at the origin of the near Room (ambient) Temperature Project, also mentioned in Fig. 1.

The experimental work presented here was carried out using electrolyte and composite-electrode films obtained by solution-casting techniques as described previously [1, 2]. The results at high temperature are based on commercial POE from Polyscience and on TiS_2 and V_6O_{13} powders prepared by in-house synthesis. A description of the experimental devices used, including the first scale-up (70 cm^2) cells, will be presented elsewhere [3].

Most of the results presented here are related to the characterization of Li/POE/TiS_2 and Li/POE/V_6O_{13} cells in terms of their cycling performance. Typical results are illustrated in Figs. 2 and 3. Figure 2 provides a good

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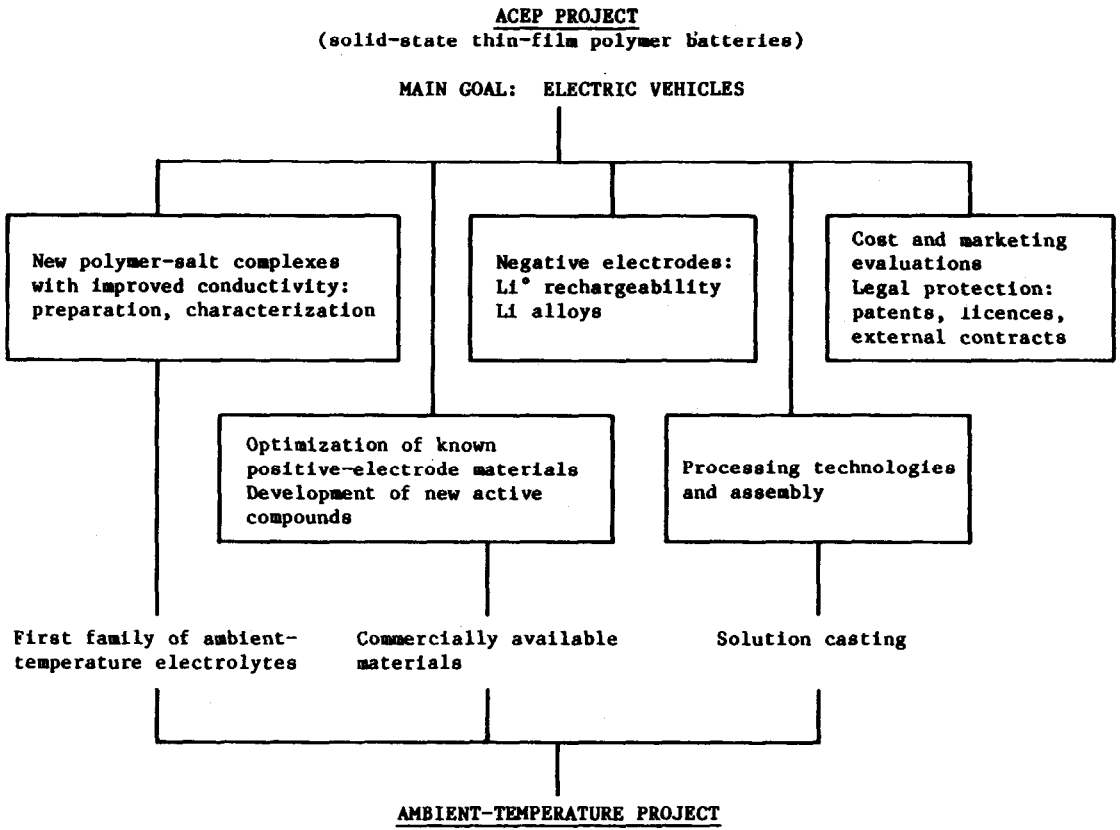

Fig. 1. Organisation of ACEP Project

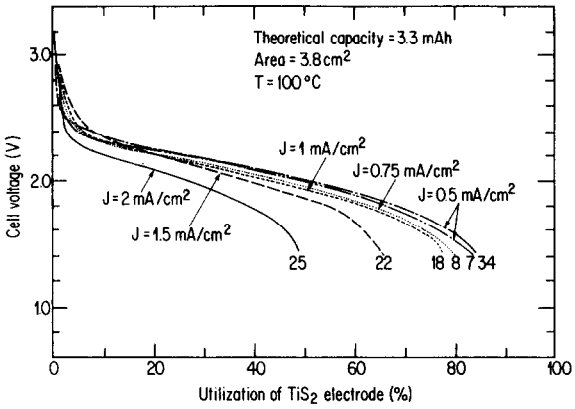

Fig. 2. Discharge plateaux of Li/TiS_2 cell at different currents and cycle number, T = 100 °C, POE (5M)–$LiClO_4$ (O/Li = 8/1).

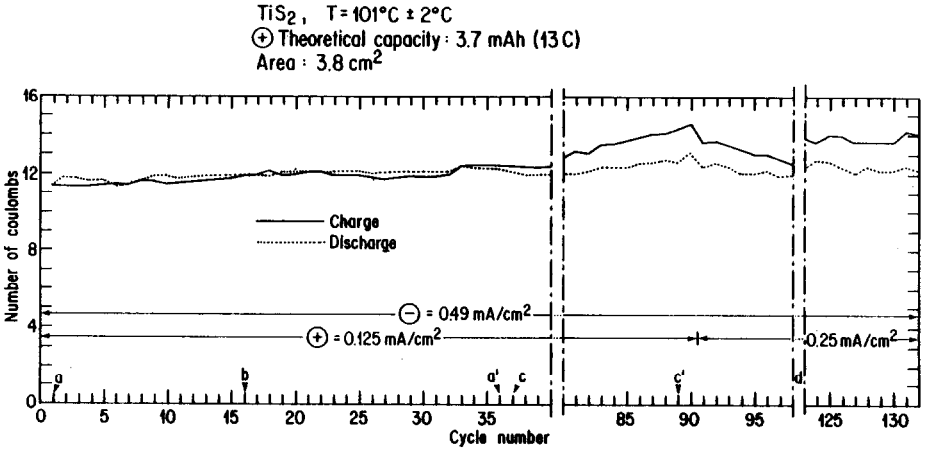

Fig. 3. Cycling profile of an Li/TiS_2 cell; number of coulombs observed on charge or discharge *vs.* cycle number, T = 100 °C, POE (5M)–$LiClO_4$ (O/Li = 8/1).

example of the discharge characteristics *versus* current density of a cell operated at 100 °C with a TiS_2 composite electrode, while Fig. 3 presents the cycling performance of a similar cell, still cycling after 250 deep discharge/charge cycles (>80%). Other results presented deal with the presence or the nature of the lithium salt used in the composite electrode, $LiCF_3SO_3$ *vs.* $LiClO_4$, or with the dendrites that occur on occasion but are not detrimental to cell performance. Results are also included on V_6O_{13} composite electrodes, and the first scale-up attempts (140 cm^2) are presented with performances representative of the smaller cells (3.8 cm^2). Finally, energy densities in excess of 100 W h/kg, with power densities ranging from 70 to 250 W/kg are shown to be possible, assuming that the negative lithium capacity is three times the positive electrode value. An energy efficiency, (W h-out at $C/2$)/(W h-in at $C/7$), in excess of 90% is found for $Li/POE/TiS_2$ cells.

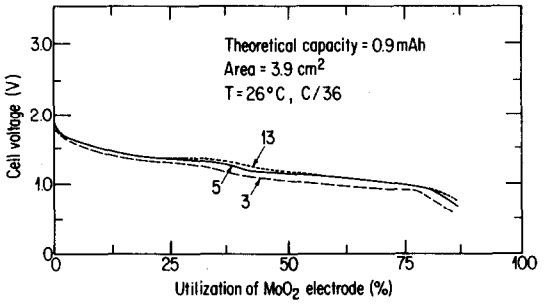

Fig. 4. Discharge plateaux *vs.* cycling for an Li/MoO_2 cell operated at 26 °C.

These results mark, in fact, a first step towards performance optimization based on presently known or commercially available materials. Efforts are now being pursued in an endeavor to improve these performances by increasing the surface capacities of the positive composite electrode and to determine the behavior and cost of larger installations of thin-film polymer electrolyte cells.

Finally, preliminary results for polymer electrolyte batteries operated at 26 °C are presented. High utilization of positive-electrode materials is demonstrated on primary (Li/MnO_2) and secondary ($Li//TiS_2$, $Li//MoO_2$) cells for discharge rates from $C/15$ to $C/600$. More than 20 deep discharge/charge cycles (>75%), or over 300 partial cycles (15 - 50%) have already been attained (Fig. 4). Preliminary calculations based on such experimental data indicate promising energy densities, especially for rechargeable cells with volumetric densities in the range 0.1 - 0.2 W h/cm^3, packaging not included. These preliminary results, together with other characteristics of ACEP technology such as no self-discharge, no liquid electrolyte, and good storage properties, make the polymer electrolyte battery promising for microelectronic or other applications, especially those requiring a rechargeable power source.

References

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