Activated carbon and poly(3-methylthiophene)-based hybrid supercapacitor—Basic Studies

M. Mastragostino, F. Soavi
UCI-Scienze Chimiche, Università di Bologna,
via San Donato 15, 40127 Bologna (Italy)
C. Arbizzani, A. Balducci
Dip. Chimica "G. Ciamician", Università di Bologna
via Selmi 2, 40126 Bologna (Italy)

Electrochemical supercapacitors were under study in the framework of the European Project Joule III “Supercapacitors of Power and Energy” (SCOPE). The SCOPE Project started on 1998 and involved the Universities of Palermo-Bologna (Italy) and Paris-CNAM (France), the governmental energy agency ENEA (Italy) and the companies Arcotronics Italia S.p.A. (Italy) and CEAC-Exide (France).

The goal of SCOPE project is to outperform the double layer carbon supercapacitors (DLSs) based on activated carbons (AC) of high surface area with polymer-based supercapacitors for electric vehicle applications. The electronically conducting polymers (ECPs), indeed, show pseudocapacitive behavior and are promising electrode materials for supercapacitors because they are materials of high specific capacitance, as the charge process involves the entire polymer mass, and they are materials of high conductivity at least in the p-doped state, so that devices with low equivalent series resistance are feasible. Basic studies on several ECPs carried out in the framework of this Project permitted to select the poly(3-methylthiophene) (pMeT) for its high specific capacitance and cycling stability. Symmetric n/p pMeT supercapacitors were assembled and tested over several thousand of cycles. However, from these studies resulted that these n/p type supercapacitors, for the intrinsic limitation related to the negative n-doped electrode, do not appear competitive with the carbon DLSs. On the other hand, the high performance of pMeT as positive electrodes indicated that hybrid supercapacitors, in which the positive electrode is a p-doped polymer and the negative is an activated carbon, are an excellent strategy to outperform the DLSs still maintaining a reasonable cost-to-performance ratio, as the Ragone plot in Figure 1 shows.

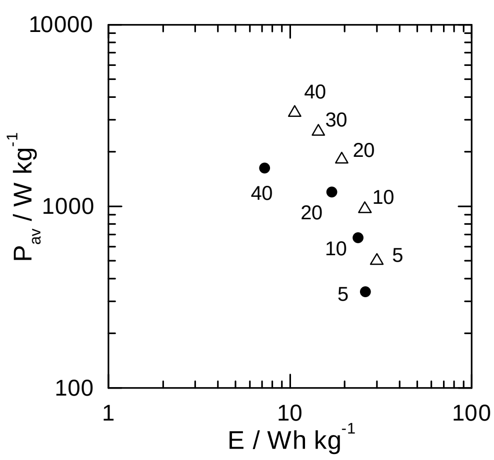

Figure 1. Ragone plot for AC/pMeT hybrid super capacitor (△) (cut off: 1.0-3.0 V) and DLS (•) (cut off: 0.0-2.8 V) with the same electrolyte, cell assembling and total mass loading. Labels indicate the current density in mA cm^{-2}.

In addition, it has been demonstrated that the high performance of such laboratory-scale hybrid supercapacitors are still exhibited by larger module prototypes. Results of impedance spectroscopy as well as of galvanostatic charge-discharge cycles of AC/pMeT-based laboratory-scale hybrid supercapacitors will be presented and compared with those of DLSs.

Acknowledgments
The authors want to thank the European Commission for the financial support and the partners of the SCOPE Project (JOE3-CT97-0047).

References

1. A. Di Fabio, A. Giorgi, M. Mastragostino, F. Soavi, *J. Electrochem. Soc.* 2001, 148 A845-A850
2. A. Laforgue, P. Simon, J. F. Fauvarque, J.F. Sarrau, P. Lailler, *J. Electrochem. Soc.* 2001, 148 A1130-A1134
3. C. Arbizzani, M. Mastragostino, F. Soavi, *J. Power Sources* 2001, 100, 164-170
4. A. Laforgue, P. Simon, J. F. Fauvarque, J. F. Sarrau, P. Lailler, *11th International Seminar on Double Layer Capacitors and Similar Energy Storage Devices*, Florida Educational Seminars, Inc., Deerfield Beach (FL), December 2001