“Green” carbon for energy storage systems in non-aqueous electrolytes

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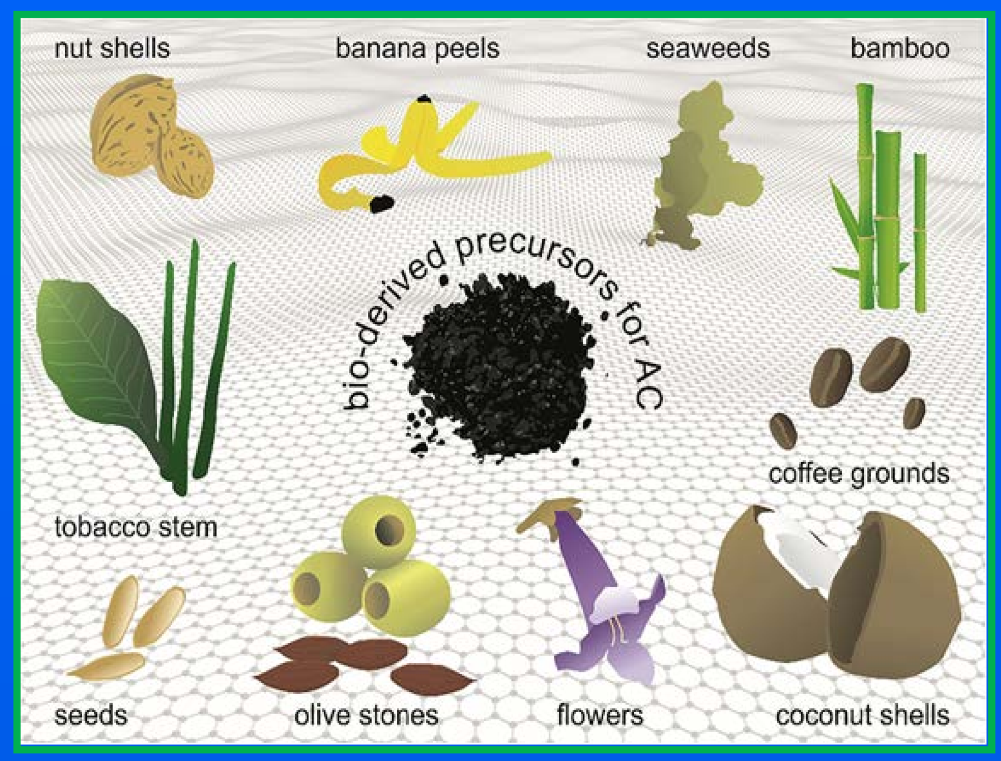
Introduction

The nanostructured carbon-based materials fabricated from renewable bio-resources have great potential in the rechargeable energy storage systems - a modern, inexpensive and affordable approach. Carbon is one of the most abundantly available and structurally diverse materials, and most present-day EDLCs employ porous carbons as the active electrode material. Abundantly available organic materials such as coconut shells, charcoal, nut shells, wood, and food waste are a particularly attractive natural resource for the commercial production of porous carbon materials. The coconut shell produces nanostructured carbon with a relatively low internal resistance and good electrical conductivity properties, which determines their potential in the rechargeable energy storage systems.

The supercapacitors are known to be promising energy storage devices for applications requiring high power and long cycle life. There are two basic and interlinked approaches to improving their capacity and stability, focusing on the appropriate choice of electrode material on the one hand and the electrolyte on the other.



The improvement of the supercapacitor performance can further be achieved by the appropriate selection of the electrolyte composition. The desirable properties of an electrolytic system for supercapacitors are: high ionic conductivity, wide voltage window, and high electrochemical and thermal stability, low viscosity, low toxicity, low cost, etc.

Aqueous electrolytes have a limited cell voltage window and most commercial electrochemical capacitors use organic electrolytes instead of aqueous electrolytes. It is known that the higher operation voltage will give rise to a significant improvement of energy density, because it is proportional to the square of the operation voltage. Therefore, replacing conventional aqueous electrolytes (1 V) with organic electrolytes (2.7 V) is desirable for high-energy-density supercapacitors.

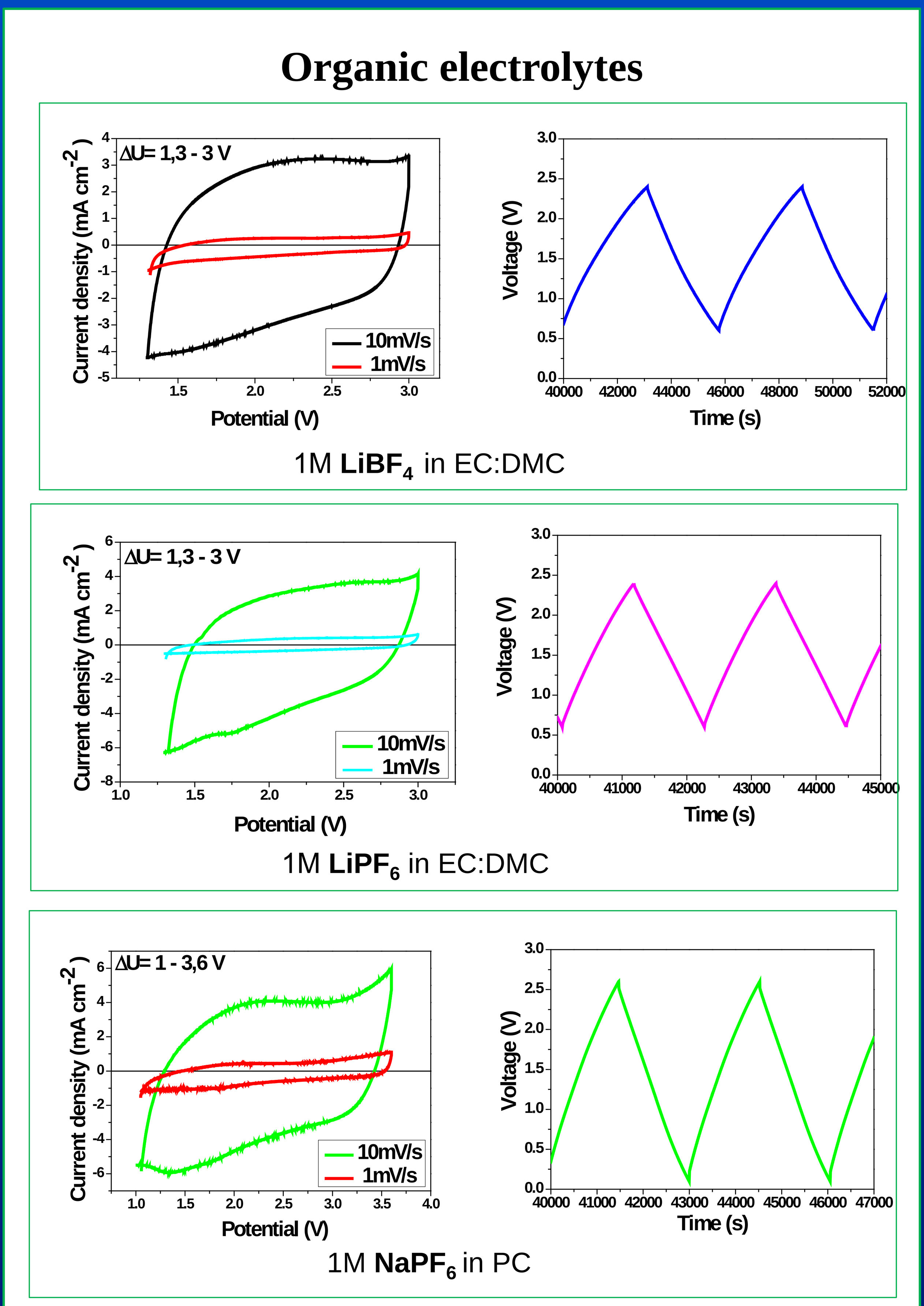
Ionic liquids are becoming more and more popular in modern green technologies and more widely used as electrolytes in supercapacitors due to their: electrochemical and thermal resistance; wide volt window (up to 4 V); suitable mechanical stability; low flammability; environmentally friendly and others.

Therefore the proper selection of an electrolyte and a potential window is essential for optimal performance of the supercapacitor.

Experimental

The commercial activated carbon (YP-50F, “Kuraray Europe” GmbH) were used to fabricate electrodes for supercapacitor cells for electrochemical measurements. The symmetric supercapacitor cell contains two identical coin type electrodes from activated carbon and different electrolytes – $LiBF_4$ with solvent ethylene carbonate/dimethyl carbonate mixture 1:1, $LiPF_6$ and $NaPF_6$ with solvent propylene carbonate, and ionic liquid 1-ethyl-3-methylimidazolium tetrafluoroborate ($EMIMBF_4$). By adding a binder – PVDF to the electrode material, a paste is formed, which is glued to Al foil discs. The formed sheet electrodes were dried in vacuum at 80 ^oC for 12 hours and pressed under pressure of 20 MPa. The obtained electrodes were mounted in the electrochemical cell with Whatman separator and filled with electrolyte in a dry box under argon atmosphere. The reference electrode was Li/Li+ or Na/Na^+. All measurements were performed at room temperature.

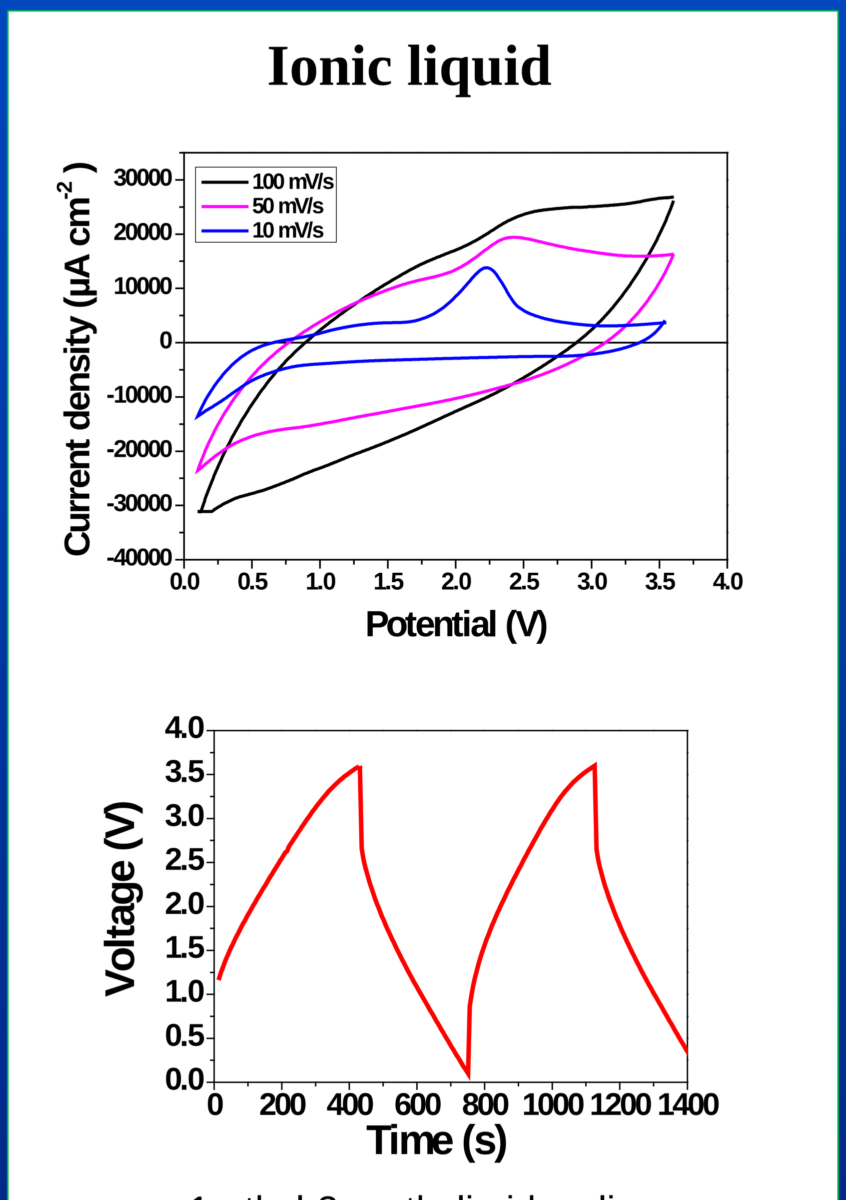
Results & Discussion



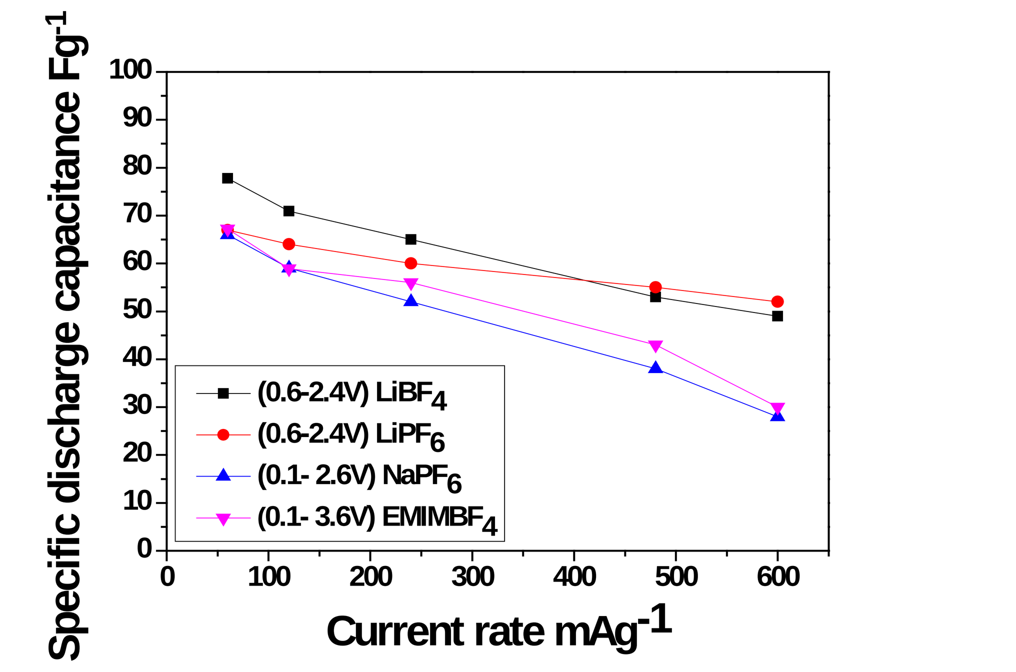
1M $LiBF_4$ in EC:DMC

1M $LiPF_6$ in EC:DMC

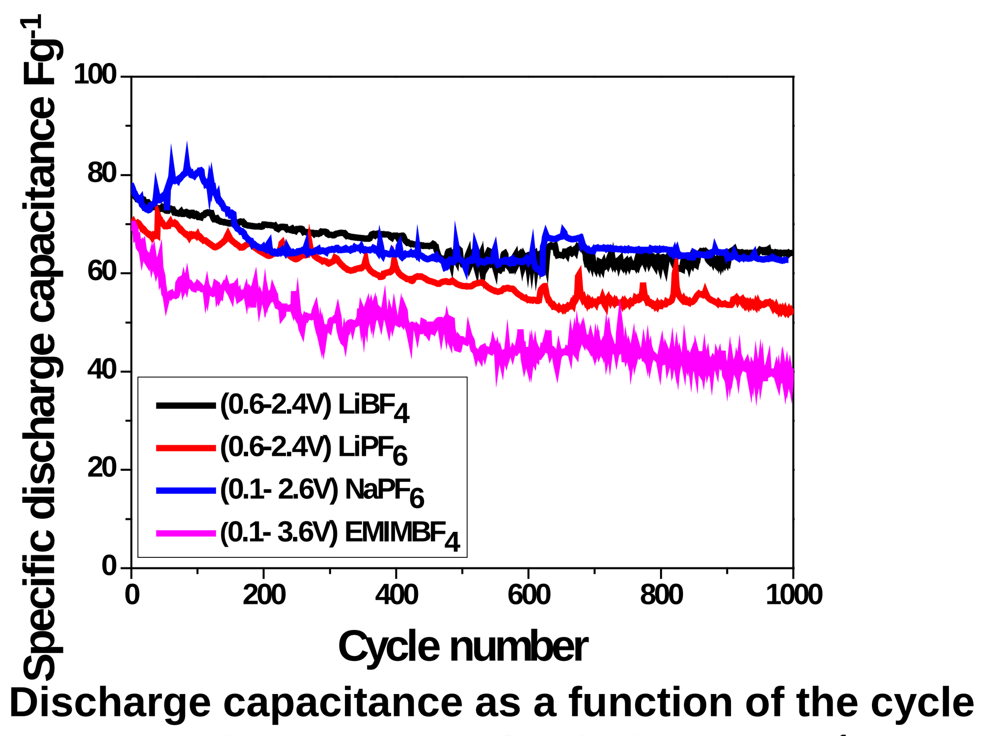
1M $NaPF_6$ in PC



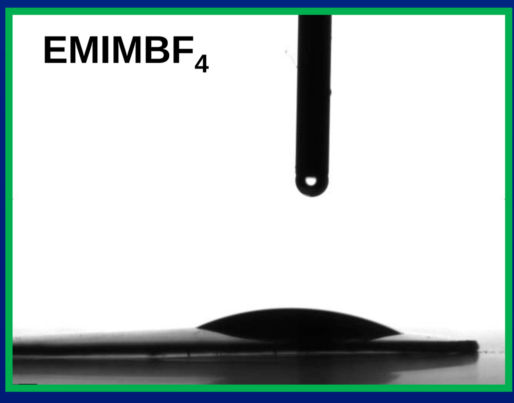
1-ethyl-3-methylimidazolium tetrafluoroborate (**$EMIMBF_4$**)



Discharge capacitance as a function of the current load



Discharge capacitance as a function of the cycle number at current load of 240 mAg^{-1}



Electrolyte	1M $LiBF_4$ in EC/DMC	1M $LiPF_6$ in EC/DMC	1M $NaPF_6$ in PC	$EMIMBF_4$
Wetting angle°	0°	18.4°	38.8°	26.3°

Conclusions

The present study shows that the potential window in which the supercapacitor operates depends on the electrolyte stability. The correct determination of potential limits is essential for achieving the optimal supercapacitors performance. The results obtained are a good prerequisite for future research and for a more complete elucidation of the processes occurring in various organic electrolytes and ionic liquids.

Acknowledgments: This work was funded by Bulgarian National Science Fund, grant number No KP-06-OPR 04/5 and agreement with the Bulgarian National Program "Young Scientists and Postdoctoral Students". Some of the experiments were performed using equipment included in the National Infrastructure NI SEVE supported by the Ministry of Education and Science under grant agreement N° DO1-160/28.08.18.