Organic electrode materials: an alternative for greener lithium battery

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Lithium-ion batteries are considered as the most promising energy storage technology to enable the successful electrification of modern society's mobility needs. However, beside the necessity for increased energy and power, two main issues remain which are the high cost and severe safety concerns. The first issue is particularly related to the incorporation of pricey metals as cobalt or nickel in the composition of positive electrode and copper as current collector. For example, cobalt is a critical metal widely used in batteries and which is approaching the near-critical level of supplying.[1]

An interesting alternative could be the use of organic electrode materials such as carbonyl-contained molecules or polymers which can be derived from biomass. Furthermore, they have also proven to be superior hosts in storing lithium, sodium, potassium or magnesium ions.[3] Lithium π-conjugated carboxylates discovered by Armand et al in 2009,[4] are among the best candidates for organic batteries in cation-ion configuration because they benefit from a relatively low working potential 0.8-1.4 V vs Li^+/Li and have high capacities 150-300 $mAh.g^{-1}$. On the other hand, aromatic polyimides are also good candidates for an organic cation-ion battery thanks to the coupling of the carbonyl group (imide) with a π-conjugated platform. They also exhibit an attractive working potential around 2.3-2.6V vs Li^+/Li. [6]

We have recently demonstrated that the extended aromatic system of the perylene unit is beneficial to (i) the electrochemical properties (low irreversible capacity, high cycling stability, good rate capability) and (ii) the suppression of the dissolution into the electrolyte in the case of carboxylate or imides moieties (cf Figure 1).[2]

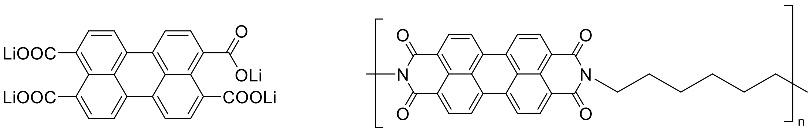

Figure 1: Lithium perylene-3,4,9,10-tetracarboxylate and Polyhexamethylene-perylene-3,4,9,10-tetracarboxylic diimide

Herein, we report our work focusing on the optimized scale-up synthesis of both compounds and new method to produce each materials.
We also performed detailed physico-chemical and electrochemical characterizations demonstrating high electrochemical performances with 120$mAh.g^{-1}$ at low potential (1.1V vs Li^+/Li) for carboxylates and 80 $mAh.g^{-1}$ at high potential (2.5V vs Li^+/Li) for polyimides which paves the way to assemble full organic batteries.

References

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