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Green processing of Li-ion battery electrodes using polysaccharide-derived materials (Starbons®)

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PURPOSE OF THE ABSTRACT

Renewable materials and processes complying with the principles of green chemistry must be used as much as possible for the elaboration of energy storage devices to make them sustainable. Amongst those devices, lithium-ion (Li-ion) batteries have attracted considerable attention as promising power sources for electronic devices or electric vehicles, due to their high energy density and long cycle life compared to lead?acid, nickel?cadmium or nickel metal hydride batteries. Typically, Li-ion battery electrodes are prepared by mixing an electroactive material (e.g. metal oxide) with a conductive additive (e.g. carbon black) and a polymeric binder (e.g. polyvinylidene fluoride, PVDF) in an organic solvent (e.g. N-methyl-2-pyrrolidone), then tape casted onto an aluminium or a copper current collector. Although the mainstream of research has been the development of different kinds of electroactive materials, the research on inactive materials such as carbon additives and binders cannot be overlooked. With an increase of concern on environmental issues, eco-friendly electrode processing based on water-soluble binders and biomass-derived additives has emerged.

Starbon® and its derivatives have been highlighted as inexpensive biomass-derived highly mesoporous carbonaceous materials.[1-3] Its production process, which consists in a direct thermal transformation of various polysaccharides (e.g. starch [2], alginic acid, pectin [3]) without any template, greatly satisfies the main sustainability terms such as simplicity, cost effectiveness and most importantly, eco-friendliness. Recently, in the frame of the POROUS4APP project [4], we have shown the strong potential of Starbons® for the green synthesis and formulation of Li-ion battery electrodes.[5-9]

In a first approach, Starbons® were employed as highly efficient carbon additives for both negative (LTO) [6] and positive (LMO, NMC) Li-ion electrodes [7], even surpassing conventional carbon black additives (e.g. Super P). The improved electrochemical performances are ascribed to (i) their highly mesoporous texture, providing efficient access for the lithium ions to the active material surface, and (ii) their fibrous morphology, facilitating the electron transport by connecting the active material particles. A synergistic effect was observed for a binary carbon additive system composed of Starbon® with Super P, improving both the initial capacity and the rate capability of LMO and NMC positive electrodes.[7] Interestingly, the use of sodium alginate, a water-soluble and biomass-derived binder, instead of PVDF wasn't detrimental to electrochemical performances.

In a second approach, alginic acid-derived Starbons® were employed as template for the synthesis of LTO/C [8] and LMO/C nanocomposites [9]. Well-crystallized aggregated LMO and LTO nanoparticles were successfully synthesized and showed promising performances as electrode materials for Li-ion batteries. The presence of homogenously grafted and/or coated carbonaceous species around metal oxide nanoparticles has been demonstrated to ensure better electronical interconnection between particles.

In this communication, we will present and discuss our latest results regarding the use of Starbon® materials as carbon additives and/or templates for the synthesis and formulation of Li-ion battery electrodes.

FIGURES

FIGURE 1

FIGURE 2

KEYWORDS

Polysaccharide | Porous carbon | Li-ion battery | Nanocomposite

BIBLIOGRAPHY

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