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Impact of the electrolyte salt anion on the solid electrolyte interphase formation in sodium ion batteries

Gebrekidan Gebresilassie Eshetu ^{a, b, c, d, e}, Thomas Diemant ^f, Maral Hekmatfar ^{a, b}, Sylvie Grugeon ^g, R. Jürgen Behm ^{a, f}, Stephane Laruelle ^g, Michel Armand ^c, Stefano Passerini ^{a, b, g}^a Helmholtz Institute Ulm (HIU) Electrochemical Energy Storage, Helmholtzstr. 11, D-89081 Ulm (Germany)^b Karlsruhe Institute of Technology, P.O. Box 3640, D-76021 Karlsruhe (Germany)^c Electrical Energy Storage Department, CIC Energigune, Parque Tecnológico de Álava, Albert Einstein 48, E-01510 Miñano, Álava (Spain)^d Department of Chemistry, College of Natural and Computational Sciences, Mekelle University, P.O. Box-231, Mekelle (Ethiopia)^e Institute for Power Electronics and Electrical Drives (ISEA), RWTH Aachen University, Jägerstraße 17/19, D-52066 Aachen, (Germany)^f Institute of Surface Chemistry and Catalysis, Ulm University, Albert-Einstein-Allee 47, D-89081 Ulm (Germany)^g Laboratoire de Réactivité et de Chimie des Solide (LRCS) CNRS UMR7314, Réseau sur le Stockage Electrochimique de l'Energie, CNRS RS2E FR-3459 Amiens (France)

Abstract

Aiming at a more comprehensive understanding of the solid electrolyte interphase (SEI) in sodium ion batteries (NIBs), a detailed X-ray photoelectron spectroscopy (XPS) investigation of the few-nanometer thick passivation film formed on hard carbon (HC) in contact with various Na⁺-ion conducting electrolytes is reported. The electrolytes investigated include 1 M solutions of NaPF₆, NaClO₄, NaTFSI, NaFSI, and NaFTFSI, all dissolved in a common mixture of ethylene carbonate (EC) and diethylene carbonate (DEC) (EC/DEC = 1/1 wt. ratio). For comparison, the study of analogous Li-based electrolytes containing LiPF₆ and LiFSI as representative electrolyte salts is also reported. The anion and cation of the electrolyte salt appear to play a key role in determining the overall SEI layer composition, including its depth evolution and thickness. The SEI building species formed on hard carbon by solvent reduction upon sodiation are found to decrease with the various salts in the order: NaPF₆ > NaClO₄ ≈ NaTFSI > NaFTFSI > NaFSI. The comparison of lithiated and sodiated HC electrodes shows that the SEI layer is more homogeneous and richer in organic species upon the use of Na-based electrolytes. Surface and depth-profiling XPS analysis on HC electrodes charged in the various electrolyte formulations provides in-depth insights on the differences and similarities of the SEI (composition, thickness, depth evolution, etc.) evolving from the variation in the chemical structure of the cations and anions of the respective salts.

Graphical abstract

