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高能锂离子电池 **PET** 基复合集流体的力学性能研究

摘要

塑料膜复合集流体（PFCC）是一种具有"金属层 + 聚合物层 + 金属层"的类三明治结构的新型电池集流体，由于可以提高锂离子电池（LIB）的能量密度和安全性，PFCC 受到了电池相关研究者的广泛关注。然而，目前对 PFCC 各项性能的研究相对较少，其在 LIB 中的应用仍然存在很多挑战，例如：聚合物-金属间粘合力弱、导电性差、耐腐蚀性差等。本文以传统金属集流体为参考，针对聚对苯二甲酸乙二醇酯（PET）基 PFCC 的力学性能进行了对照研究。研究的主要工作如下：

（1）以活性浆料组成及其压实密度为力学工况参数同步制备三种工况下的传统铝金属集流体（Al-CC）、传统铜金属集流体（Cu-CC）、聚合物基铝金属集流体（Al-PFCC）和聚合物基铜金属集流体（Cu-PFCC）电池极片。

（2）通过 SEM 形貌表征、EDS 组成表征和 CAD 标准化破损度拟合计算分析正极 Al-PFCC 和负极 Cu-PFCC 在相同力学工况下的金属涂层损伤情况。实验发现，Al-PFCC 的极限浆料压实密度（1.07-2.01 g/cm3）明显低于 Al-CC 的极限浆料压实密度（2.04-3.12 g/cm3），Cu-PFCC 的极限浆料压实密度（0.83-1.26 g/cm3）明显低于 Cu-CC 的极限浆料压实密度（1.30-1.70 g/cm3）。

（3）从 PFCC 的材料特性、结构特征和加工工艺三个方面对其力学性能的不足进行了机理分析。

（4）针对不同的成因可能，提出了可以从界面防护工程、调控活性材料层、改良聚合物基膜三个角度对 PFCC 的力学性能进行改进，例如：设置加工保护层、设置导电底涂层、设计功能化活性浆料、分区化浆料涂布等。

以上研究工作可以为 PFCC 在 LIB 中的进一步应用提供一定的参考价值。

关键词

锂离子电池；复合集流体；塑料基膜；金属涂层；力学性能；界面问题

Abstract

Plastic film composite current collector (PFCC) is a new type of battery collector with a sandwich-like structure of "metal layer + polymer layer + metal layer", which has attracted a lot of attention from battery researchers due to its ability to improve the energy density and safety of lithium-ion batterie (LIB). However, studies conducted on the various properties of PFCC are relatively few, and there are still many challenges for its application in LIBs, such as weak polymer-to-metal adhesion, poor electrical conductivity, and poor corrosion resistance. In this article, a controlled study was conducted for the mechanical properties of PET-based PFCC using conventional metal collectors as a reference. The main work is as follows:

(1) Use the composition of the activated slurry and its compaction density as the parameters of the mechanical operating conditions, simultaneously preparing Al-CC, Cu-CC, Al-PFCC and Cu-PFCC battery electrodes in three mechanical processing conditions.

(2) Analyze the metal coating damage of anode Al-PFCC and anode Cu-PFCC by SEM morphological characterization, EDS compositional characterization and CAD standardized breakage fitting under the same mechanical processing conditions. It was found that the ultimate slurry compaction density of Al-PFCC (1.07-2.01 g/cm3) was significantly lower than that of Al-CC (2.04-3.12 g/cm3), and the ultimate slurry compaction density of Cu-PFCC (0.83-1.26 g/cm3) was significantly lower than that of Cu-CC (1.30-1.70 g/cm3).

(3) Analyze the mechanism of the deficiencies in the mechanical properties of PFCC from three aspects: material properties, structural characteristics and processing.

(4) Regarding the above possible causes, propose that the mechanical properties of PFCC can be improved from three perspectives: interfacial protection engineering, modulation of the active material layer and modification of the polymer film, such as: setting up a processed protective layer, setting up a conductive undercoating, designing a functionalized active slurry and partitioning slurry coatings, etc.

The research above can provide some reference for PFCC's further application in LIB

Keywords

Lithium-ion battery; composite collector; plastic film; metal coating; mechanical property; interface problem

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