Title of the project	Enhanced safety materials for Li-ion batteries
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Deliverable number	**Deliverable**	**Work package code**	**Entity responsible for deliverable**	**Type**	**Access and dissemination**	**Method of verification**	**Delivery (project implementation month)**
D1.3	Properties and performance of a full cell laboratory demonstrator composed of enhanced safety materials	WP1	CEMEA	Report	N	Experimental results	M20

D1.3 Properties and performance of a full cell laboratory demonstrator composed of enhanced safety materials (CEMEA), M20

Introduction

Goal of this part of the project is a construction and test of performance of full cell laboratory demonstrator composed of enhanced safety materials. To describe properties and performance of the full cell laboratory demonstrator was fabricated on a coin cell level from the developed safety enhanced materials - silicon/graphite anode coated by ZnO nanometer thin film using ALD and flame retardant binder, ALD coated cathode, and ALD and polymers flame retardant coated separator. Electrochemical properties of standard cells and those fabricated using enhanced safety materials were compared.

Electrochemical performance comparison of standard and enhanced safety full cell.

It should be noted that the full-cell capacity is typically limited and balanced by the N/P ratio (the ratio of negative-to-positive electrode capacity, recommended around 1.0 to 1.2). If the N/P ratio is outside of the recommended region, the capacity of the cell is limited by the capacity of one of the electrodes. Matching to the appropriate negative-to-positive ration requires careful optimization of the capacity performance (i.e., matching the whole rate capability behavior). In addition, voltage range of the battery operation should be also carefully adjusted. We present here the first results obtained without further optimization of the battery electrodes capacity. The results should be therefore understood rather as proof of the concept than as exact final evaluation of the full cell battery properties. Certainly, evaluation of a full cell configuration performance deserves more time to optimize the electrochemical performance and obtain quantitative comparison results.

Figure 1 shows standard rate capability test – discharge capacity as a function of charging/discharging cycles at C-rates from 0.05 (formation cycle) up to 2 for the full cell composed of Si/Gr anode (20 wt% Si), LFP cathode and polypropylene (Celgard) separator in a coin cell configuration. In order to compare the performance with the Si/Gr anode itself, tested in Deliverable D1.1 and D4.1 the values of the discharge capacity were recalculated to Si/Gr anode values. We note that the recalculated capacity is lower than that obtained for a Si/Gr anode in a

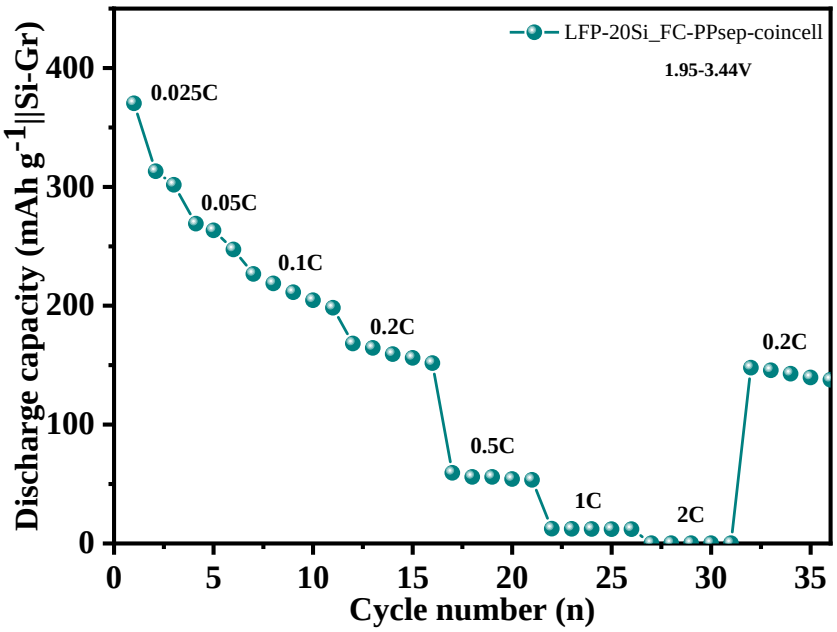


Figure 1. Discharge capacity as a function of charging/discharging cycles at different C rates for a standard full cell composed of Si/Gr anode (20 wt% Si), LFP cathode and polypropylene separator.

half-cell configuration for the reasons explained above. N/P ratio for the full cell battery was 0.8. Nevertheless, Figure 1 demonstrates fully operational full cell battery with Si/Gr anode, LFP cathode and (Celgard) polypropylene separator. Due to too low N/P ratio the battery does not operates properly at high charging rate (C-rate 2). We believe that for battery with correct N/P ration discharge capacity discharge capacity above C-rate 0.2 will be higher.

Figure 2 displays rate capability test – discharge capacity as a function of charging/discharging cycles at C-rates from 0.05 (formation cycle) up to 2 for the full cell composed of Si/Gr anode (20 wt% Si), coated by 20 cycles ZnO, LFP cathode, coated by 5 cycles of Al_2O_3 and separator with 50 cycles of Al_2O_3 and DMP polymer coated polypropylene separator. This cell contains components composed of enhanced safety materials: Si/Gr anode is coated by ALD ZnO (20 ALD cycles), LFP cathode is coated by ALD Al_2O_3 (5 ALD cycles) and separator covered by Al_2O_3 (50 ALD cycles) and flame retardant DMP polymer.

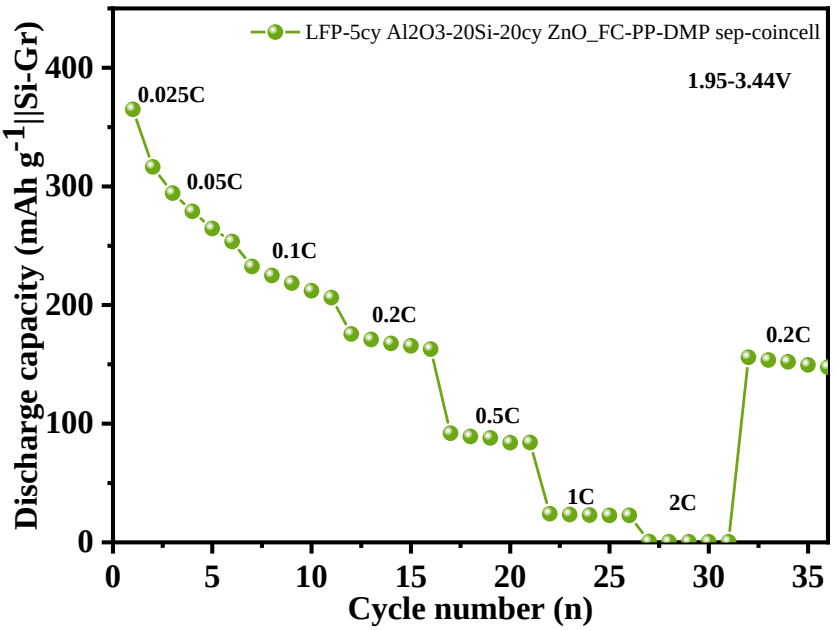


Figure 2. Discharge capacity as a function of charging/discharging cycles at different C rates for a standard full cell composed of Si/Gr anode (20 wt% Si), coated by 20cycles ZnO, LFP cathode, coated by 5 cycles of Al_2O_3 and separator with 50 cycles of Al_2O_3 / DMP polymer coated polypropylene separator.

Again, the values of the discharge capacity were recalculated to Si/Gr anode values. N/P ratio of anode/cathode capacity was 1.04. We note that the battery is functional and exhibits slightly better capacities comparing to the battery containing no flame retardant materials.

Goal of this part of the project is a construction and test of performance of full cell laboratory demonstrator composed of enhanced safety materials. Electrochemical properties of standard cells and those fabricated using enhanced safety materials were compared. Based on achieved results we conclude that the goal of the part D1.3 Properties and performance of a full cell laboratory demonstrator composed of enhanced safety materials was successfully achieved.