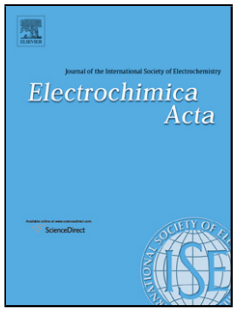

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<AT>Experimental Investigation of a New Passive Thermal Management System for a Li-Ion Battery Pack Using Phase Change Composite Material

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<ABS-HEAD>Abstract

<ABS-P>A pack level passive thermal management system has been designed, developed and experimentally investigated using a phase change composite material. Three 20 Ah capacity $LiFePO_4$ prismatic cells connected in series are used to form the battery pack and phase change composite material of different thicknesses are tested. The battery pack has been charged at 1C and discharged at 1C, 2C, 3C and 4C. A total of 18 thermocouples are used to measure the temperature at the principal surface of all three cells. The results obtained with the phase change composite material are compared with no cooling and liquid cooling options. The results show that, with the use of 6 mm thick phase change composite material plates, the battery surface temperature reduces from 56.5°C at no cooling to 36.5°C at a 4C discharge rate. Even at a 1C discharge rate, the temperature of the battery pack drops from 33.5°C with no cooling to 29.1°C with phase change material plates. It is also observed that the effect of an increase in phase change material thickness on the battery pack temperature is insignificant beyond a 6 mm thick plate. The results show that the temperature gradient is significantly lower with phase change composite material compared to no cooling and liquid cooling.

<KWD>Keywords: Lithium-ion battery; Thermal management; Phase change composite material; Temperature gradient.

<H1>1. Introduction

Batteries are a major component of the powertrain in electric vehicles (EVs) and hybrid electric vehicles (HEVs). Li-ion batteries are considered one of the best options for EVs and HEVs, due to their high energy and power density, high life cycle, low self-discharge, and no memory effect [1, 2]. But there are also weaknesses associated with Li-ion batteries, one of which is heat generation during charging and discharging. In the case of poor insulation, ambient temperature also has an adverse effect on battery performance. The operating temperature range for the Li-ion batteries provided by most manufacturers varies from -20°C to 60°C. However, to achieve a full life span, battery temperature should not exceed 40°C while the acceptable temperature excursion should be less than 5°C. The internal resistance of the battery increases at low temperature (<20°C), leading to more heat generation and a decrease in available capacity. A high temperature (>45°C) may lead to safety issues and ageing problems [3-6]. In the case of failure of an interior cell, the energy released from the cell suddenly flows to neighbouring cells, leading to a drastic increase in temperature. This can create local hot spots, which are responsible for battery pack failure [7]. This phenomenon, known as thermal runaway, is caused by stressful operating conditions such as overcharging, over discharging, exposure to fire, short circuiting, and vibration.