Accepted Manuscript

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PII: S1359-8368(18)32025-0

DOI: 10.1016/j.compositesb.2018.08.080

Reference: JCOMB 5910

To appear in: *Composites Part B*

Received Date: 28 June 2018

Accepted Date: 20 August 2018

Please cite this article as: Singh R, Singh H, Farina I, Colangelo F, Fraternali F, On the additive manufacturing of an energy storage device from recycled materials, *Composites Part B* (2018), doi: 10.1016/j.compositesb.2018.08.080.

On the additive manufacturing of an energy storage device from recycled materials

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ABSTRACT

The disposal/recycling of plastic materials are one of the biggest challenges of 21st century. Some studies have been reported in recent past on recycling of thermoplastics via three-dimensional (3D) printing as a novel technique under primary and secondary recycling. But hitherto no work has been reported on use of recycled/ virgin thermoplastics for use as energy storage devices (ESD). In this paper an effort has been made to develop in house ESD in form of dry cell by printing with low cost fused deposition modelling (FDM) based commercial open source 3D printer. The feed stock filament of FDM has been prepared by twin screw extrusion (TSE) comprising of advanced composite materials (thermoplastic: acrylonitrile butadiene styrene (ABS) matrix, reinforced with different proportions of chemicals/salts namely: MnO_2, $ZnCl_2$, NH_4Cl and graphite), which has been used to print dry cell for energy storage applications. The commercial dry cell consists of four zones/sections and feed stock filaments for three zones have been prepared separately on TSE (with different proportions of ABS and reinforcement of chemical/salts) and fourth zone (of Zn metal) has been casted with conventional sand casting route. Finally, all four zones have been assembled in series to develop fully functional prototype of ESD. This study highlights that with the proposed methodology, dry cell comprising of minimum 40% by weight recycled thermoplastics can be prepared successfully having voltage potential at par with commercial dry cell. Another major advantage of using this novel route is that the ESD prepared is more thermally stable (confirmed by differential scanning calorimetry (DSC) analysis) and can operate up to 95°C temperature. Along with this the ESD so prepared has better rheological, mechanical properties (tensile, surface hardness) ensuring it to be useable under severe loading conditions. The results are also supported by photomicrographs.

Keywords: Energy storage devices, dry cell, additive manufacturing, recycling

Introduction

Waste management is one of the challenging job for mankind now days [1]. Government, researchers and other local bodies are working on decomposing and recycling of thermoplastic waste polymer by reinforcing them with some other metallic and non-metallic materials [2]. But still plastic waste management is one of the biggest crises [1]. The recycling of thermoplastics has been mainly categorized into four categories, namely primary (1°), secondary (2°), tertiary