

3D printing of polymers onto textiles

An innovative approach to develop functional textiles

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Abstract

This thesis aims at characterizing tridimensional (3D) printed polymers onto PET textile materials via fused deposition modeling (FDM) that uses both non-conductive and conductive polymers, optimizing their mechanical and electrical properties through statistical modeling and enhancing them with pre and post-treatments and the development of polymer blends. This research work supports the development of technical textiles through 3D printing that may have functionalities. The FDM process was considered in this thesis for its strong potential in terms of flexibility, resource-efficiency, cost-effectiveness tailored production and ecology compared to the existing conventional textile finishing processes, for instance, the digital and screen printings. The main challenge of this technology is to warranty optimized electrical and mechanical (bending, flexibility, tensile, abrasion, etc.) properties of the 3D printed polymer onto textiles for the materials to be used in textile industry. Therefore, the development of novel 3D printed polymers onto PET materials with improved properties is necessary.

First of all, 3D printed non-conductive Polylactic Acid (PLA) and PLA filled with 2.5wt% Carbon-Black filled onto PET fabrics were purchased and manufactured through melt extrusion process respectively, to characterize their mechanical properties including adhesion, tensile, deformation, wash ability and abrasion. Then, the relationship between the textile structural characteristics and thermal properties and build platform temperature and these properties through statistical modeling was determined. Subsequently, different textile pre-treatments that include atmospheric plasma, grafting of acrylic acid and application of adhesives were suggested to enhance the adhesion properties of the 3D printed PLA onto PET fabrics. Lastly, novel biophasic blends using Low-Density Polyethylene (LDPE) / Propylene- Based Elastomer (PBE) filled with multi-walled carbon nanotubes (CNT) and high-structured carbon black (KB) were developed and manufactured to improve the flexibility, the stress and strain at rupture and the electrical properties of the 3D printed PLA onto PET fabric. The morphology, thermal and rheological properties of each blends are also accessed in order to understand the material behavior and enhanced mechanical and electrical properties.

The findings demonstrated that the textile structure defined by its weft density and pattern and weft and warp yarn compositions has a significant impact on the adhesion, deformation, abrasion, tensile properties of 3D printed PLA onto PET fabrics. Compromises have to be found as porous and rough textiles with low thermal properties showed better wash-ability, adhesion and tensile properties and worse deformation and abrasion resistance. Statistical models between the textile properties and the 3D printed PLA onto PET materials and the properties were successfully developed and used to optimize them. The application of adhesives on treated PET with grafted acrylic acid did significantly improve the adhesion resistance and LDPE/PBE blends filled with CNT and KB that have co-continuous LDPE and PBE phases as well as CNT and KB selectively located at the interface and in the LDPE phase revealed enhanced deformation and tensile and electrical properties.

Keywords: 3D printing, Fused deposition modeling, Adhesion, Textile Functionalization, Statistical Modeling, Non conductive and conductive polymer, Multi-walled carbon nanotube, Carbon Black, Deformation, Tensile, Abrasion, Biphasic polymeric bends