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RESEARCH ARTICLE

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Evaluation of shellac-polyethylene glycol as an alternative material for fabrication of fused filament fabrication 3D printing filament at low extrusion temperature

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Abstract

The lack of biopolymer filament has been recognized as a significant challenge to fused filament fabrication (FFF) or fused deposition modeling (FDM) 3D printing. According to the restricted choice, shellac is a natural polymer of interest due to its thermoplastic property at a low temperature. The purpose of this study was to evaluate the feasibility of applying shellac as a candidate biopolymer for FFF 3D printing filaments. Shellac matrices and plasticized shellac matrices of varying grades of polyethylene glycol (PEG) were prepared using hot melt processes, and their physicochemical properties and filament properties were investigated. The results showed that a shellac matrix could be easily prepared at 80°C and stayed stable for up to 12 h. The addition of PEG could improve the stability of the shellac matrix as demonstrated by a slight deviation in acid value, percent insoluble solid, and FTIR spectra after annealing for 24 h. The shellac filaments with acceptable appearance and mechanical properties were also produced at 80 ± 5°C by the incorporation of 10–20% w/w of PEG 4000 or PEG 10000. Therefore, SHL-PEG might be a good candidate material for the fabrication of 3D printing filament, especially at low extrusion temperature.

KEYWORDS

3D printing filament, hot melt extrusion (HME), hot melt process, plasticizer, polyethylene glycol, shellac

1 | INTRODUCTION

Three-dimensional (3D) printing is anticipated to be a disruptive technology within the pharmaceutical industry as it transitions from the traditional unit operations of medicine to personalized medicinal products that are customized for each individual.[1] Among the many types of 3D printing techniques, fused filament fabrication (FFF) or fused deposition modeling (FDM) is one of the widely used techniques in pharmaceutical applications to generate 3D dosage forms because of its cost-effectiveness, affordability, lack of a requirement for solvents, ease of use, and precisely controlled size and complex geometries of printlet with remarkable reproducibility.[2–5] In the FFF process, a thermoplastic polymer filament is melt, extruded through a high temperature nozzle and then hardened layer by layer onto a platform until printing was completed.[6] FFF requires filament with good mechanical properties and thermoplastic characteristics. Nevertheless, the applications of FFF 3D printing for pharmaceutical dosage form design