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Synthesis, thermal, mechanical and hydrolysis properties of poly(hexamethylene furandicarboxylate)-based copolyesters

Shiwei Feng , Zhaobin Qiu *

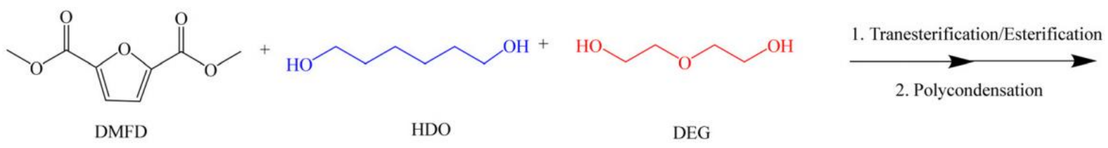
College of Materials Science and Engineering, Beijing University of Chemical Technology; Beijing , China.

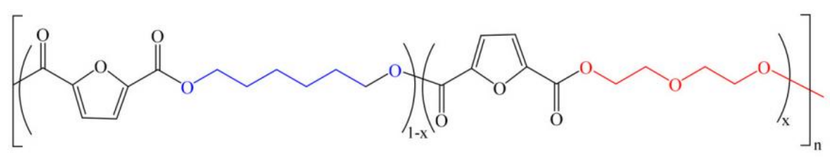
INTRODUCTION

To resolve the environmental and resource issues, the design, synthesis, and production of sustainable polyesters are increasingly emphasized. Currently, 2,5-furandicarboxylic acid (FDCA) is one of the most important biobased aromatic monomers. FDCA-based polyesters have superior thermal and gas barrier properties compared to the matching terephthalic acid-based polyesters. Poly(hexamethylene 2,5-furandicarboxylate) (PHF) has attracted attention due to its excellent toughness and rapid crystallisation rate.However, PHF is hardly biodegradable in natural environments, which will lead to serious environmental problems. Aliphatic comonomers containing ether bonds are also helpful in enhancing the degradability of copolyesters.

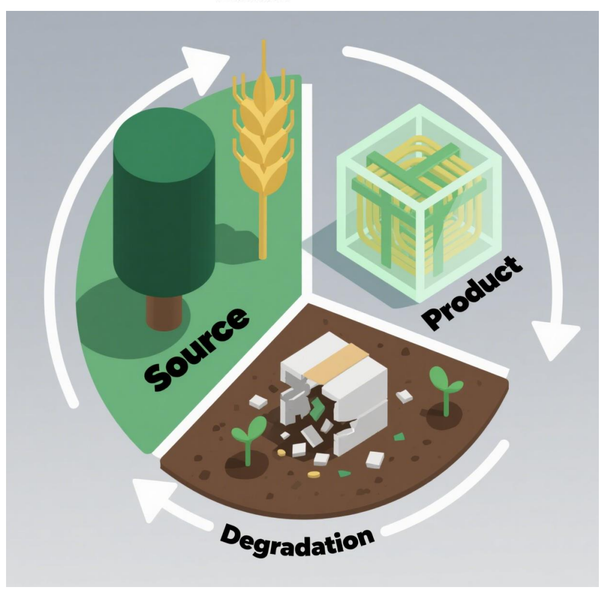
In this study, a series of novel biobased poly(hexamethylene-*co*-diethylene glycol furandicarboxylate) (PHDEGF) copolyesters were also synthesized by a two-stage melt polycondensation method using diethylene glycol as the comonomer to improve the mechanical and hydrolytic degradation properties and extend the practical application of PHF from a sustainability view point in this research.

SYNTHESIS ROUTE





PHDEGF



RESULTS

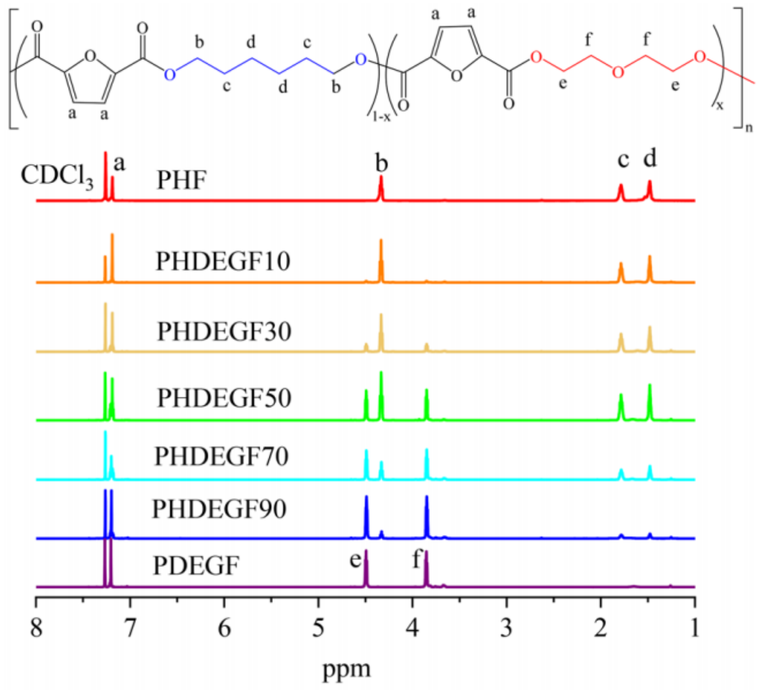


Fig. 1 (a) Chemical structure and ^{1}H NMR spectra of PHDEGF.

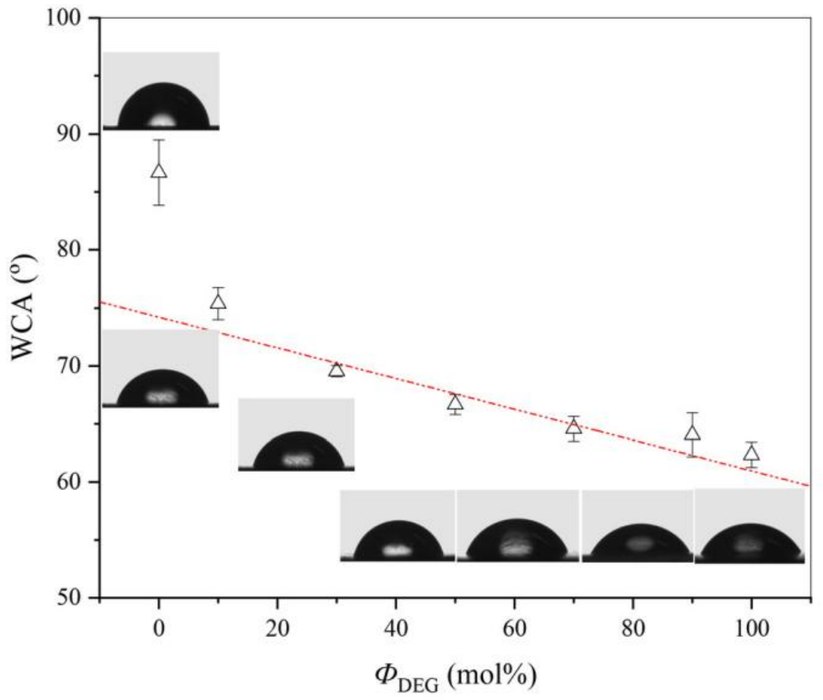


Fig. 3 Water contact angle of PHF, PDEGF and PHDEGF and images of water droplets on the polymer film surface.

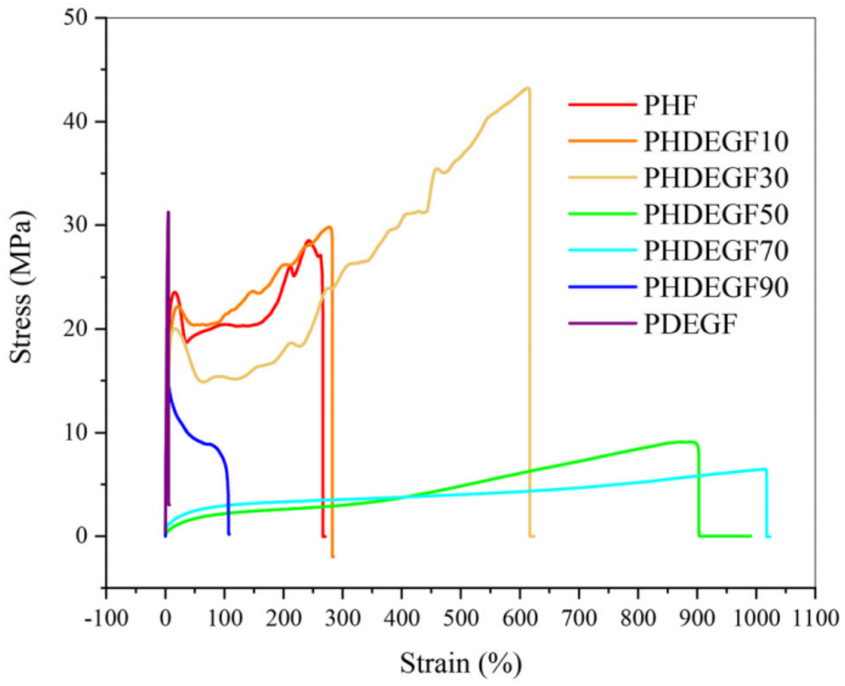


Fig. 2 Stress–strain curves of PHF, PDEGF, and PHDEGF.

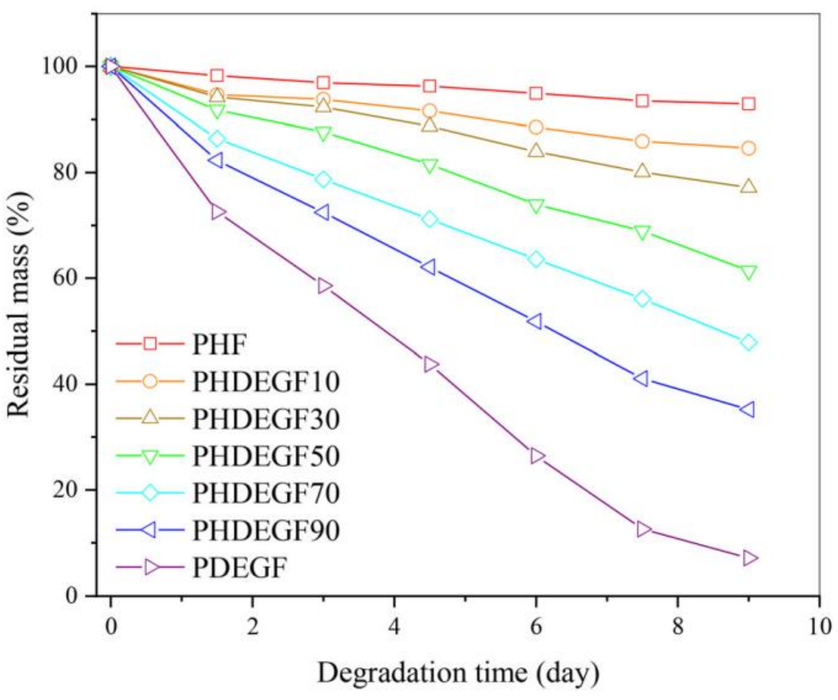


Fig. 4 Hydrolytic degradation behavior of PHF, PDEGF and PHDEGF.

CONCLUSIONS

- All PHDEGF were random copolyesters.
- Both PHF and PHDEGF displayed high thermal stability.
- The crystallinity of PHDEGF gradually decreased with the increase of the DEGF unit content.
- PHF, PHDEGF10, and PHDEGF30 were semicrystalline, while PHDEGF50, PHDEGF70, PHDEGF90, and PDEGF were amorphous.
- PHDEGF30 demonstrated comparable or even superior mechanical properties to PBS and PBAT, which should be very important for its practical application.
- The incorporation of the DEGF unit significantly accelerated the hydrolytic degradation of PHDEGF copolyesters due to the decreased crystallinity and increased hydrophilicity.