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ORIGINAL PAPER

Optimization of biodegradation of natural fiber (*Chorchorus capsularis*): HDPE composite using response surface methodology

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Abstract Deterioration in mechano-chemical properties due to biodegradation of prepared high-density polyethylene and jute eco-friendly polymer composites in soil and pure microbial culture was investigated through a programmed experimental design. The composite was prepared by compression molding process and then subjected to biodegradation. The biodegradation process was studied using face-centered central composite experimental design protocol and the model equations were formulated to assess the effects of jute fiber loading and treatment time on biodegradation (expressed as percentage loss in composite weight and tensile strength) of the composite. The optimal process conditions corresponding to maximum biodegradation were evaluated for both the media using response surface methodology. The maximum weight losses were 25.8924 % for soil medium and 12.4167 % for pure culture medium at 30 wt% jute fiber loading and 6 months of treatment time. At the derived optimal conditions, the effects of biodegradation were also manifested as 84.2621 and 70.9842 % losses in the tensile strength in soil and pure culture media, respectively. The present study, thus, demonstrates that HDPE/jute composite polymer can be appreciably biodegradable and the extent of biodegradation is more pronounced in soil medium compared to pure microbial culture. The analyses of the evolution of chemical composition and microstructure of the composite before and after biodegradation were performed through Fourier transform infrared spectroscopy (FTIR) and scanning electron microscopy. FTIR spectra indicated significant changes in chemical composition due to biodegradation, while the ruptured structure of the treated composite revealed notable changes in the morphology due to biodegradation.

Keywords HDPE/jute composites · Biodegradation · Response surface methodology · Optimization · Tensile strength

Introduction

Widespread use of synthetic non-degradable polymer has led to serious environmental pollution. Progress in natural fiber development, genetic engineering and composites offer noteworthy opportunities for better materials from renewable resources with improved support for worldwide sustainability [1]. Many attempts have led to exploration of a large range of raw materials including the advancement of biodegradable materials [2] which resulted in the development of commercially viable biodegradable polymer composites with increased focus on eco-friendliness. These natural fiber–thermoplastic composites [3] have found ample range of applications in the building and construction industries such as door and window frames, decking materials, railings, furnitures and their packing, computer casings and other electronic components, as well as in a number of industrial applications [4, 5].

Cellulosic fibers [1, 4] such as sisal, coir, jute, flax, cotton, and paper have been employed in their native condition for reinforcement of different thermoplastic materials. Among the above ligno-cellulosic bast fibers, jute [6] contains a comparatively higher proportion of stiff

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