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Green Materials

Developing nanocellulose-loaded chitosan–polylactic acid biofilms for green food packaging

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The food industry is considered one of the main contributors to plastic waste due to packaging. Sustainable and degradable packaging solutions are the need of the hour. Biopolymers have proved to be a promising replacement for petroleum-based polymers. The main reason is their various intrinsic properties, such as antimicrobial nature and degradability. The main objective of this study was to develop chitosan/nanocrystalline cellulose- and polylactic acid-based biofilms. The biofilms were developed using the drop-casting method. The developed biofilms were characterized by scanning electron microscopy, Fourier transform infrared spectroscopy, X-ray diffraction, differential scanning calorimetry and thermogravimetric analysis. The performance of the biofilms was checked using mechanical, water solubility, porosity, antioxidant and antibacterial activity tests. The developed biofilms can solve the issues of environmental pollution being faced by the food packaging industry.

Keywords: biodegradable/biopolymer/chitosan/film/green polymers/nanocrystalline cellulose/packaging/poly(lactic acid)/UN SDG 14: Life below water

Notation

V_1	volume of ethanol before immersion
V_2	volume of ethanol after immersion
W_1	initial dry weight
W_2	final dry weight
ρ	density

1. Introduction

Petroleum-based polymers are a continuous concern for the environment, and in the past decade, significant research has been done to replace them with biodegradable, environmentally friendly polymers.[1] Biopolymers originating from renewable sources have gained popularity due to rising environmental concerns.[2,3] Researchers are looking to replace petroleum-based polymers with biopolymers for various applications, including health and food packaging. The packaging industry is one of the significant producers of waste plastics, as only in 2018, the industry produced around 82.2 Mt of solid municipal waste (28.1% of the total plastic).[4] Biopolymers came up as the ideal candidates due to their main property biodegradability, while petroleum-based polymers are non-biodegradable or require quite harsh treatment conditions and, in some cases, a proper processing facility. They also possess properties such as low process temperatures (in comparison with those of metal and glass), reduction of water and oxygen permeability, antimicrobial properties, printability, heat sealability and simplicity of processing into multiple shapes. These are just some of the features that make biopolymers excellent for designing packaging materials.[5,6] Despite all positive aspects, biopolymers lack mechanical strength comparable with those of plastic polymers, have high production costs and have ethical concerns.[7,8] These issues are the major hindrance to biopolymer-based packaging materials taking over the food packaging market.[9]

Biopolymer-based food packaging material typically depends on the blending of multiple polymers to create materials with novel properties that a single biopolymer cannot attain and to overcome the shortcomings of the individual biopolymers.[10] Cellulose is the most prevalent biodegradable and renewable polymer in nature and has several benefits, including low density, non-toxicity, flexibility and excellent mechanical qualities.[11] Food packaging materials based on cellulose, such as paper and fabric, have seen extensive use. Novel food packaging with numerous functional qualities must be investigated immediately to meet increased food