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Hydroxy citric acid cross-linked chitosan/guar gum/poly(vinyl alcohol) active films for food packaging applications

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ABSTRACT

The present work aims to prepare Chitosan (CS)/Guar gum (GG)/Poly(vinyl alcohol) (PVA) cross-linked with Hydroxy citric acid (HCA) (CGPH active film) by solvent casting technique. The influence of HCA on different CS/PVA ratio (1:3, 1:1, 3:1) in presence of the fixed amount of GG (0.2%) was investigated. The analysis of the results showed that the addition of HCA to the different ratio of CS/PVA increased the degradation temperature and improved the mechanical properties of CGPH active films. FTIR spectra and XRD analysis revealed strong interactions among the components of CGPH active films. The analysis of SEM images and water contact angle suggested a compact, dense film surface with hydrophobic nature. Further, all the active films have shown a decrease in water vapour permeability (WVP) and acted as a barrier to UV-light. CGPH active films effectively inhibited the growth of *S. aureus* and *E. coli* bacteria. With all these features the CGPH active films can find application in food packaging.

1. Introduction

Polymers have been used in our daily life in various fields such as medical, pharmaceutical, tissue engineering, coating and packaging products [1]. Therefore in recent years the production and utilisation of synthetic petroleum-based polymers have grown up enormously. This has created associated environmental issues because they are voluminous and non-biodegradable [2–4]. Bio-based films are the promising alternative to minimise the use of conventional plastic materials and to safeguard the environment [5,6]. Polymer blends are preferred than individual polymers for their low cost and enhanced physicochemical properties [7]. The compatibility among the individual polymers will influence thermal, mechanical properties and morphology of the blend films [8]. Natural polymers which are easily available at low cost are often blended with a synthetic polymer for different types of applications as well as to improve cost performance [9,10].

Currently, special consideration has been given to chitosan (CS) due to its remarkable properties such as nontoxicity, nonallergenic, biodegradability, biocompatibility and antibacterial activity which makes it a suitable candidate for packaging applications [11]. Although CS exhibits good film-forming ability, the mechanical and barrier properties were not promising. Blending of CS with different polymers has been proved to be a convenient approach to enhance the properties of the end product. Therefore many researchers have reported blending of CS with different polymers such as natural gums [12–14], starch [15–17], cellulose [18,19], poly vinyl alcohol [20–22] etc. to improve its mechanical and barrier properties [23].

Guar gum (GG) is a natural polysaccharide chiefly available in the seeds of the plant *Cyamopsis tetragonoloba* [24]. Its polymer chain is made up of mannose [(1–4)-linked-D-mannopyranose] backbone with galactose side groups [(1–6)-linked-D-galactopyranose] [25]. GG is soluble in water due to the formation of a hydrogen bond with water molecules [26,27]. It is used as an emulsifying agent, gelling and stabilising agent hence finds applications in different fields such as textile, food, petrochemical etc. These favourable properties encourage to use GG in packaging applications with other polymers to enhance intrinsic properties of the blend films [27,28].

Among the synthetic polymers Poly(vinyl alcohol) (PVA) is considered as a versatile polymer which is non-toxic, water-soluble, biodegradable with good film-forming ability. It is highly compatible with other biodegradable polymers owing to the formation of hydrogen bonds [29]. These properties have been exploited in preparing blend films of PVA with biopolymers, which otherwise possess poor physical properties. The compatibility of PVA with CS and GG owing to the formation of intramolecular hydrogen bonds [26] makes it suitable for blending with CS and GG [30].

In recent years, the awareness about environmentally safer products has created an increased demand for natural products over the

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