UNIVERSITÀ DEGLI STUDI DI SALERNO

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Analysis of the swelling behavior of low methoxy calcium pectin hydrogels

Thesis in

Transport Phenomena in Food Processes

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Abstract

Nowadays, food and pharmaceutical sector require the employment of materials that possess essential qualities, including biocompatibility, stability, non-toxicity, and, where applicable, controlled release capabilities. Hydrogels are peculiar macromolecules, characterized by a polymeric matrix, an interstitial fluid and, eventually, some ionic species. There is an obvious interest in natural polymer-based hydrogels. Polysaccharide are gaining attention as hydrogel forming biopolymers, as they are synonyms of biocompatibility, and water absorbtion capacity.

Pectin is a natural water-soluble polysaccharide that can be found in plant cells. It consists of linear chains of 1-4-D-galacturonic acid residues that contain carboxyl groups. Low methoxy pectin (degree of esterification <50%) is capable of forming insoluble hydrogels, such as calcium pectinate, when the acid chains are crosslinked with a divalent cation, calcium, which can be used, for instance, for nutraceutical molecules delivery purpose. Calcium pectinate(CaP) hydrogels are known to be nontoxic and can be degraded by colonic bacteria, being able to remain into the upper gastrointestinal tract. It has been investigated as a carrier for controlled drug release and the protection of drugs against gastric environment. Specific properties of these gels based on new models and their applications in functional food structure design deserve a further study.

Calcium Pectin Hydrogels(Ca-PEC) can be characterized as physically cross-linked network, whose swelling behavior is not fully understood, despite its significance in many applications. In simulating the swelling response of such systems, the experiments are of high importance because of two reasons: finding the necessary parameters for simulation; verification of the theory and numerical implementation. One of the two external stimuli that can alter the swelling response of Ca-PEC hydrogels, are the pH and ionic strength of the medium these gels interact with. pH is a very important factor in studying pectin gels because these are always used for food and pharmaceutical products

with different pH values. pH can alter the dissociation of carboxylic groups in pectin thus its binding with calcium ions. On the other hand, many studies have also investigated the effects of pectin on the in vitro absorption of minerals, such as calcium, zinc, magnesium and iron. Thus, it is essential to discuss the influence of the ionic strength on the general behavior in solution as ions could potentially replace the bound calcium, leading to structure weakening and loss of stability.

Given that swelling properties of hydrogels are important factors for any application, aim of this thesis project is to study the swelling behavior of calcium pectin gel, obtained through ionotropic gelation, in aqueous solutions. Dynamic swelling experiment were carried out with a gravimetric method. Swelling kinetics were well fitted by a saturation growth model. Equilibrium swelling response was analysed as function of the external medium pH and ionic strength. As an additional tool to have more insights about the pH role on the gel diffusive properties in solution, EDTA complexometric titration was performed to monitor calcium ions release in solution Unconfined compression tests were performed to characterize the main mechanical properties of the prepared hydrogels. In the end, the prepared pectin hydrogels did not show pH responsive properties, in classical sense and this is more typical of chemically crosslinked systems with superabsorbent properties. Ionic strength contributed to swelling through a general polyelectrolyte behavior. The findings can be further exploited for modelling purpose and formulating delivery systems with desired properties.

Chapter One

Introduction

In this chapter, a general description of polysaccharide-based hydrogels is presented. Pectin Hydrogels properties are highlighted. At the end of the chapter, after a review of the state of the art, the aims of this work are illustrated.

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