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Review

Superabsorbent hydrogels based on polysaccharides for application in agriculture as soil conditioner and nutrient carrier: A review

Marcos R. Guilherme [a], Fauze A. Aouada [b], André R. Fajardo [c], Alessandro F. Martins [a,d], Alexandre T. Paulino [e], Magali F.T. Davi [f], Adley F. Rubira [a], Edvani C. Muniz [a,f,*]

[a] Departamento de Química, Universidade Estadual de Maringá (UEM), Av. Colombo, 5790, 87020-900 Maringá, PR, Brazil
[b] Departamento de Física e Química, Faculdade de Engenharia de Ilha Solteira, UNESP, 15385-000 Ilha Solteira, SP, Brazil
[c] Centro de Ciências Químicas, Farmacêuticas e de Alimentos (CCQFA), Universidade Federal de Pelotas, 96010-900 Pelotas, RS, Brazil
[d] Universidade Tecnológica Federal do Paraná (UTFPR-DV) – Estrada para Boa Esperança, 85660-000 Dois Vizinhos, PR, Brazil
[e] Universidade do Estado de Santa Catarina, Centro de Ensino Superior do Oeste, Dep. de Engenharia de Alimentos, Pinhalzinho, Chapecó 89870-000, SC, Brazil
[f] Universidade Paranaense, UNIPAR – Programa de Pós-graduação em Biotecnologia Aplicada à Agricultura, 87502-210 Umuarama, PR, Brazil

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A B S T R A C T

Superabsorbent hydrogels (SH) continue being a very important issue in both academic and industrial fields due to their applications in several technologies. This is proved by the impressive number of publications, through papers and patents as well, dealing with SH. This review is targeted to update and discuss some important aspects of synthesis, characterization and application of SH in agriculture, mainly those based on polysaccharides, as soil conditioners and as polymer carriers for nutrient release. Basic properties of SH and some methods for chemically modifying polysaccharides are given and some directions for hydrogels preparation are highlighted as well. Mechanisms associated with water transport into the 3D matrix, taking into account the transference of mass from hydrogel–soil system to plant, are discussed in the light of some mathematical models. Release of nutrients either from granules coated by hydrophilic polymer or from SH, targeting applications in agriculture, is also discussed on the basis of often used mathematical models (the swelling-based kinetic models) and on a diffusion-based kinetic model with a partition activity coefficient. Examples of recent applications in agriculture as soil conditioners and carriers for nutrient release (fertilizers, etc.) are given. At the final, future trends and perspectives are considered. More than two hundreds references are cited in the whole text.

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* Corresponding author at: Departamento de Química, Universidade Estadual de Maringá (UEM), Av. Colombo, 5790, 87020-900 Maringá, PR, Brazil.
E-mail address: ecmuniz@uem.br (E.C. Muniz).

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1. Introduction

Materials are the basis of any civilization. Due to their availability the development of new technologies and the expansion of science borders are possible. The continuous claim for novel materials has stimulated studies with the most varied range of chemicals and compounds. In this sense, polymers technology has provided a massive contribution to development and design of original materials. Different technological fields, such as medicine [1,2], engineering [3,4], and agriculture [5,6], for instance, have employed polymeric materials. This is stimulated by the polymer advantages over the conventional feedstock. In general lines, polymers are easily processed and chemically modified. They show desirable physical and mechanical properties, and in some cases economically accessible. Among the more promising polymeric materials, a special class of soft materials has attracted wide interest in the last three decades: the hydrogels. The hydrogel preparation was firstly reported in the end of 60s by Witchterle and Lim [7] and since then these incredible materials have been used as powerful tools in different technological segments. A huge number of articles related to hydrogels are reported in literature in which different preparations allowing a myriad of structures, properties and applications are described. This review is devoted to discuss recent studies on superabsorbent hydrogels matrices (SH) based on polysaccharides applied in agriculture as soil conditioners and as nutrient carriers.

1.1. Basic concepts on superabsorbent hydrogels (SH)

Typically, superabsorbent hydrogels (SH) are three-dimensional matrix (3D) constituted by linear (or branched) hydrophilic polymers that are chemical of physical crosslinked, with the ability to absorb large quantities (swelling ratio (SR) > 100) of water or biological fluids [8,9]. Further, SH can keep their network stable even in the swollen state. Such characteristics result from the crosslinked structure, which assures to SH stability in different media and environments [9]. The crosslinking can be achieved through two main pathways: chemically or physically processes. The chemically crosslinked SH show as main characteristic the irreversible covalent bonds formed among the polymeric chains [10]. A great variety of methods to form crosslinking have indeed been used to prepare chemical hydrogels (e.g. radical polymerization, reaction of complementary groups, grafting reactions, enzymes, etc.) [10]. On the other hand, on physically crosslinked hydrogels the polymeric chains hold together by physical interactions, such as electrostatic interactions, Van der Waals forces and H-bonds [11]. In the last type of hydrogels, the crosslinking is reversible and the matrix can be destroyed as submitted to specific conditions. The crosslinking type used for preparing SH influences also significantly some critical parameters, thus the final properties of SH and, in consequence, the potential of SH applications [12,13]. Water uptake capacity, swelling kinetic, mechanical and rheological properties, degradation rate, porosity, toxicity, and other properties are intimately