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Electrically controlled Aloe-vera extraction release from poly acrylamide hydrogel

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Abstract

Aloein which is the active compounds that decrease pain and inflammation and stimulate skin growth and repair are selected as the model drug in this work. From the low content of active compound (<5 %v/v) in Aloe-vera, the development of controlled Aloe-vera extraction system is required to increase the efficiency of drug therapeutic. The development of control-released Aloe-vera extraction, aloein from polyacrylamide hydrogel system as transdermal drug delivery patch was studied. The apparent diffusion coefficients, Dapp, hydrogel pore size and the release mechanisms of aloein from aloein/polyacrylamide hydrogels (aloein/PAAM) were investigated in the effect of crosslinking ratio of hydrogel. The pore size of crosslinked polyacrylamide hydrogel increases with decreasing amount of crosslinker. The amount of aloin release and Dapp increase with increasing hydrogel pore size. For larger pore size of hydrogel system, aloein can easily diffuse out than smller pore size hydrogel system. Thus, the amount of aloin released and Dapp can be controlled by controlling the hydrogel pore size.

Keywords: Aloein / Hydrogel /Paper Aloe-vera Extraction, Transdermal drug delivery patch, Diffusion coefficient;

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1. Introduction

(Hydrogels, consisting of tri-dimensional structures formed by crosslinking hydrophilic polymeric chains, possess the ability to swell in solution in response to the chemical nature of the media, the pH, the ionic strength, the electric field, and temperature [1].

The Aloe-vera extraction (Aloein, Aloe-emodin and Aloesin), which is the active compounds that decrease pain and inflammation and stimulate skin growth and repair, are selected as the model drug in this work. From the low content of active compound (<5 %v/v) in Aloe vera, the development of controlled Aloe-vera extraction system is required to increase the efficiency of drug therapeutic [2].

In this work, the release characteristic of Aloe-vera extraction, aloein from PAAM hydrogel system was investigated at various hydrogel pore sizes. The rate and amount of drug release will be controlled by controlling the hydrogel pore size. These aolein/PAAM hydrogel system might increase the therapeutic efficiency and valuable of Aloe-vera extraction, subheadings, images, and formulae. The section headings are arranged by numbers, bold and 10 pt. Here follows further instructions for authors.

2. Methodology

2.1. Materials

Aloein (AR grade, Fluka), was used as the model drug. Acrylamide, AAM (AR grade, Fluka), N,N′ methylenebisacrylamide, (N,N′-MBA) (AR grade, Fluka), tetramethylenediamine, TEMED (AR grade, Fisher Scientific), and ammonium peroxodisulfate (AR grade, Fluka) were used as the monomer, crosslinker, catalyst, and initiator, respectively.

2.2. Preparation of Aloein-Loaded Polyacrylamide Hydrogel (Aloein/PAAM)

The 0.2 %w/w Aloein-loaded PAAM hydrogels (based on the weight of the acrylamide monomer) were prepared by the free-radical polymerization of 2.32 g of acrylamide in an aqueous solution of Aloein with N, N′ methylenebisacrylamide (MBA) as crosslinker [3]. Ammonium persulfate and tetramethylenediamine (TEMED) were used as the initiator and the accelerator. To study the effect of crosslinking ratio on the release of Aloin from Aloein/PAAM hydrogels, gels at various crosslink ratios (mol MBA: mol AAM; 0.001, 0.002, 0.005, 0.010, 0.016, 0.024; PAAM_01, PAAM_02, PAAM_03, PAAM_04, PAAM_05, PAAM_0, respectivele) were prepared at various amounts of N, N′ methylenebisacrylamide (MBA).

2.3. Characterization of PAAM Hydrogel

To investigate the morphology of the PAAM hydrogel at various crosslink ratios with and without an electric field, scanning electron micrographs of the hydrogels were taken using an acceleration voltage of 15 kV and a magnification of 350. Samples were prepared from frozen swollen hydrogels with and without electric field in liquid nitrogen and then dried in vacuum at -50°C.

To determine the % swelling of the PAAM hydrogels at various crosslink ratios, they were immersed in an acetate buffer, pH 5.5, at 37 °C. After 5 days the swollen PAAM hydrogels were removed, gently wiped to clean off the surface water, and then re-weighed. To determine the % weight loss, the swollen PAAM hydrogels were dried in a vacuum oven for 5 days until constant weight values were attained. The % swelling and the % weight loss were calculated using the following equations [1]:

$$\text{Degree of swelling} = \frac{M - M_d}{M_d} x100 \quad (1)$$

where M is the weight of a swollen sample, Md is the weight of swollen sample after drying in vacuum oven, and Mi is the initial weight of the sample [1]. All reported data were average values taken from repeated measurements using five specimens. The hydrogel mesh size, ξ, was calculated using the following equation:

$$\xi = v_{2,s}\left[C_n\left(\frac{2M_c}{M_r}\right)\right]^{1/2} l \quad (2)$$

where Cn is the Flory characteristic ratio for PAAM (8.8), and l is the carbon-carbon bond length (= 15.4 Å) [4].

DSC thermograms of the Aloein, the PAAM hydrogel, and the Aloein-loaded PAAM hydrogel were recorded to determine their thermal behavior. The 2-4 mg sample was accurately weighed in an aluminum pan with a sealed cover. The measurements were performed under N2 atmosphere over 30 – 400 °C at heating rate of 10 °C/min.

2.4. Release of aloin from Aloein/PAAM Hydrogel Experiments

Transdermal diffusion through a hairless pigskinwas carried out in order to study the release characteristics of the aloin from a aloein/PAAM hydrogel. A hairless pigskin (thickness ~ 1-1.5 mm) was placed on top of the acetate buffer solution on a custom built modified Franz diffusion cell. The pigskin was allowed to come into equilibrium contact with the acetate buffer in the receptor chamber; the buffer was magnetically stirred throughout the experiment period (24 h) at a thermostatically maintained temperature (37 ± 2 °C). The aloein/ PAAM hydrogel with a particular crosslinking ratio was placed between the cap and the pigskin, which was mounted onto the receptor compartment. The buffer solution, 0.3 ml was withdrawn and an equal amount of fresh buffer solution was added to the cell, every 15 minutes during the first hour. The amount of the drug in the withdrawn solution samples was determined using a UV spectrophotometer [5]. Construction of references

3. Results and Discussion

3.1 PAAM characterization

PAAM was polymerized through free radicalization and subsequently crosslinked at 27 °C [3]. The calculated mesh sizes of PAAM hydrogel is PAAM_01, 292 ± 8 Å; PAAM_02, 183 ±16 Å; PAAM_03, 161 ± 8 Å; PAAM_04, 148 ± 3 Å; PAAM_05, 119 ± 10 Å; PAAM_06, 99 ± 2; as the crosslinking ratio decreases, the mesh size increases. Scanning electron micrographs of PAAM hydrogels at various crosslinking ratios are shown in Fig. 1. The hydrogel mesh sizes also decreases with increasing crosslinking ratio. As the amount of crosslinking agent decreases, the spacing between the crosslinks becomes longer. The mesh sizes, determined visually from the SEM micrographs, are higher than the mesh sizes calculated from Eq. (2). It should be noted that mesh sizes from the SEM micrographs are "apparent" mesh sizes, appearing at the surfaces, whereas the mesh sizes from Eq. (2) are bulk pore sizes. The data clearly show that the crosslinking ratio decreases as the mesh size increases.

In this present work, the degree of swelling is related to the amount of gel required to achieve a suitable. As expected intuitively, the degree of swelling is inversely proportional to the degree of crosslinking as shown in Fig. 1. These results are consistent with theoretical predictions which describe the swelling of gel as a function of the degree of crosslinking [6].

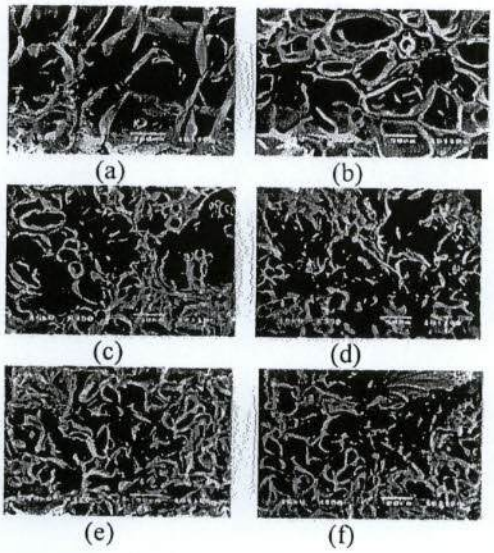

Fig. 1. The morphology of PAAM hydrogel after swelling: a) PAAM_1 ; b) PAAM_2; c) PAAM_3; d) PAAM_4; e) PAAM_5; and f) PAAM_6 at magnification of 350.

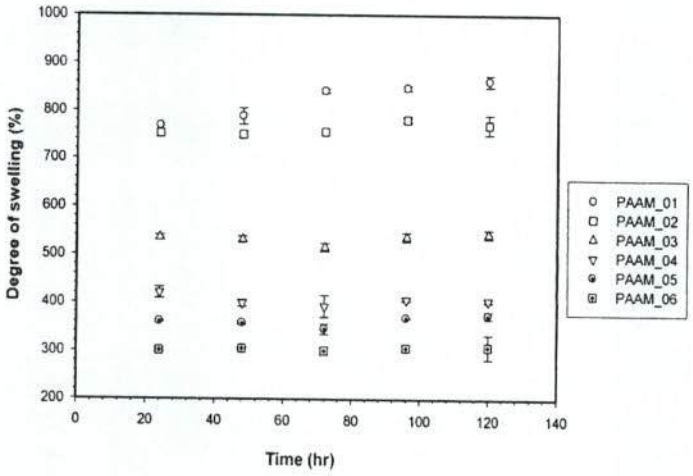

Fig. 2. Degree of swelling of polyacrylamide hydrogel.

DSC thermograms of, aloein-loaded PAAM hydrogel, and PAAM hydrogel were measured to investigate the interaction between aloein and the polyacrylamide matrix. The melting temperature (T_m) of PAAM is 219 C, consistent with a previous report [Sairam *et al.*, 2006]. However, the T_m of PAAM in aloein-loaded PAAM occurs at 241 °C, suggesting that aloein possibly interacts with the PAAM hydrogel through hydrogen bonding between the hydroxyl groups of the aloein and the amine groups of the PAAM hydrogel.

The amount of aloein released through pigskin was reported as the amount of aloein release from aloein/PAAM as shown in Fig.2. Evidently, the amount of SA released from SA-loaded PAAM through the pigskin is greater at a given time for samples with a lower crosslinking ratio. The apparent diffusion coefficients, D_{app} of aloin diffuse from aloin/PAAM were determined by Higushi's equation;

$$Q = 2C_0(D_{app}t/\pi)^{1/2} \tag{3}$$

where Q is the amount of drug released per unit area, C_0 is the initial drug concentration in the gel, and D_{app} is the apparent diffusion coefficients diffusion coefficient of a diffusant [7]. We may note D_{app} obtained from Eqs. (3) are valid over an initial period of time and based on the Fick's laws.

The effect of pore size of PAAM hydrogel on D_{app} is shown in Fig.3. The D_{app} also increases with increasing hydrogel pore size. For larger pore size of hydrogel system, aloein can easily diffuse out than smller pore size hydrogel system. Thus, the amount of aloin released and D_{app} can be controlled by controlling the hydrogel pore size [8-13].

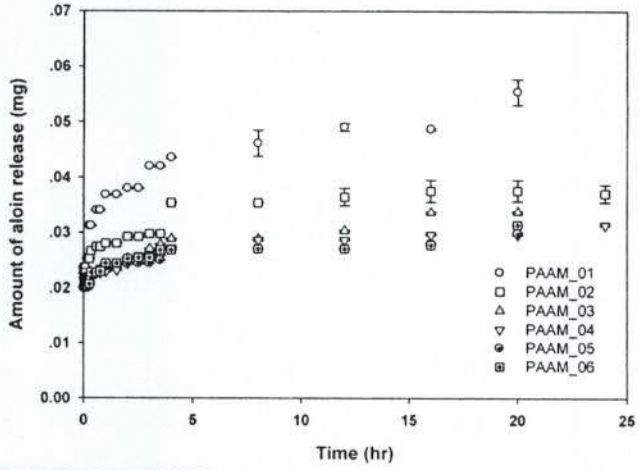

Fig. 3. Amount of aloin released from aloin/PAAM.

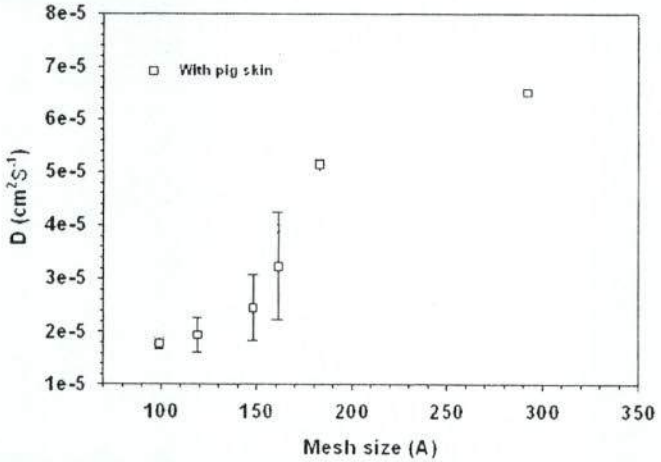

Fig. 4. D_{app} of aloein from aloein/PAAM at various hydrogel pore sizes.

4. Conclusions

These aolein/PAAM hydrogel systems increase the therapeutic efficiency and valuable of Aloe-vera extraction, Aloein. The diffusion coefficient and amount of drug release can be controlled by controlling the hydrogel pore size. The amount of drug released and diffusion coefficient increase with increasing hydrogel pore size.

Ackhowledgements

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