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Short communication

Effect of calcium chloride on physical properties of blended alginate carboxymethyl cellulose wound dressings

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Introduction

Natural polymers have been used for a variety of biomedical and pharmaceutical applications due to their resemblance of extracellular matrix components. One of these applications is the use of polysaccharides in the fabrication of film wound dressings.

Since alginate exhibits excellent film forming properties, in addition to its biocompatibility, it has been used in this research as a primary polymer, alongside with carboxymethyl cellulose. The addition of another polymer, as well as the process of crosslinking, are usual modifications made for the purpose of improving the physical and biological properties of alginate films (Aravamudhan et al.,2014).

The aim of this study was to showcase the effect of cationic crosslinking on physical properties of blended alginate carboxymethyl cellulose wound dressing.

Materials and methods

The wound dressings were prepared by film casting method. The polymer-based hydrogel formulation (1.25%) was composed of sodium alginate (SA, viscosity of 15.00-20.00 cps; Sigma Aldrich-USA) and sodium carboxymethyl cellulose (NaCMC, average MW of 250 000; Acros Organics, Belgium). SA and NaCMC in a ratio of 3.5:1 were dissolved in distilled water using a magnetic stirrer (Magnetic hotplate stirrer with temperature controller. IKA Plate (RCT Digital), IKA Werke, Germany, 3 h, 300 rpm, 60ºC). Glycerol (Alkaloid, N. Macedonia) was used as plasticizer in concentration of 1% (v/m). Subsequently, $CaCl_2$ solution was added and formulations were left to be stirred overnight at ambient conditions (300 rpm, Magnetic hotplate stirrer with temperature controller. IKA Plate (RCT Digital), IKA Werke, Germany). Two formulations that differ in amount of $CaCl_2$ were prepared, SA-MCC1 (0.025% $CaCl_2$) and SA-MCC2 (0.05% $CaCl_2$). As control SA-MC (without $CaCl_2$) was used.

Each hydrogel formulation was cast in a petri dish with a quantity of 0.08 g/cm^2 and left at ambient conditions to dry out. The films were peeled-off gently, packed in an airtight package and kept in desiccator (lower part filled with silica gel) prior testing. Each formulation was prepared at least in triplicate.

The films were characterized by thickness (µm) (manual caliper, Meopta, Czech Republic), mass (g), solvent loss (g), moisture vapor transmission rate (MVTR), rheological properties (Anton Paar Rheometer, Austria (MCR 92 SN83912283)) and swelling ratio (SwR) as described in Han & Wang, 2016 with slight modifications. Solvent loss was calculated as difference between the mass (g) of the petri dish with added hydrogel before and after drying.

The MVTR test was conducted at 32±2 ºC and >90% relative humidity (Hygrometer – Testo AG, Germany). The wound dressings were placed over the brim of glass vials containing desiccant. The mass of each glass vial was measured at predetermined time intervals (0, 1, 2, 3, 4, 5,

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24 h) and the MVTR values were calculated according to Thu et al., 2012.

Dried films were rehydrated into gel by adding the same amount of water that had been lost during the drying. Their viscosity was measured using a cone and plate rheometer (Anton Paar Rheometer, Austria (MCR 92 SN83912283), with the cone and plate system 50 mm / 1°). Viscosity was measured with the viscosity curve method, where shear rate was increased to 500 s^{-1} over a period of 3 min, and then decreased to zero over the same time interval at a fixed rate. The measurements were performed in triplicate of each formulation.

For the swelling ratio test, the formulations were placed in petri dishes containing gelatin medium and their diameters were measured over the same time period as for the MVTR test. The difference between the diameters from the starting point (t=0) and the corresponding time was calculated as swelling percentage and plotted as a function of time. Each test was done at least on triplicate on formulation each batch.

Results and discussion

All 3 formulations of the film casted wound dressings were transparent with smooth surface. Their thickness, mass and solvent loss are summarized in Table 1. It is evident that by increasing the amount of $CaCl_2$ the thickness and mass increased, while there is no difference in solvent loss (one way *ANOVA, $p < 0.05$*).

The values for MVTR of SA-MC, SA-MCC1, SA-MCC2 were 60.77, 75.343 and 65.975 g/m^2/h, respectively. Although there is not exact ideal value for MVTR for wound dressings, the values should not be either too high or too low, as this can cause very dry conditions in the wound area or can lead to accumulation of more exudate which results in greater risk of bacterial growth. According to Razzak et al., 2001, MVTR values of some commercialized wound dressings are in the range of 33 to 208 g/m^2/h. Hence, it can be concluded that the SA-MC, SA-MCC1, SA-MCC2 films are suitable for their use as wound dressings.

All rehydrated films have shown shear thinning with pseudoplastic flow properties which indicates that films were able to revert into hydrogel phase without losing their rheological behaviour. At the shear rate of 500 s^{-1} SA-MCC2 film showed highest viscosity (0,45099 Pa s) compared to SA-MCC1 (0,21550 PA s) and SA-MC (0,02752 Ps s) due to the addition of $CaCl_2$.

SwR was conducted on gelatin medium as wound model as it can mimic characteristics of a supporting wound (Matthews et al., 2005). SA-MC showed SwR of ~22%, SA-MCC1 of ~14% and SA-MCC2 of ~9% thus indicating that amount of $CaCl_2$ had significant effect on swelling degree (one way *ANOVA, $p < 0.05$*) most likely due to the improved structural integrity of the casted wound dressing by increasing the crosslinker quantity.

Table 1. Thickness, mass and solvent loss of film casted wound dressings

Samples	Thickness (µm)	Mass (g)	Solvent loss (g)
SA-MC	22.5±2.5	0.123±0.01	5.94±0.03
SA-MCC1	26.67±2.35	0.135±0.02	5.93±0.05
SA-MCC2	36.66±7.45	0.139±0.02	5.96±0.03

Conclusion

In the presented study, blended alginate carboxymethyl cellulose films were successfully prepared and characterized. It was demonstrated that the crosslinking process significantly affects their properties. Moreover, it was shown that the concentration of $CaCl_2$ as a crosslinker can alter the physical properties of such films, hence affecting their potential application as wound dressings.

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