# Creation of alginate hydrogel plates structured by microhydrogel calcium preparations

Dron I.A., Nosova N.G., Bukartyk N.M., Lugova Yu.R., Lyah V.I.
Department of organic chemistry, Lviv Polytechnic National University.
S.Bandera str., 12, Lviv-79013, Ukraine. E-mail: irynadron@ukr.net

## Introduction

Natural polysaccharides are widely used in the food industry as gelling polymers (thickeners) and for various biomedical applications. Due to the high biodegradability, biocompatibility, and ability to accelerate wound healing, such polymers are used to create novel medical materials [1,2]. However, alginate plates do not have sufficient capacity for the sorption of wound secretions and physical and mechanical properties. Therefore, their application for wound therapy is limited.

The purpose of this study is to create alginate hydrogel plates with sufficient sorption properties for wound secretions and satisfactory physical and mechanical properties for further medical application.

## Methods

**Materials** – sodium alginate (Utraco Holland b.v.) polypropylene glycol (PPG-2000, Aldrich), glycerin (Aldrich), calcium salt of crosslinked polyacrylic acid (LSPAA-Ca), distilled water.

**Hydrogel plates** were obtained using sodium alginate as a polymer-gelling agent and calcium salt of crosslinked polyacrylic acid (LSPAA-Ca) as a structuring agent; glycerin / PPG-2000 as the plasticizers.

**The degree of exudate absorption** was researched using the escudat models described in [2].

## Results

We have formed hydrogel plates based on sodium alginate - an available plant polysaccharide with carboxyl groups. The calcium salt of crosslinked polyacrylic acid (LSPAA-Ca) was used as a structuring agent; the structural formula is shown in Fig.1.

While alginate hydrogel plate is formed, intermolecular ionic bonds are formed not only between the macromolecules of alginate but also between the macromolecules of alginate and polyacrylic acid. Thus, the morphology of the hydrogel is a cross-structured network of sodium alginate as a continuous phase with the inclusion of LSPAA hydrogel (Fig.2).

A new composite material with hydrogels of different nature performing the function of the polymer matrix and the dispersed medium is formed due to this technique. According to the general qualification, such a composite material can be attributed to interpenetrating grids. The combination of two hydrogels with different properties in one material forms new, not typical for alginate plates properties.

The table shows the main characteristics of the obtained alginate hydrogel plates depending on the synthesis conditions. Increased swelling capacity in the exudate was achieved only due to partial drying. The presented data indicates that partial dehydration allows obtaining alginate hydrogel plates with sufficient absorption capacity for exudate. Thus, due to the partial drying of the manufactured hydrogel plates with a thickness of 4 ÷ 6 mm, the absorbing capacity of the exudate makes from 40 to 50 grams per 1 dm2 for 3 hours of swelling. The mechanical properties of the hydrogel increase with the increased introduction of LSPAA-Ca.

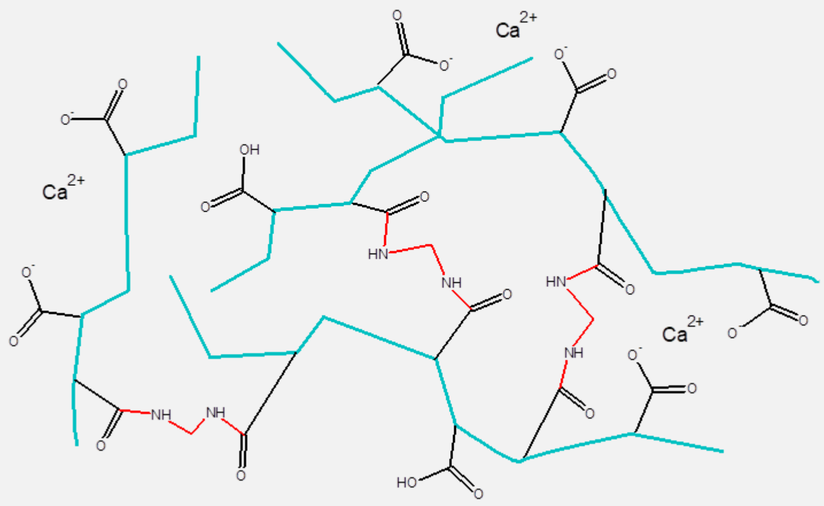


Figure 1. Structural formula of liquid-structured poly-acrylic acid calcium salt (LSPAA-Ca)

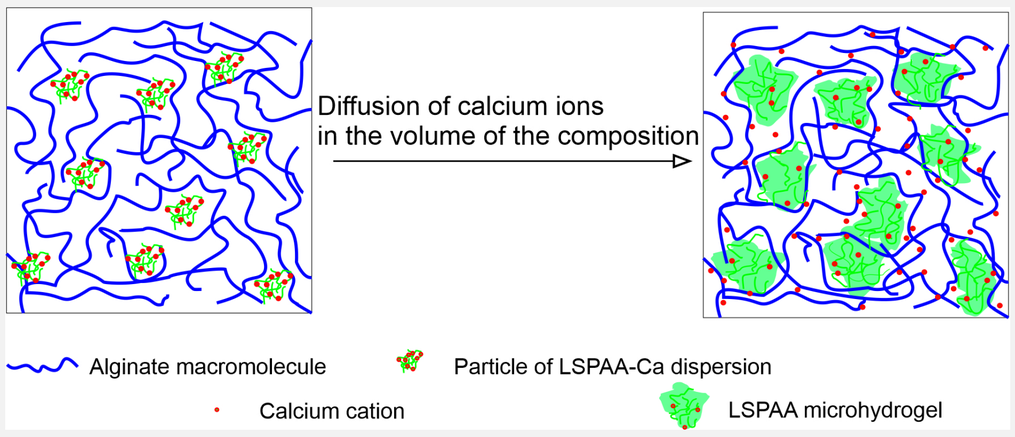


Figure 2. The scheme of alginate hydrogel formation with LSPAA-Ca as a source of calcium ions

**Table 1**

**Dependence of the degree of exudate absorption by alginate hydrogels on the conditions of their synthesis and dehydration degree (content of sodium alginate - 3%, LSPAA-Ca 1%)**

| № | Structuring agent | | Synthesis medium | Content of –COOH groups · 104, eq/g | Ion $Ca^{2+}$ content · $10^5$, eq/g | Content of Na(K) · $10^4$, eq/g | Content of water, (degree of drying) % | Swelling, g/g | Exudate absorption | | The modulus of elasticity, Pa |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Composition / (the degree of substitution) | Concentration, % | | | | | | | 3 h, g/g | 3 h, g/dm$^2$ | |
| 1 | LSPAA-Ca (0,34) | 0,7 | water | 1,68 | 3,1 | 1,07 | 78,4 | 21,6 | 25,4 | 7,7 | 240 |
| | | | | | | | **18,0** | **1,3** | **8,5** | **50,2** | |
| 2 | LSPAA-Ca (0,34) | 1,0 | | 2,29 | 4,43 | 1,07 | 78,1 | 19,8 | 24,0 | 10,5 | 250 |
| | | | | | | | **10,0** | **0,6** | **6,0** | **49,2** | |
| 3 | LSPAA-Ca (0,53) | 0,7 | | 1,57 | 4,5 | 1,07 | 78,4 | 21,6 | 26,4 | 13,2 | 280 |
| | | | | | | | **28,6** | **3,8** | **10,7** | **41,9** | |
| 4 | LSPAA-Ca (0,53) | 1,0 | | 2,24 | 6,43 | 1,07 | 78,1 | 19,8 | 22,6 | 6,9 | 590 |
| | | | | | | | **34,0** | **2,9** | **9,1** | **40,5** | |
| 5 | LSPAA-Ca (0,85) | 1,0 | | 2,15 | 9.54 | 1,07 | 78,1 | 19,8 | 22,6 | 6,0 | 620 |
| | | | | | | | **19,8** | **1,4** | **2,8** | **7,5** | |
| 6 | LSPAA-Ca (0,85) | 2,0 | | 4,7 | 22 | 1,07 | 77,1 | 15,6 | 16,2 | 1,2 | 940 |
| | | | | | | | **14,2** | **0,8** | **3,5** | **17,8** | |
| 7 | LSPAA-Ca - Na (1,0) | 1,0 | | 2,15 | 9.54 | 1,24 | 78,1 | 19,8 | 22,6 | 5,3 | 1002 |
| | | | | | | | **20,0** | **1,4** | **7,8** | **24,6** | |
| 8 | LSPAA-Ca - Na (1,0) | 1,0 | Phosph. buffer (pH7) | 2,15 | 9.54 | 4,0 | 78,1 | 19,8 | 27,5 | 15,0 | 800 |
| | | | | | | | **14,8** | **1,0** | **8,4** | **26,5** | |
| 9 | LSPAA-Ca (1,0) | 2,0 | | 3,15 | 22 | 4,0 | 77,1 | 15,6 | 17,9 | 6,4 | 715 |
| | | | | | | | **13,8** | **0,7** | **5,9** | **24,3** | |

## Conclusions

According to the results of studies for alginate hydrogel dressings (sorption capacity for exudate, physical and mechanical properties), proposed hydrogels are perspective as wound-healing and postoperative hydrogel dressings for the treatment of uninfected wounds on the second and third stage and burns at all stages of therapy.

## References:

1. *Sun J., Tan H.* Alginate-based biomaterials for regenerative medicine applications // Materials.- 2013.**- N 6.-** P. 1285-1309.
2. *Rezvaniana M., N.Ahmad.* Optimization, characterization, and in vitro assessment of alginate-pectin ionic cross-linked hydrogel film for wound dressing applications // International Journal of Biological Macromolecules.- 2017.- N 97.- P. 131-140.

## Contact information:

**Nosova Nataliya**
e-mail: nnosova2121@gmail.com
**Dron Iryna**
e -mail: irynadron@ukr.net