



# STUDY OF POLY VINYL ALCOHOL (PVA $\ell$ ) AND POLY(ETHYLENE GLYCOL)(PEG) HYDROGELS BY CHEMICAL CROSSLINKING WITH CITRIC ACID



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## Abstract

The aim of this work is to study the Poly(vinyl alcohol) PVA $\ell$  hydrogels modified by a second polymer, polyethyleneglicol (PEG). In the presence of PEG300 it was observed a hydrogel formation of lower swelling capacity considering the water uptake (%) in comparison of the hydrogel absent of PEG300. The increase of citric acid (% w/w) concentration, at the low level used (0.3-0.8) also varied the swelling of the hydrogel.

## Introduction

Poly(vinyl alcohol) (PVA $\ell$ ) is a water-soluble polymer, employed in practical applications due to its excellent chemical resistance, processing facilities, biodegradability and physical properties <sup>1,2</sup>. The presence of a second polymer can performs significant change in the overall crystalline structure of the hydrogel. PVA softening hydrogel could be obtained with adequate blend composition by chemical crosslink of PVA $\ell$  in the presence of citric acid. The acid catalyzed (HCl) esterification reaction occurs between the citric acid and hydroxyl group of the PVA $\ell$ . Two chains of the polymer (alcohol function) are linked by the citric acid. Morphological changes can lead to different performance of the hydrogel and the characteristics of swelling degree and diffusional behavior may change under physiological stimuli <sup>3</sup>, as important feature for controlling release of bioactive species.

## Methods and materials

PVA $\ell$  (Mw = 85000-115000, degree of hydrolysis 98.4%) from Celvol<sup>TM</sup> 325 Dermat Agekem. PEG 300 from Oxiteno and citric acid (99.9 %) from Merck.

### Swelling and Gel Fraction

After synthesis, the samples were dried in stove at 60 °C until constant mass. For swelling determination they were immersed in distilled water and weighed in periods of time until 22h and the result was obtained using the equation A.

$$\text{Swelling} = (m_s - m_d)/m_d * 100 \quad \text{i.e. (g H}_2\text{O.g}^{-1} \text{ dry polymer)} \quad (\text{A})$$

Where:  $m_s$  is the mass of swelled polymer and  $m_d$  is the mass of the dry polymer.

The gel fraction was obtained with the dried samples by immersion for 12h in boiling water. The sample extracted was dried in oven (60 – 70 °C) and the gel fraction was calculated as equation B.

$$\text{Gel fraction} = 100 - [100 * (m_i - m_f)/m_s] \quad (\text{B})$$

Where:  $m_i$  is the mass of sample before extraction and  $m_f$  is the final mass of dried sample after extraction.

## Results

Figures 1 to 6 show illustrations of the hydrogels. Table 1 indicates the formulations used in this study. PVA $\ell$  hydrogel were compared with PVA $\ell$ /PEG hydrogel crosslinked chemically with citric acid. In Figure 5 are shown the swelling results of formulation varying the polymer quantity. In the equilibrium time of the curve there is no difference of swelling percent. Figure 6 shows the water uptake of the dried hydrogels in distilled water until equilibrium. In the presence of PEG 300 it was observed a hydrogel formation of lower swelling capacity (F4, F5 and F6) considering the water uptake in comparison of the hydrogel absent of PEG 300. The increase of citric acid concentration, at the low level used (0.3 - 0.8 % w/w) also varied the swelling of the hydrogel. The gel content agrees with those results (Table 1). In this sense the results shown

that probably chemical crosslink occurred of the PVA $\ell$  and PEG 300 in the chemical reaction.

**Table 1** – Formulations of the hydrogels in % w/w, in water.

	F1	F2	F3	F4	F5	F6	F7
PVA $\ell$	10	20	10	10	10	10	10
Mw=85000							
PEG 300	1.5	1.5	---	---	1.5	1.5	1.5
Citric acid	0.5	0.5	0.3	0.5	0.3	0.5	0.8
HCl (37%)	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Agar	1.0	1.0	1.0	1.0	1.0	1.0	1.0

**Table 2** – Gel fraction of dried hydrogels.

F1	0.64
F2	0.27
F3	0.58
F4	0.53
F5	0.60
F6	0.95
F7	0.80



**Figure 1** – Dried PVA $\ell$  hydrogel



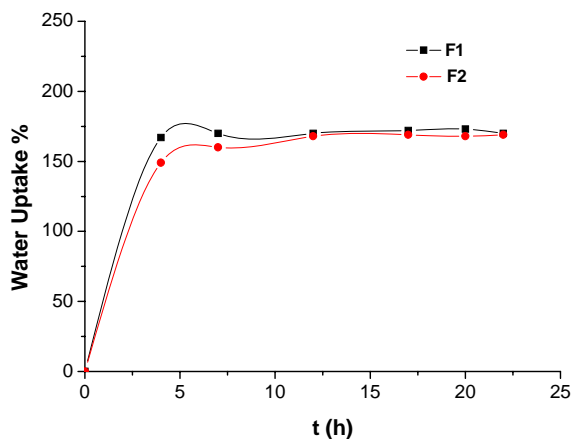
**Figure 2** – Swelled PVA $\ell$  Hydrogel



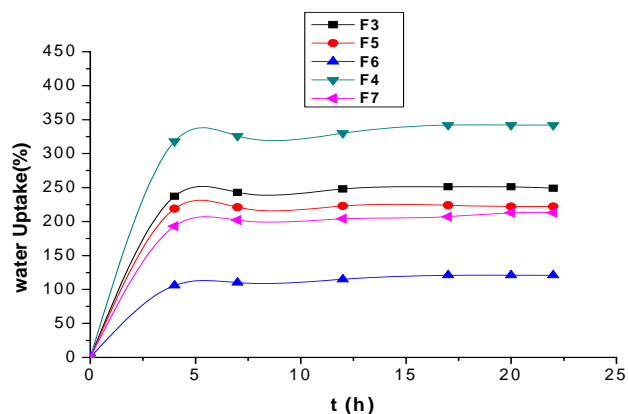
**Figure 3** – Dried hydrogel from PVA $\ell$  / PEG



**Figure 4** – Swelled hydrogel from PVA $\ell$  / PEG



**Figure 5** – Equilibrium water uptake of hydrogel at different concentrations of PVA $\ell$



**Figure 6** - Equilibrium water uptake of hydrogel in presence of PEG300

## Conclusion

The presence of PEG in PVA $\ell$  hydrogels has changed the characteristics of water uptake and gel content. The chemical crosslink occurred with the PVA $\ell$  and PEG polymers.

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