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INFLUENCE OF POLYMER CONCENTRATION ON SWELLING AND MECHANICAL PROPERTIES OF HYDROGELS BASED ON FUNCTIONALIZED POLY (N-VINYL-2-PIRROLIDONE), PREPARED BY IONIZING RADIATION

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ABSTRACT

Use hydrogels based on Poly (n-vinyl-2-pirrolidone) (PVP), obtained by ionizing radiation and simultaneous sterilization present some eligible properties for using as topic dressing. With the purpose of obtaining a new hydrogel, PVP was functionalized with diethyl maleate by polymerization in emulsion and the physic gel obtained with 10%, 12% and 16% of PVPF was irradiated in an electron accelerator with a dose of the order of 25kGy. The obtained hydrogels were characterized by tensile test and swelling in water. An improvement of the mechanical properties and swelling with concentration of the PVPF was observed. It seems crosslinking density increases with concentration of PVPF in the hydrogel.

1. INTRODUCTION

Hydrogels obtained by irradiation are systems constituted by two components, one of these is an insoluble and crosslinked polymer, and the other is water.

Such systems are capable to absorb water until reaching an equilibrium state and holding back it without losing its original form. The interactions responsible for water absorption include processes related to the presence of hydrophilic groups in the polymer and capillarity diffusion between areas with different osmotic pressures [1-2].
The hydrogels based on poly(N-vinyl-2-pirrolidone) (PVP) obtained second the procedure described by Rosiak [1] can be used as dressing in the treatment of burnings and injuries of the skin in general. The use of those hydrogels diminishes the time of cicatrisation and the pain [3-4]. The therapeutic properties of the hydrogel membranes are highly influenced by water concentration which determines the life time of the product, and must be 85 to 90%.

Also the lowest mechanical properties of the hydrogels are not adequate for dressings with bigger dimensions [5].

In the irradiation of a polymeric system in solution, in particular hydrophilic polymers dissolved in water, the properties of the resultant system are function of characteristics such: polymer molecular structure, hydrophilicity, molecular weight and its distribution, polymer concentration in the solution, radiation dose and atmospheric composition during the irradiation [5-8].

Preliminary studies regarding the properties of the membranes with only PVP showed that the ideal dose to obtain best properties is 25kGy [5-11].
The objective of this study was to obtain new hydrogels, by means of ionizing radiation and evaluated the mechanical properties and the degree of water absorption (swelling). The hydrogels used were based on poly (N-vinyl-2-pirrolidone) functionalized with diethyl maleate (PVPF).

2. EXPERIMENTAL

2.1 Materials

In this study, it was used poly (N-vinyl-2-pirrolidone) functionalized with diethyl maleate (PVPF), obtained in accordance to Miranda et al. and Terence et al. [12,13], polyethylene glycol (PEG) with molecular weight 400, supplied by Oxiteno of Brazil; agar supplied by Oxoid, with L-13 code.

2.2 Methods

Obtaining hydrogels

It was prepared hydrogels with three different concentrations of PVPF: 10, 12 and 16%; 3% of PEG and 0.8% of agar. The reagents, previously dissolved in water, were hot mixed and the concentration of the components in the final solution was adjusted by addition of water in enough amounts for 100% in weight.

The mixtures: PVPF, agar and PEG were flowed in molds, in order to obtain membranes with 3 mm of thickness.Thermal reversible physical gel was obtained by cooling in the presence of agar. The molds containing the physical gel, wrapped appropriately, were irradiated with electron beam, from Dynamitron electron accelerator, with energy in the order of 1.5MeV and dose rate of 11.3kGy/s, in the dose of 25kGy.

Hydrogels Characterization

The hydrogels were characterized by tensile test and swelling in water.

• ***Tensile Tests:*** Those tests were in agreement with ABNT NBR 6241/80, and were support in a Q-Test universal machine of tests, model 65X, with specimen type I. The test speed was 25mm/mim.

• ***Swelling:*** The water absorption was determined by the weight increase of the membranes in relation to permanence in water time (swelling) in agreement with norm ASTM D 570. The samples were maintained in water for a period of 216 hours, being verified the water absorption every 24 hours until constant weight. The water absorption was determined for the humid membranes, after 7 days they had been radiated.

3. RESULTS AND DISCUSSION

Strain Strength: One week after irradiation the tensile strength was evaluated for the hydrogels gotten with 10, 12 and 16%, based on PVPF. Figure 1 and 2 show the tensile strength and the elongation in rupture, respectively.

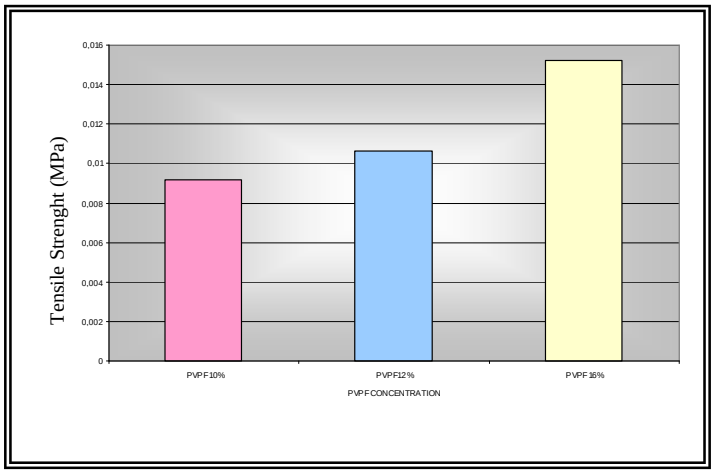

Figure 1 – Tensile strength showed by the hydrogels based on PVPF.

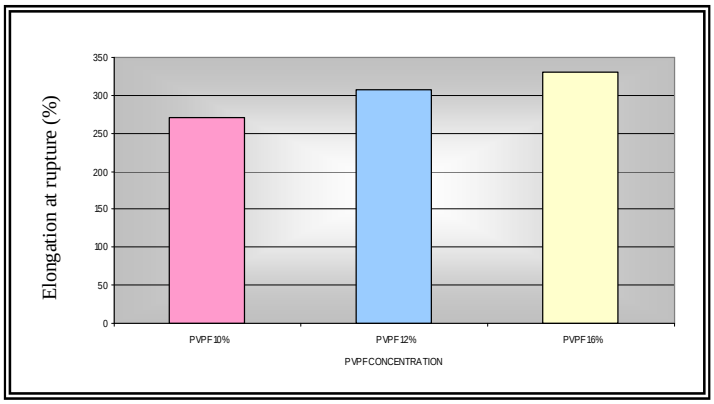

Figure 2 – Elongation in the rupture showed by the hydrogels based on PVPF.

In accordance to Figures 1 and 2, the strain strength and the elongation in the rupture increase with the PVPF concentration present in the hydrogel.

Swelling

One week after irradiation the water absorption was evaluated for the hydrogels gotten with concentrations of 10, 12 and 16%, based on PVPF. Figure 3 presents the water absorption obtained by the humid hydrogels based on PVPF. It shows that water retention increase with PVPF concentration.

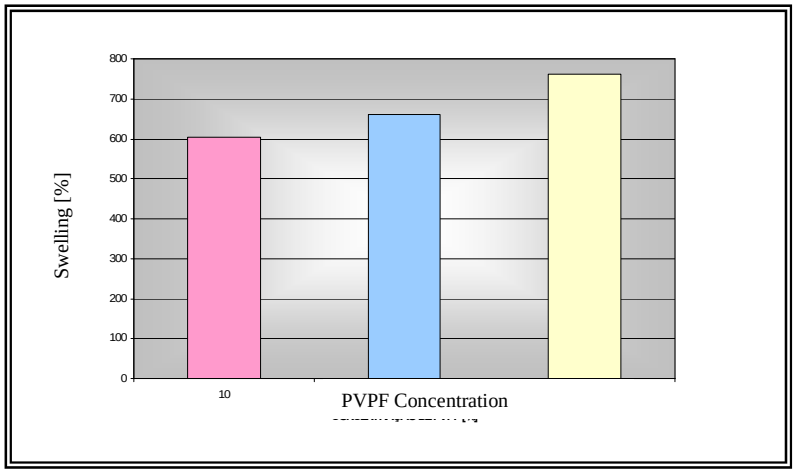

Figure 3 – Swelling presented by humid hydrogels, obtained with 10,12 e 16% of PVPF.

The water absorption (swelling) of the humid membranes are presented in Figure 4. The results were calculated on dry hydrogel weight.

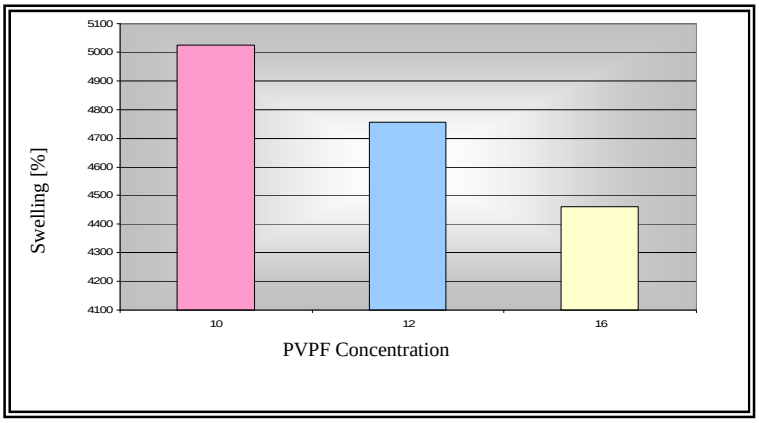

Figure 4 – Swelling presented by humid hydrogels, obtained with 10,12 e 16% of PVPF, and calculated on hydrogel dry weight.

For the radiation dose used it is verified that water absorption, corrected for dry weight, decreases with the increase of PVPF concentration, showing that the polymeric network decrease with the increase of PVPF concentration is due to the biggest density of crosslinkings. This trend of results is similar to the presented by hydrogel based on PVP [14].

4 CONCLUSIONS

The results for the concentration of PVPF studied show that:

-There is an increase in water absorption with PVPF concentration;

-There is water absorption by dry hydrogel decrease with PVPF concentration;

-There is an increase in crosslinking density with PVPF concentration;

- -There is strain strength and elongation in rupture increase with PVPF concentration.

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REFERENCES

1. J. M.Rosiak in *Radiation Effects on Polymers*. Clough, R. C. and Shalaby, S. W. Eds., ACS Books, ser. 475, p.271-299, Washington D.C. 1991.

2. L.D. B. Machado; L. F.Miranda; L.C. Penteado; A.B. Lugão; L.G.Andrade e Silva; M. Forti; B.W. Hulzler. in ENAN Proceedings Águas de Lindóia, 1998, Vol. n, pp.134-156 .

3. J.M.Rosiak; A.Ruci Ska-Rybus; W. Pekala. *Method of manufacturing hydrogel dressings***.** Polithechnika Lodzka. US Pat. 4,871,490. Oct. 3,1989.

4. J.M. Rosiak; J. Olejniczak *Radiat. Phys. Chem*. 1993, *42*, 903-906.

5. A.B. Lugão, L.D.B. Machado, L.F. Miranda, M.R. Alvarez, J.M. Rosiak in IMRP Proceedings, Annahein, 1997.

6. L.F. Miranda; A.Miranda; H.U.Nakahira; L.G. Andrade E Silva, A. B. Lugão in III Encontro Nacional de Biomateriais, 1996, São Paulo, CD-ROM, São Paulo: IPEN-CNEN/SP.

7. L.D.B. Machado; R. Siemens; A. B. Lugão; G.B.Ribeiro; L.C.Penteado; L. G.Andrade E Silva in XXXVI Congresso Brasileiro de Química. 1996, São Paulo, Livro de resumos. São Paulo: ABQ, n. AT26.

8. D. Darwis; N. Hilmy; L. Hardningsih *Radiat. Phys. Chem.* 1993, *42,* 907-910.

9. L.F. Miranda. Estudo de parâmetros de processo para a síntese de membranas hidrofílicas a base de poli (N-vinil-2-pirrolidona). Tese de Doutorado, IPEN/USP-SP, 1999.

10. OLEJNICZAK, J.; ROSIAK, J.;CHARLESBY. A. Gel/Dose Curves for Polymers Undergoing Simultaneous Cross-linking and Scission. **Radiat. Phys. Chem**. v. 38, p113-118, 1991.

11. DARWIS, D.; HILMY, N.; HARDNINGSIH, L; ERLINDA, T. Poly(n-vinylpyrrolidone) hydrogels: 1. Radiation polymerization and crosslinking of n-vynilpyrrolidone. **Radiat. Phys. Chem**. v.42, n. 4-6: p. 907-910, 1993.

12. L. F Miranda; M. C. Terence; S. B Faldini; V. H Kubota. Comparative study of hydrogels based on pvp and functionalized pvp with diethyl maleate. In: World polymer congress - MACRO 2006 - 41Simpósio internacional de macromoléculas, 2006, Rio de Janeiro. World polymer congress - MACRO 2006 - 41Simpósio internacional de macromoléculas, 2006. p. 1-3.

13. M. C. Terence; L. F Miranda; V. H Kubota; L. G. A. e Silva; S. B Faldini. Obtenção de hidrogéis a base de poli (N-vinil-2-pirrolidona funcionalizada preparados por radiação ionizante. In: International nuclear atlantic conference, 2005, Santos. International nuclear atlantic conference, 2005.

14. M. C. Terence; L. F Miranda; S. B Faldini; V. H Kubota. Estudo da funcionalização do poli (N-vinil-2-pirrolidona) com maleato de dietila. In: 17 Congresso Brasileiro de Engenharia e Ciência dos Materiais - CBECIMAT, 2006, Foz do Iguaçu. 17 Congresso Brasileiro de Engenharia e Ciência dos Materiais - CBECIMAT, 2006.