*2011 International Nuclear Atlantic Conference - INAC 2011*
*Belo Horizonte,MG, Brazil, October 24-28, 2011*
*ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR - ABEN*
***ISBN:* 978-85-99141-04-5**

# POLYMERIC HYDROGELS WITH INORGANIC NANOPARTICLES FOR DRUG DELIVERY

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## ABSTRACT

Nanoscience has been applied in research of intelligent systems for drug delivery. The use of biodegradable synthetic polymers in diagnostics and therapy application has stimulated the nanotechnology of polymer systems. The study of the modification of polymeric structure of hydrogels through the incorporation of inorganic nanoparticles has being developed in order to obtain an efficient support for the release of drugs. Poly(vinyl pyrrolidone) (PVP) hydrogels were obtained with Laponite RD clay at concentrations of 0.5, 1.0 and 1.5%. Characterizations were done using: swelling, gel fraction, thermogravimetric analysis (TGA) and infrared spectroscopic analysis (FTIR). The results were quite consistent with expectations, changing clay concentration interferes significantly with the swelling behaviour of the samples.

**Keywords:** Hydrogel, PVP, Clay, Nanocomposite.

## 1. INTRODUCTION

The current study of polymer science considers science as a biomedical application areas of great importance to establishing the changes in order to obtain polymeric materials new. Such as catheters, pacemakers, replacement tissues, cell immobilization, diagnosis and supports for controlled release of drugs from hydrogels made of synthetic and nanogel microgel [1; 2]. The use of ionizing radiation as reticulation process has demonstrated over the years, progress in studies of hydrogels for various applications including the release of drugs [3].

Recently, especially polymeric nanocomposites polymer nanocomposites with natural clays have been highlighted arousing the interest of many researchers [4]. These represent a rational alternative to conventional polymers, employing a small percentage of clay resulting in polymers with improved mechanical properties, good transparency, thermal stability, low gas permeability [5].

The dispersed clay hydrogels are a new class of composite materials that combine the elasticity and permeability of the hydrogels with high capacity clays adsorb different substances [6]. The exfoliated clay nanocomposites that stand out are attracting more interest. Because they increase the interactions between the polymer and clay [7].

In this work, hydrogels were formulated from poly(N-2-vinyl-pyrrolidone) (PVP) with nanostructured clays in order to enable controlled release systems of high efficiency.

## 2. MATERIALS AND METHODS

### 2.1 Materials

Poly(N-2-vinyl pyrrolidone) (PVP) *Kollidon* 90F from Basf. Agar provided by Oxoid and clay laponite RD coding S/11176/10 provided by Buntech.

The formulations prepared for crosslinking range were obtained by dissolving in water PVP (10% w / v) using a hot plate with magnetic stirrer and temperature between 90 ° C stirring until total homogenization of the solution and the procedure was performed at room temperature. The clay, after the dissolution was added to the Agar and PVP solution about agitation and temperature of 85 °C for five minutes. Were placed in Petri dishes and sent to the crosslinking process by gamma irradiation with $^{60}$Co source, dose 25 kGy.

### 2. 2 Swelling

After synthesis, the samples were immersed in distilled water and weighed in periods of time until 10h and the swelling was calculated according to the equation A.

$$\text{Swelling} = (ms - md)/md.\ 100\ (\%H_2O \text{ per g hydrogel}) \qquad (A)$$

where: ms is the mass of swelled polymer and md is the mass of the hydrogel.

### 2.3 Gel content

The gel fraction was obtained by immersion of the samples in water 100°C for 12h to proceed the extraction, under stirring. The water was replaced after each 4h. After that the samples were dried in oven (100 °C) and the gel fraction was calculated by the equation B.

$$\text{Gel fraction} = mf / ms\ .100 \qquad (B)$$

where: ms is the mass before extraction and mf is the mass of the dried sample after extraction.

### 2.4 Thermogravimetry (TG)

TG technique was accomplished in a Mettler-Toledo TGA/SDTA 851 thermobalance, using inert atmosphere of $N_2$ from 25 to 600 °C at heating rate of 10° C min$^{-1}$.

### 2.5 Fourier Transforms Infrared Analysis

FTIR analysis was done using a Thermo Nicolet FTIR-6700 Smart Diamond ATR de 4000 a 400 cm$^{-1}$.

## 3. RESULTS

The hydrogels obtained from PVP with 0.5, 1.0 and 1.5% clay changes are observed more consistent after four hours of testing, where the swelling is higher for 0.5% PVP and 1.0% clay least amount of gel in comparison to the pristine PVP, Fig 1.

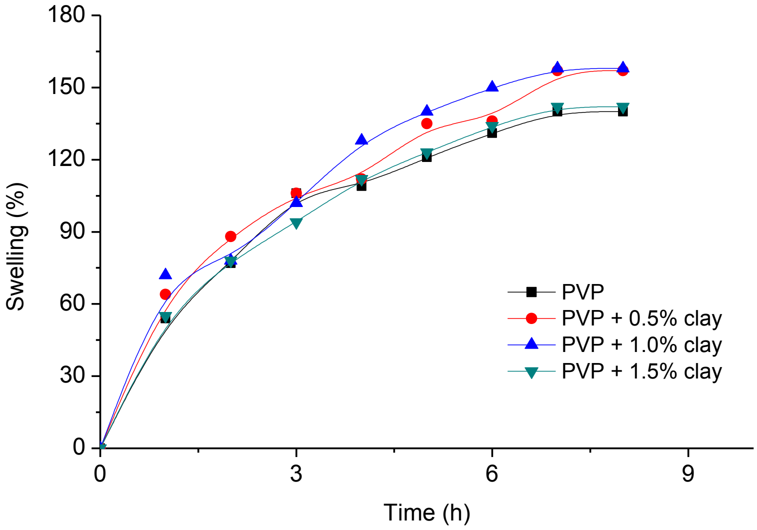

**FIGURE 1 – Swelling behavior of hydrogels PVP and clay laponite RD, obtained by gamma irradiation dose 25 kGy.**

The hydrogel membranes obtained with PVP and 0.5, 1.0 and 1.5% clay showed variations in gel fraction compared to the PVP without clay. With higher concentrations of clay the gel fraction decreases. The results follow the swelling from the initial period of four hours. This result was associated with ionic interactions present in the clay, which probably hampered the reticulation system, table 1.

**TABLE 1- Gel fraction of hydrogels PVP and clay laponite RD, obtained by gamma irradiation dose 25 kGy.**

| Membranes | **Gel fraction (%)** |
|---|---|
| PVP | 233 |
| PVP + 0.5 % clay | 220 |
| PVP + 1.0 % clay | 216 |
| PVP + 1.5 % clay | 178 |

The results presented by TG curves of PVP hydrogels with 0.5, 1.0 and 1.5% clay. They feature two events; the first is associated to water loss and second associated with decomposition of the polymer chain. It is observed that there was no displacement of the decomposition temperature significant compared to PVP without clay, Fig. 2A and 2B.

The curves show the amount of waste for PVP without clay of 9.43% according to the percentage of clay increases the amount of waste reaching 18.56% PVP with 1.5 for the clay.

We associate these increases of residue to a possible intercalation of polymer clay or a folding of the polymer chains around the particles of clay.

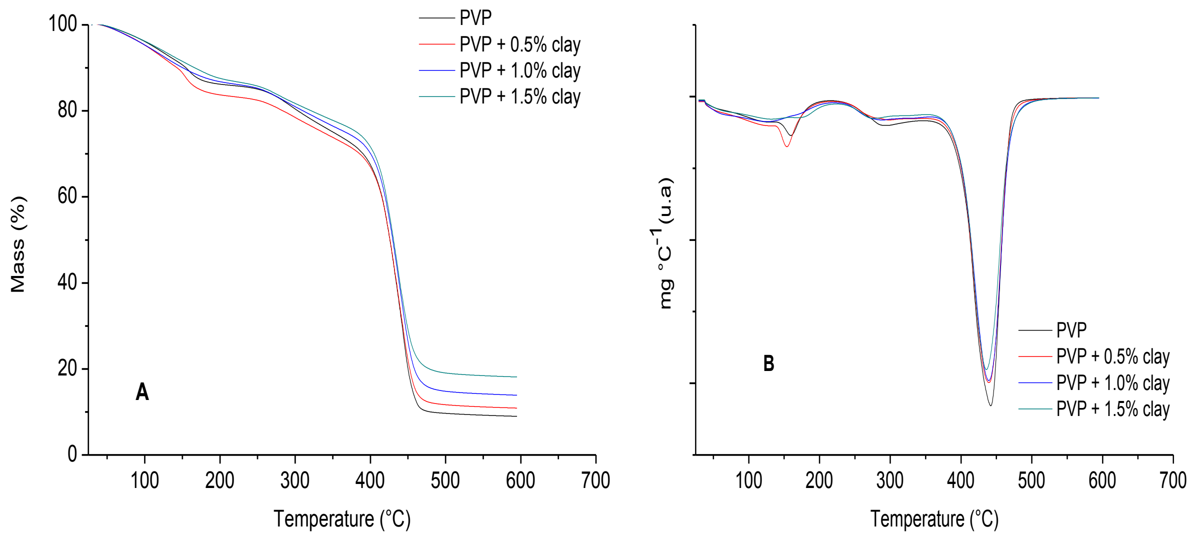

**FIGURE 2** – **(A) TG curves and (B) DTG curves of dried hydrogels PVP and clay laponite RD, obtained by gamma irradiation dose 25 kGy.**

The IR spectra for all samples, including pristine samples used as a point of reference in identifying the peaks of the nanocomposites of the PVP hydrogels with clay, there is enlargement of the peak around 1000 cm$^{-1}$ due to the presence of clay.

There is a peak around 1070 cm$^{-1}$ due to the displacement of the peak at 938 cm$^{-1}$ clay. The shift can be attributed to the interactions of polymer clay with the contribution of the silanol group.

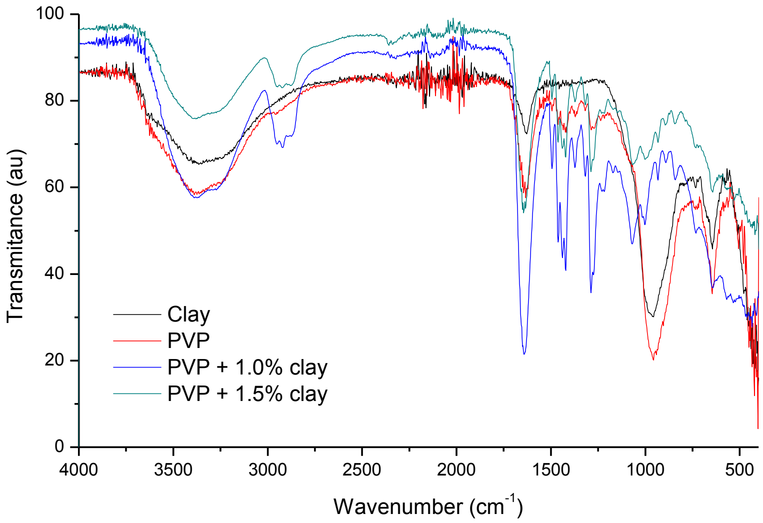

**FIGURE 3** – **Infrared curves of hydrogels PVP and clay laponite RD, dried films obtained by irradiation gamma dose 25 kGy.**

## 4. CONCLUSIONS

The hydrogels of PVP with clay present considerable increasing in swelling. At the same dose of irradiation, different concentration of clay, reduces the concentration of gel content of the membrane.

FTIR results indicated the displacement of absorption peaks. These shifts can be attributed to interaction between the polymer PVP and clay through Si-OH groups. This hydrogel can be exploited for drug delivery in biological systems.

## ACKNOWLEDGMENTS

**S**upport by FAPESP 09/50926-1**,** FAPESP Process nº 2009/18627-4 CNPq Process n° 310849/2009-8, CAPES, IPEN/CNEN and technicist Eleosmar Gasparin by thermal analysis.

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