Study of radiation-induced crosslinking of Polyvinyl pyrrolidone/Carboxy methyl cellulose (PVP/CMC) blends

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Abstract

Polymerics hydrogels, materials with capacity to absorb very high amount of water, have found applications in industry and as biomaterials in biomedicine area. Based on PVP (polyvinyl pyrrolidone), a particularly interesting hydrogel dressing which was introduced in the European market and is now reaching others regions can be found. However some of its properties like absorption of body fluids still need improvement. Processing by radiation seems to be a useful tool to promote the crosslinking of polymers. PVP is supposedly one of most common polymers employed as biomaterial due to its good biocompatibility properties. In this work the hydrogel studied was synthesized from PVP, from different amounts of CMC (carboxymethyl cellulose) and crosslinked using different doses of gamma radiation. The present work aimed the preparation of PVP/CMC blends and studies their physical chemical properties as gel fraction and swelling. The results showed that the CMC addition decreased the gel fraction and increased the swelling of a high amount of fluids.

1. Introduction

Polymeric hydrogels are highly swollen materials and crosslinked hydrophilic polymers. When selecting the most suitable materials for a given application, it is essential to take into account the properties of a specific hydrogel [1].
PVP hydrogel shows excellent transparency and biocompatibility. Besides PVP blending with other polymers played a significant role in a series of PVP hydrogels as biomedical materials [2] and CMC is one of the most useful cellulose derivatives [3].
Radiation technology, which is employed to modify the structures and properties of such polymers are the subject of several studies [4], was employed in this work. The ultimate aim of the present study was to obtain PVP and CMC blends and study their possible use as biomaterials.

2. Materials and methods

In this study the PVP (K90) used was the Kollidon 90F produced by Basf KGAa and Aqualon 7MF sodium CMC from Hercules/Aqualon division, all of which were medical grade.
The hydrogels were prepared by mixing CMC and PVP with distilled water and the blends were packed in Eppendorf tubes and irradiated with gamma rays generated from a ^{60}Co at doses of 5, 10, 15 and 20 kGy. Table 1 shows the composition of prepared samples.

Table 1 - Formulations of prepared samples

Samples	A (%)	B (%)	C (%)	D (%)
PVP K 90	7,0	7,0	7,0	7,0
CMC	0	1,5	3,0	4,5
H_2O	93	91,5	90	88,5

3. Characterization of hydrogels

Gel fraction

The dried samples were immersed in boiling water for 24 h and there was water change every 4 hours. Gel fraction was calculated by equation (1).

$$\textbf{Fraction gel (\%)} = (W_f / W_o) \times 100 \quad (1).$$

Where: W_f is the weight of dry gel after extraction and W_o is the dry weight before extraction.

Swelling

The dried hydrogels were immersed in distilled water at 30°C for 68 h. Swelling was calculated by equation (2).

$$\textbf{Swelling (g}H_2O\textbf{/g dried polymer)} = (W_f - W_o)/W_o \quad (2)$$

Where: W_o is the weight of dried hydrogel and W_f is weight of swollen sample.

4. Results and Discussion

Gel fraction presented in Table 2 and Fig. 1 indicates that the hydrogel crosslinking degree decreases with increasing amount of CMC and increases with radiation dose increase.

Table 2 - Gel fraction of studied hydrogels

Gel fraction (%)				
Dose (kGy)	A	B	C	D
5	87	18	1	0
10	95	63	48	15
15	96	65	53	18
20	97	87	83	59

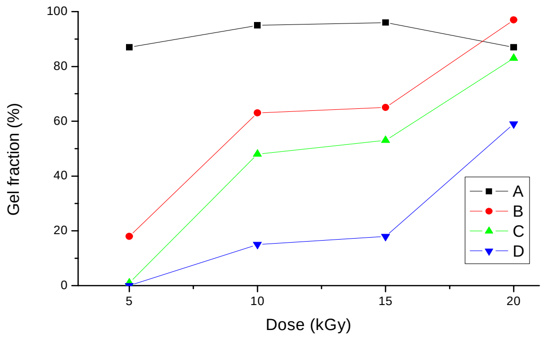

Figure 1 – Gel fraction of studied hydrogels

Table 3 shows swelling results of prepared hydrogel blends. The swelling is improved by increasing the amount of CMC and reducing the radiation dose. Fig 2 illustrates the greatest swelling for each formulation.

Table 3 - Swelling of prepared blends

Swelling ($g\ H_2O$ absorbed/g dried polymer)					
Dose (kGy)	**Tempo (h)**	A	B	C	D
5	**24**	19	120	137	210
	44	32	244	245	394
	68	32	300	450	578
10	**24**	16	102	197	95
	44	23	196	234	261
	68	24	244	253	280
15	**24**	16	98	129	163
	44	19	146	193	237
	68	21	175	238	232
20	**24**	12	56	92	102
	44	14	78	117	132
	68	15	80	117	121

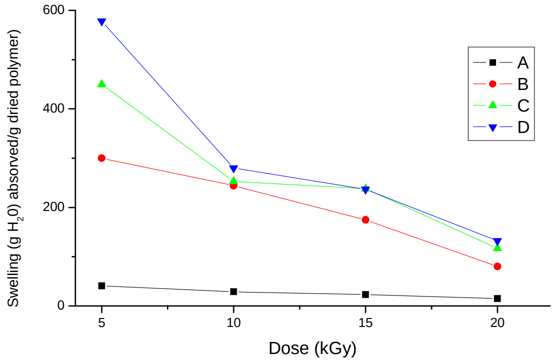

Figure 2 – Swelling curves of hydrogel blends

PVP/CMC blends hydrogels showed a big difference of swelling compared with the hydrogels without CMC and this difference is even greater at radiation dose of 5 kGy.

Figure 3 – Samples aspect before and after swelling assay:
1. Sample before swelling; 2. Sample A after swelling;
3. Sample D after swelling

5. Conclusion

As a result the present work demonstrated that in hydrogel blends the crosslinking degree decreases with the increase of CMC in the formulations and it increases with decrease of radiation dose.
In addition hydrogel blend swelling is improved by increasing the amount of CMC and reducing the radiation dose.
In conclusion high swelling property of studied hydrogel blends is found to be very effective in polymeric matrix to compose some biomedical devices such as drug delivery systems.

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