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SYNTHESIS AND CHARACTERIZATION OF POLYMERIC HYDROGEL CONTAINING CAFFEINE FOR COSMECEUTICAL APPLICATIONS

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ABSTRACT

Caffeine, a substance with belongs to the group of methylxanthines, is alkaloids that penetrate in the human epidermis but is not easily absorbed into the bloodstream. With a dermatological active substance, it exerts action on the subcutaneous adipose tissue causing adipocyte lipolysis through the inhibition of phosphodiesterase. Based on these considerations, the objective of this study was to investigate the behavior of caffeine in a polymeric hydrogel matrix, for possible cosmeceutical applications. The hydrogels were cross-linked and sterilized by colbat-60 source gamma irradiation. In the characterization, were used thermogravimetry (TGA), scanning electron microscopy (SEM), differential scanning calorimetry (DSC). It was possible to observe by SEM the presence of crystals in the hydrogel sample. The DSC experiment confirmed a crystallinity of the sample and that caffeine is not degraded by gamma irradiation at 25 kGy. The results were satisfactory, allowing a new investigations that certify the benefits of its application.

1. INTRODUCTION

Caffeine is identified as 1,3,7-trimethylxanthine, as dermatological active principle exerts action on the subcutaneous adipose tissue, through the inhibition of phosphodiesterase, causing lipolysis of the adipocyte. It is an alkaloid that penetrates the human epidermis, has a good general and localized tolerance [1].

The use of topical caffeine in cosmetics is old, because of many positive effects on the epidermis, usually used in anti-cellulite preparations and anti-aging products [2]. Besides that, inhibits the phosphodiesterase, which degrades cyclic adenosine monophosphate (AMPc), as well as the adenosine receptor, blocking its anti-lipolytic effect [3]. It has a diversified action that causes diverse effects, among them, in the central nervous system, cardiovascular system and in the corporal homeostasis. It also has an effect on human behavior, with increased alertness and reduced fatigue, with a significant improvement in the performance of activities that require more vigilance [4].

In addition, its high biological activity and its ability to permeate the epidermis resulted in a wide and diversified use. Evidence that dermatological applied caffeine may cause protection from skin cancer induce by sun exposure [5].

Biomaterials are a group of materials used in the medical field. They may also be applied separately or in combination with other substances. They are usually used in wounds, drug release systems, dental products, ophthalmic [6], as well in the aesthetic field [7].

To obtain the hydrogel it was used ionizing radiation with a source of cobalt-60 in dose 25kGy, since it can be applied as different purposes, among them: Polymer crosslinking, , preservation and disinfection of food products and sterilization of medical, pharmaceutical and surgical products [8].

Therefore, the objective of this work was to investigate the behavior of the caffeine added in a polymeric hydrogel, from the characterization by thermogravimetry (TGA), scanning electron microscopy **(**SEM), differential scanning calorimetric (DSC).

2. MATERIAL AND METHODS

2.1 Obtaining the hydrogel membrane

The reagents used were Polyvinylpyrrolidone (PVP) K90 from Êxodo 8%, 1.5% agar provided by Labsynth, 1.5% polyethylene glycol 300 (PEG) Labsynth and caffeine Sigma Aldrich, solubilized with milliq water, using autoclave for 40 min. After that the ready formulation was placed in 13cm x 8cm x 2cm plates, sealed and sent to the crosslinking and sterilization process by ionizing radiation of gamma cobalt-60 source, at doses 25 kGy.

2.2 TGA/ DTGA Thermogravimetric

The hydrogels were submitted to thermal characterization tests from TGA / DTGA thermogravimetric analysis in Mettler-Toledo SDTA / 851^e apparatus (heating rate: 10 ºC min^{-1} from 25 to 600 ºC, under N_2 flow (10 $mL.min^{-1}$).

2.3 Scanning electron microscopy (SEM)

For morphological investigation, Scanning Electron Microscopy (SEM) was done using an EDAX PHILIPS XL 30. In this work, gold sputter-coated layer was deposited onto the samples of non conducting materials. Allocated in the Center for Science and Technology of Materials (CCTM) of IPEN-CNEN / SP

2.4 Differential Scanning Calorimetric (DSC).

The characterization by DSC was done in Mettler-Toledo DSC822e apparatus. The dry polymeric hydrogel sample and the caffeine samples were submitted to heating with a velocity of 10 ºC/min ,from 25 to 400 ° C, and the enthalpic events and changes from the crosslinking processes were verified. The apparatus was checked with indium of melting point 156 ° C and melting enthalpy 24.75 g^{-1}.

3. RESULTS

For the DSC technique no changes were observed in the character of the curves before and after the irradiation which could witness the presence of radiolysis products or changes in the physico-chemical properties of the compound studied, since the DSC for the drugs of low radiochemical stability Demonstrate peaks of radio degradation and impurities [9]. It is observed in Fig. 1 that the irradiated caffeine exhibits similar stability to uniradiated, whereas the PVP curve and caffeine in the hydrogel show a slight shift to the left presenting lower thermal stability, also observed a disappearance of the melting peak of caffeine in the region of 240 °C.

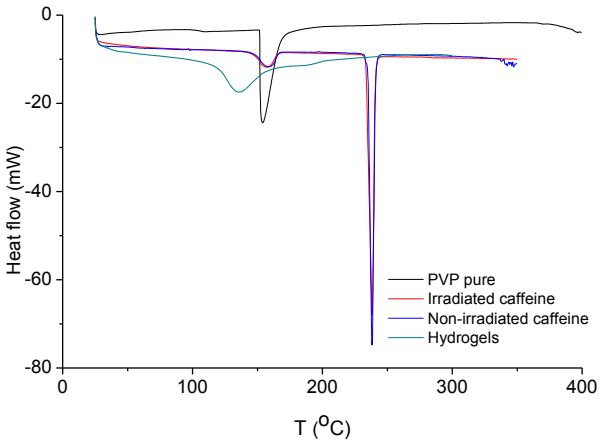

Figure 1: DSC Caffeine hydrogel (green line), pure PVP (black line), irradiated (red line), non-irradiated caffeine (blue line).

TGA is a technique used to measure mass change as a function of temperature in an atmosphere of N_2. For pharmaceutical purposes, its use is proposed for determination of purity and humidity, identification of false polymorphisms in the evaluation of substance stability and degradation kinetics [9]. The caffeine decomposition occurs around 125 °C and finalized at 160 °C for both irradiated and non-irradiated caffeine. While the hydrogel curve show three events the first at 100 ° C associated with the decomposition of caffeine, the second at 160 ° C associated decomposition of PEG and agar and the third at 240 to 275 ° C the decomposition of PVP, Fig 2. the behavior of the irradiated caffeine curve is similar to non-irradiated, the use of irradiation did not interfere with degradation, of caffeine in the dose range study.

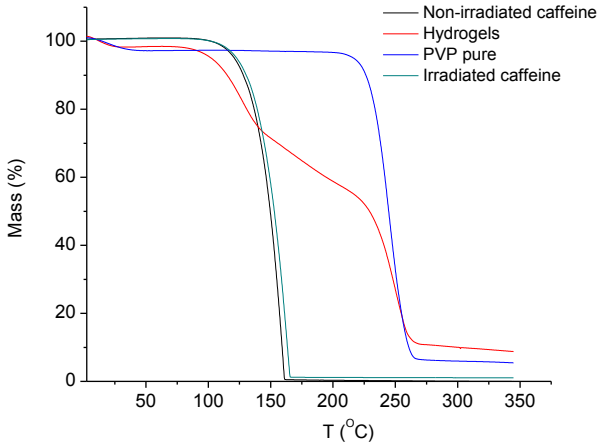

Figure 2: Curves of TGA non-irradiated caffeine, irradiated caffeine, hydrogels and PVP pure

Polymers exhibiting a regular geometric orientation in their structure are characterized as crystalline, having a melt temperature (T_F), and crystallization (Tc). Polymers without chain orientation are defined as amorphous is the case of PVP, have a second order transition temperature, called the glass transition temperature (Tg). In structural terms, it can be affirmed that above the glass transition temperature molecules rearrangements occur, whereas below this it is not possible [10]. A microscopies Fig. 3 confirm the crystalline of caffeine, since the polymer PVP is amorphous. There is a great importance of the control of the polymorphism in the development of bioactive compounds of therapeutic utility, since it is mainly related to its physico-chemical properties, which directly affect dissolution rate (which can lead to deviations in bioavailability) and, therefore, its effectiveness [11].

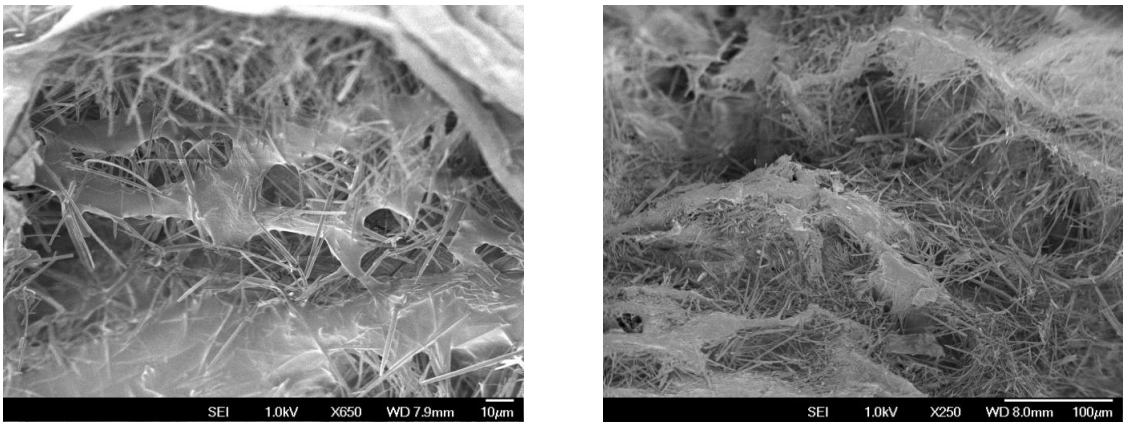

Figure 3: Micrograph of the fracture surface of the lyophilized hydrogel with 3% caffeine

4. CONCLUSIONS

In short, caffeine was physically and chemically stable in relation to the techniques used, with no changes in its behavior, showing advantage for cosmetic purposes. However, new in vitro and in vivo studies are needed for greater reliability of use.

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