RETASTE Conference Abstracts
RETASTE-NOV-1456-In-person Poster
Rethymno, September 16-18, 2026
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DOI:10.5281/zenodo.23678200

Synthesis of Keratin/PVA/PVP Hydrogels by Gamma Irradiation: Evaluation of Economical Coatings to Minimize Oxygen Inhibition

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Abstract

Hydrogels synthesized by ionizing radiation have attracted considerable interest due to their high purity, absence of chemical crosslinking agents, and tunable physicochemical properties for diverse applications. However, atmospheric oxygen can interfere with radiation-induced crosslinking reactions, making the development of effective oxygen-barrier strategies essential. In this study, keratin/polyvinyl alcohol/polyvinylpyrrolidone (keratin/PVA/PVP) hydrogels were synthesized by gamma irradiation using five different surface coatings intended to minimize contact between the precursor solution and atmospheric oxygen: vegetable oil, mineral oil, liquid paraffin, solid paraffin, and polyethylene film. Hydrolyzed keratin was obtained from waste chicken feathers. The precursor solutions were irradiated at 40 kGy using a cobalt-60 source, and the resulting hydrogels were characterized in terms of gel fraction, swelling behavior, physical appearance, and stability during repeated swelling–drying cycles. All coatings enabled successful hydrogel formation, yielding gel fractions above 80%, which indicated effective oxygen isolation and adequate crosslinking. Swelling percentages ranged from 310% to 480%, with hydrogels prepared using solid paraffin, liquid paraffin, and polyethylene film exhibiting the highest water uptake capacities. In contrast, hydrogels synthesized with oily coatings showed lower swelling values, likely due to residual hydrophobic compounds that hindered water diffusion into the polymer network. Physical examination revealed that oily coatings produced transparent hydrogels with smooth surfaces, whereas solid paraffin generated surface irregularities associated with trapped gas bubbles formed during irradiation. Reusability tests demonstrated weight losses below 30% after seven swelling–drying cycles for all treatments, confirming acceptable structural stability and potential for repeated use. The results demonstrate that several simple and low-cost coating strategies can effectively support the synthesis of radiation-crosslinked keratin/PVA/PVP hydrogels. Nevertheless, coating selection should be guided by the intended application, as residual compounds, surface morphology, swelling behavior, and long-term stability differ among coatings. The proposed methodology may also be extended to the synthesis of hydrogels based on other polymeric precursor systems.

Keywords: Chicken feather keratin, gel fraction, hydrogel synthesis, oxygen barriers, radiation crosslinking

Acknowledgments: The authors express their gratitude to Escuela Politécnica Nacional, Quito,

Ecuador, and the Research Project “Preparation and modification of new materials derived from organic waste using ionizing radiation“ [project code PIGR-23-09] for the financial support for this research.

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