Radiation Modification of the Properties of PEG–PVA-Based Hydrogels in the Presence of Silver Nanoparticles

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Introduction

Hydrogels based on poly(ethylene glycol) (PEG) and poly(vinyl alcohol) (PVA) are promising biomaterials due to their biocompatibility, high water content, and tunable physicochemical properties. Incorporation of silver nanoparticles (AgNPs) into hydrogel matrices provides antibacterial activity and alters structural stability. Ionizing radiation is a powerful tool for cross-linking, sterilization, and modification of hydrogel properties. This work investigates how radiation exposure affects PEG–PVA hydrogels with and without AgNPs.

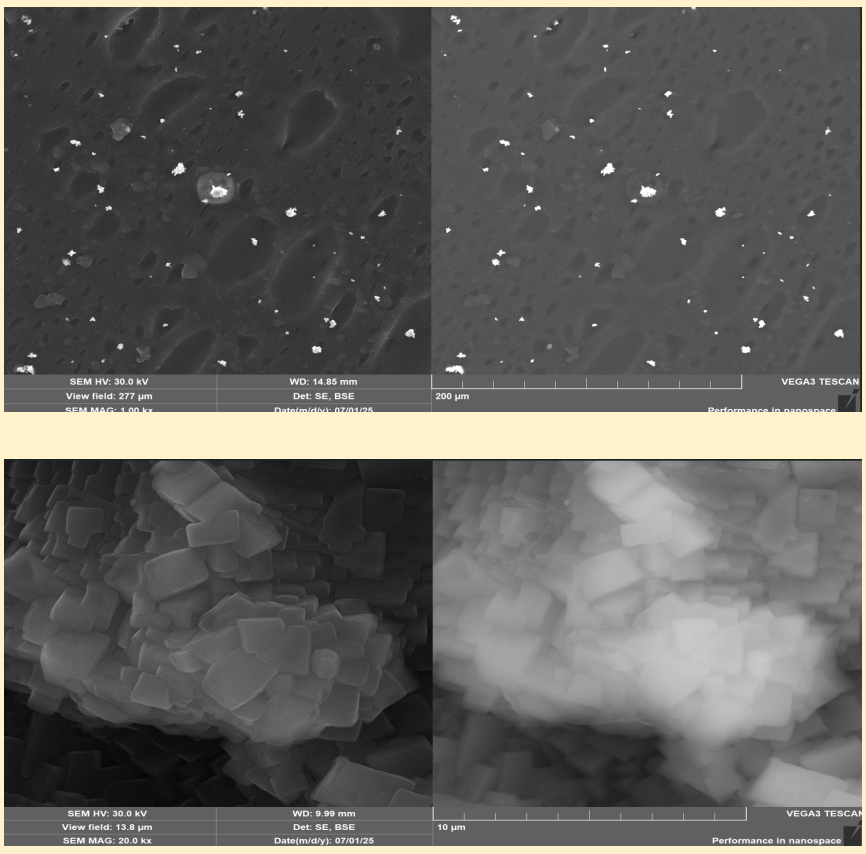

Fig. 1. SEM images of hydrogel films containing silver nanoparticles at magnifications up to 200 µm, 10 µm, and 1 µm, using reflected and secondary electrons.

Potential applications

These hydrogels can act as **next-generation boluses** in radiotherapy:

- adapt closely to patient anatomy and modify radiation dose distribution,
- deliver chemotherapy drugs directly within the material,
- provide antibacterial protection thanks to silver nanoparticles.

Such multifunctional boluses combine **dose modulation, local drug release, and antiseptic effect** in a single material — something classic boluses cannot do.

How it was done

- **Making the films:** PEG–PVA hydrogels were prepared, some of them with silver nanoparticles mixed in.
- **Radiation test:** Samples were exposed to different doses of ionizing radiation (up to 1000 MGy).
- **What we looked at:**
  - Structure — with Scanning Electron Microscopy (SEM)
  - Light absorption — with UV–Vis spectroscopy
  - Chemical bonds — with FTIR spectroscopy
  - Vibrational features — with Raman spectroscopy

What we found

- Films with silver nanoparticles show a clear absorption peak at 420 nm.
- Radiation changes the internal structure of both pure and silver-loaded hydrogels.
- With silver, the films are more stable and show stronger signals in spectroscopic tests.
- The polymer network rearranges depending on the radiation dose.

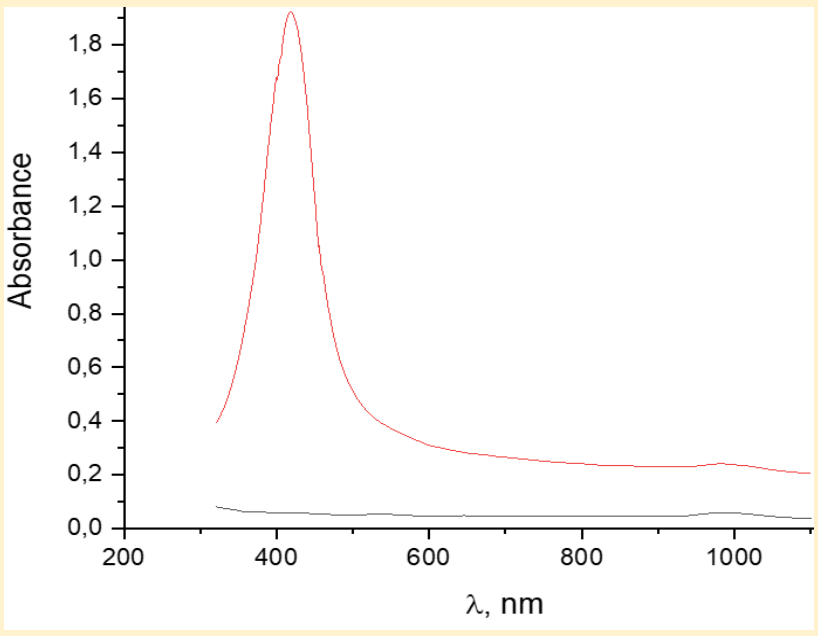

Fig. 2. Absorption spectra of hydrogel films with (black curve) and without (red curve) silver nanoparticles. The absorption peak of silver nanoparticles is located at 420 nm.

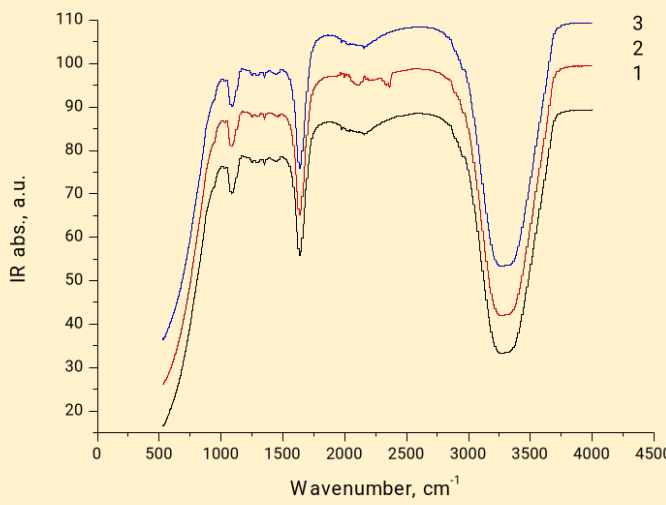

Fig. 3. IR absorption spectra of hydrogel films in the initial state (1) and after irradiation with doses of 70 and 1000 MGy.

PEG–PVA hydrogels with silver nanoparticles change their structure under irradiation but stay stable and keep unique optical features. Adding silver makes them tougher and gives antibacterial potential, which opens the door for real biomedical use.