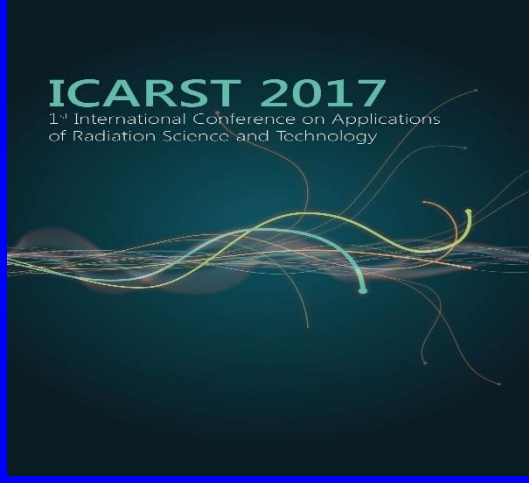

Radiation Processing of Natural and Synthetic Polymers for Potential Applications

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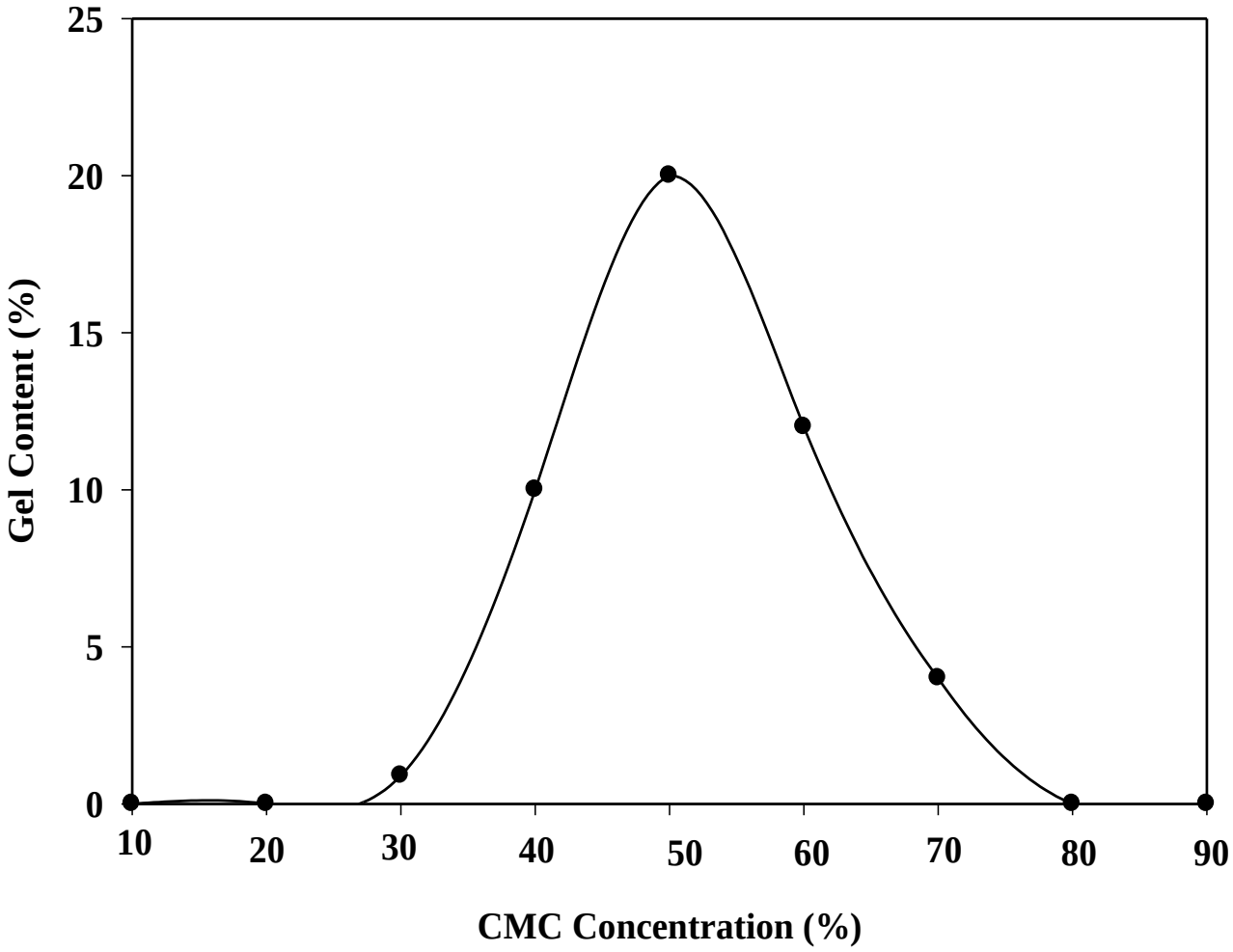
Former Chairman, National Center for Radiation Research and Technology
Atomic Energy Authority
Cairo, Egypt

OBJECTIVE:

To study the effect of ionizing radiations on the crosslinking and degradation of some natural polymers such as CMC-Na, chitosan and alginate. Super absorbant materials and nano gels were prepared by radiation copolymerization of natural and synthetic polymers for possible use in industrial, agricultural and biomedical applications.



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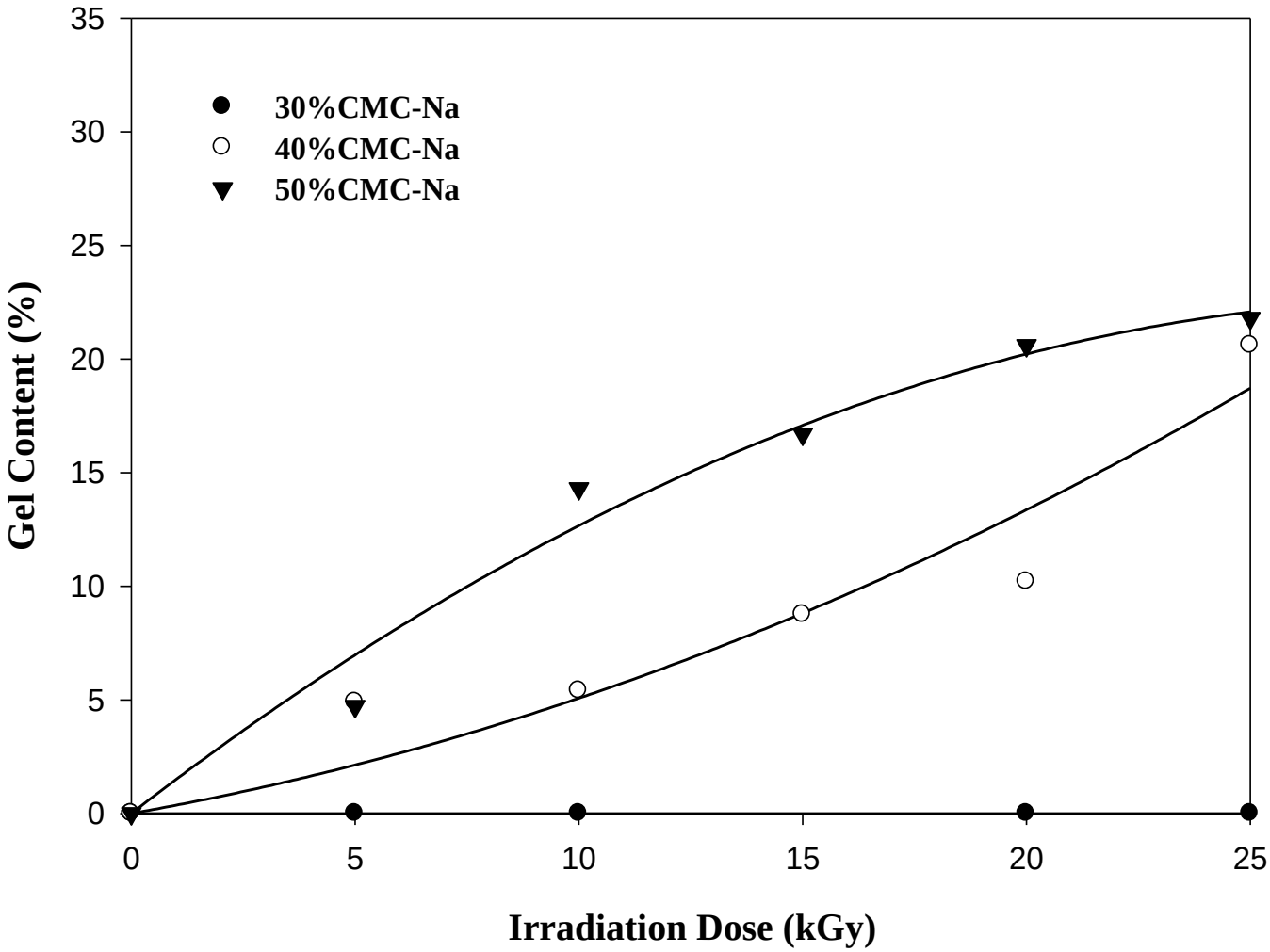
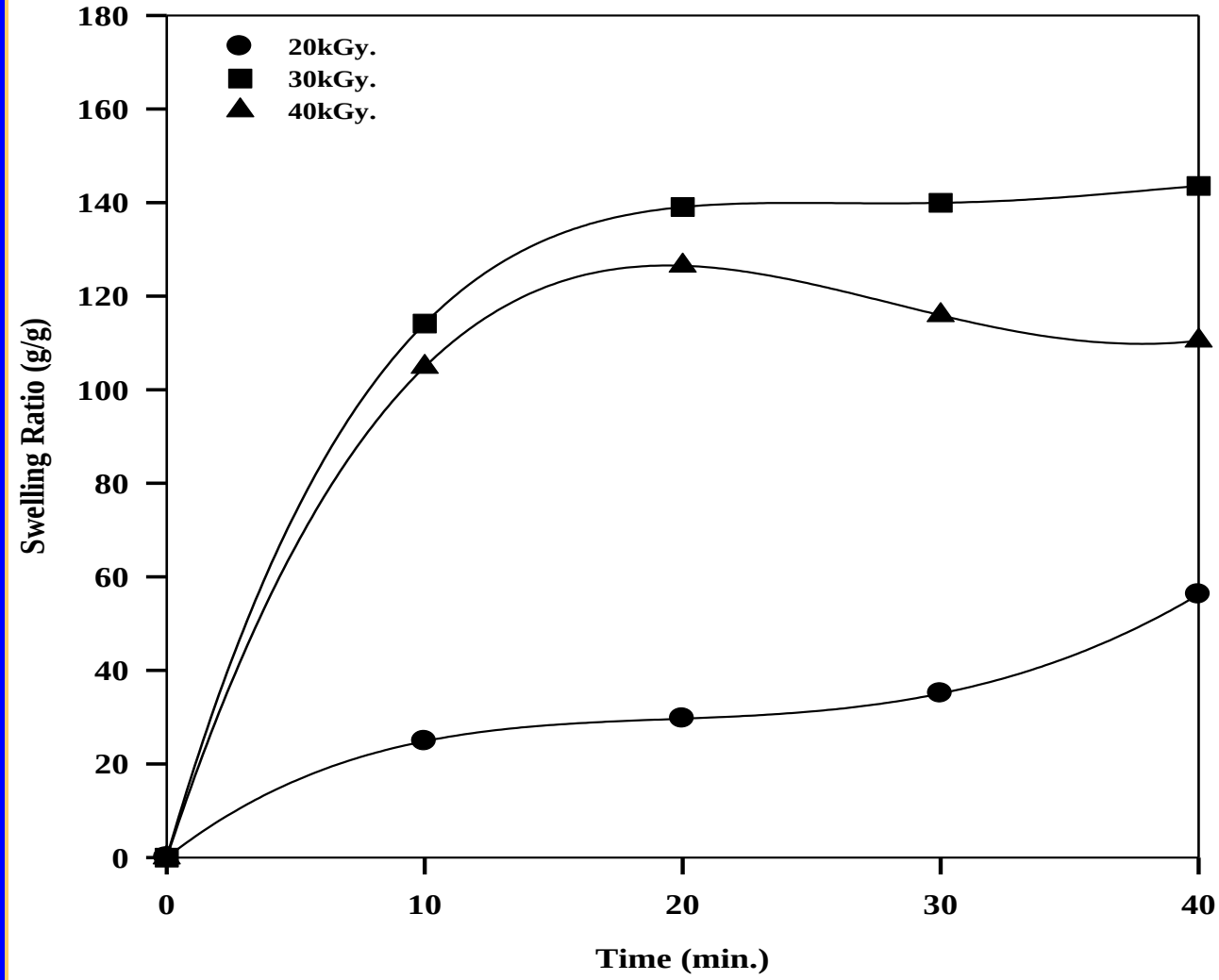
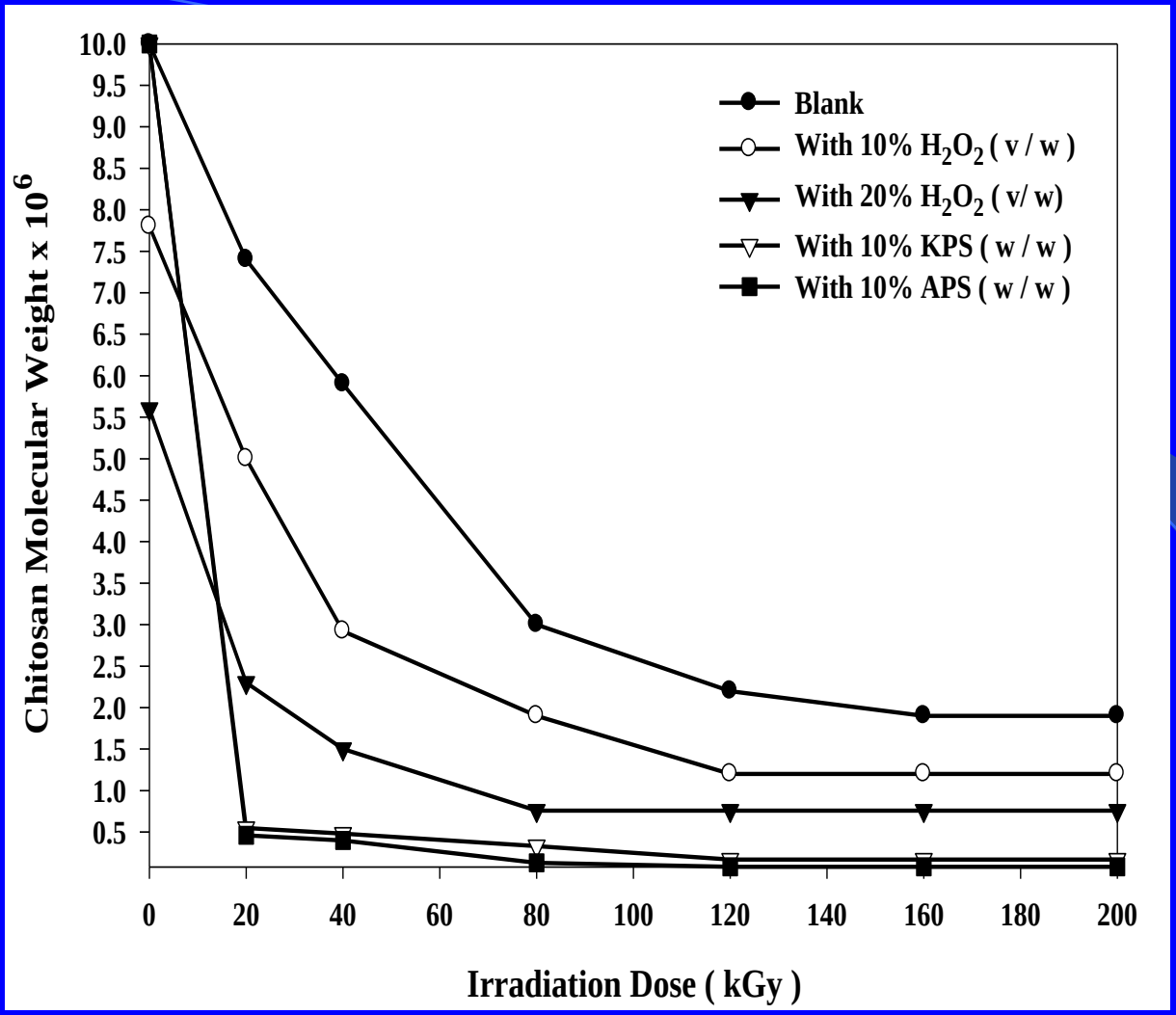
Effect of different CMC concentrations in water on its gel content at 20 kGy using EB irradiation in air atmosphere.

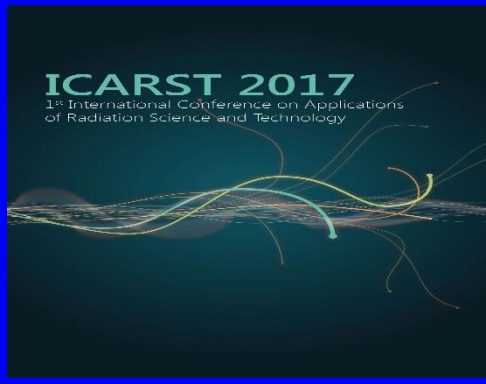


Gel content (%) of cross linked CMC-Na as a function of irradiation dose at 35 °C.

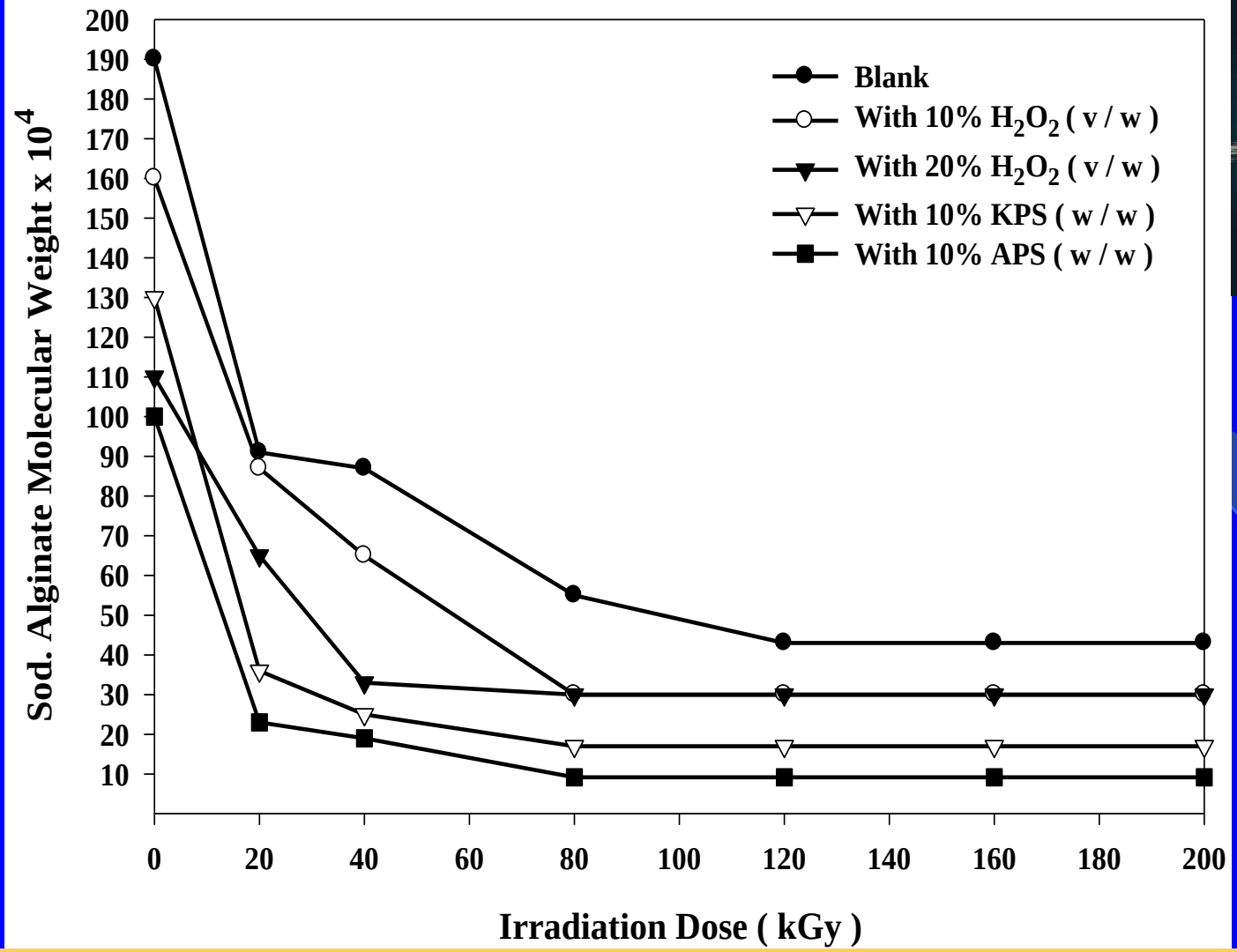


Effect of applied irradiation dose on the swelling ratio of crosslinked CMC-Na in distilled water (50 wt%).





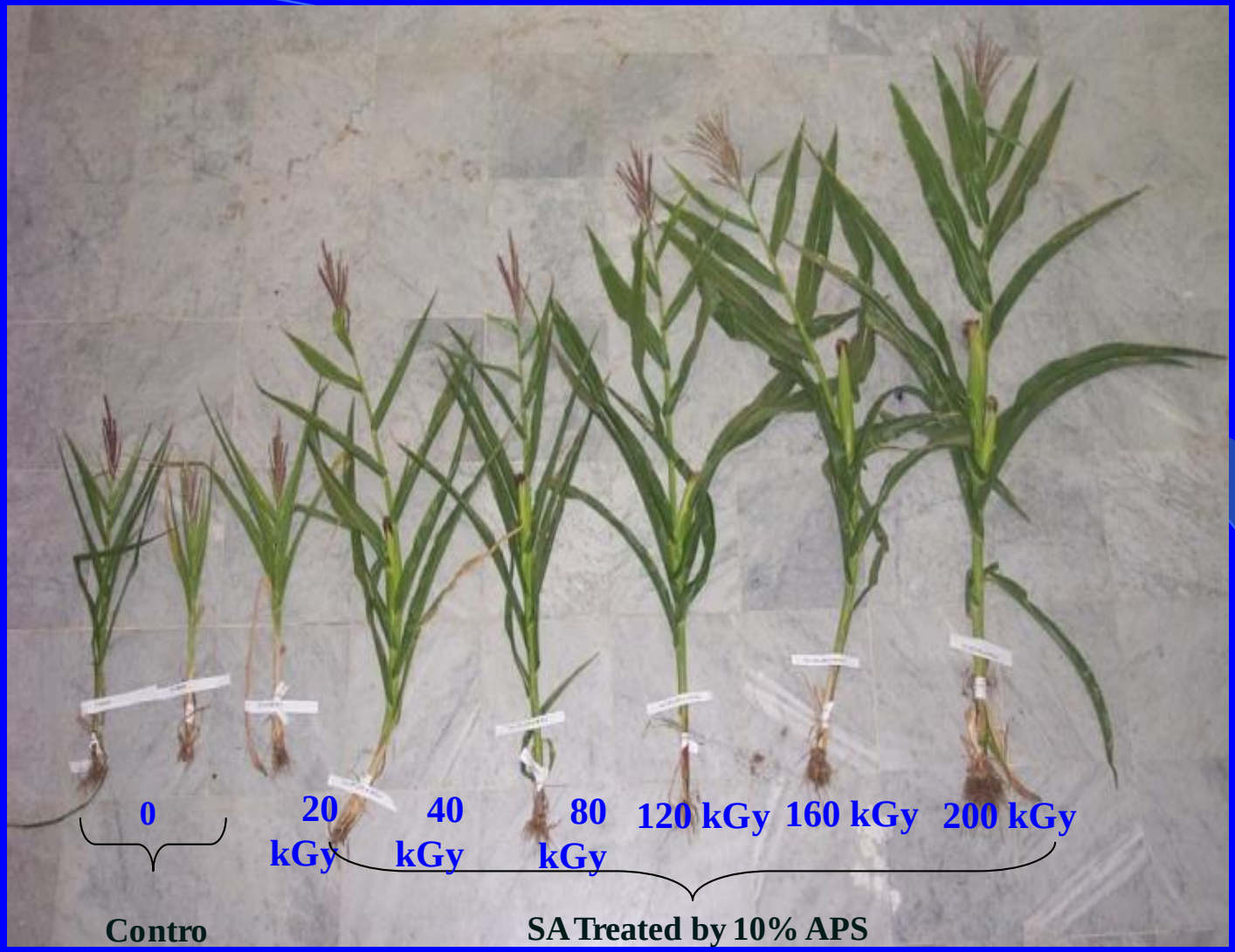
Effect of irradiation dose on the degradation of chitosan in the presence and absence of additives



Effect of irradiation on the degradation of Na-alginate in the presence and absence of additives.

Use of Degraded Natural polymers in agriculture as a growth promoter

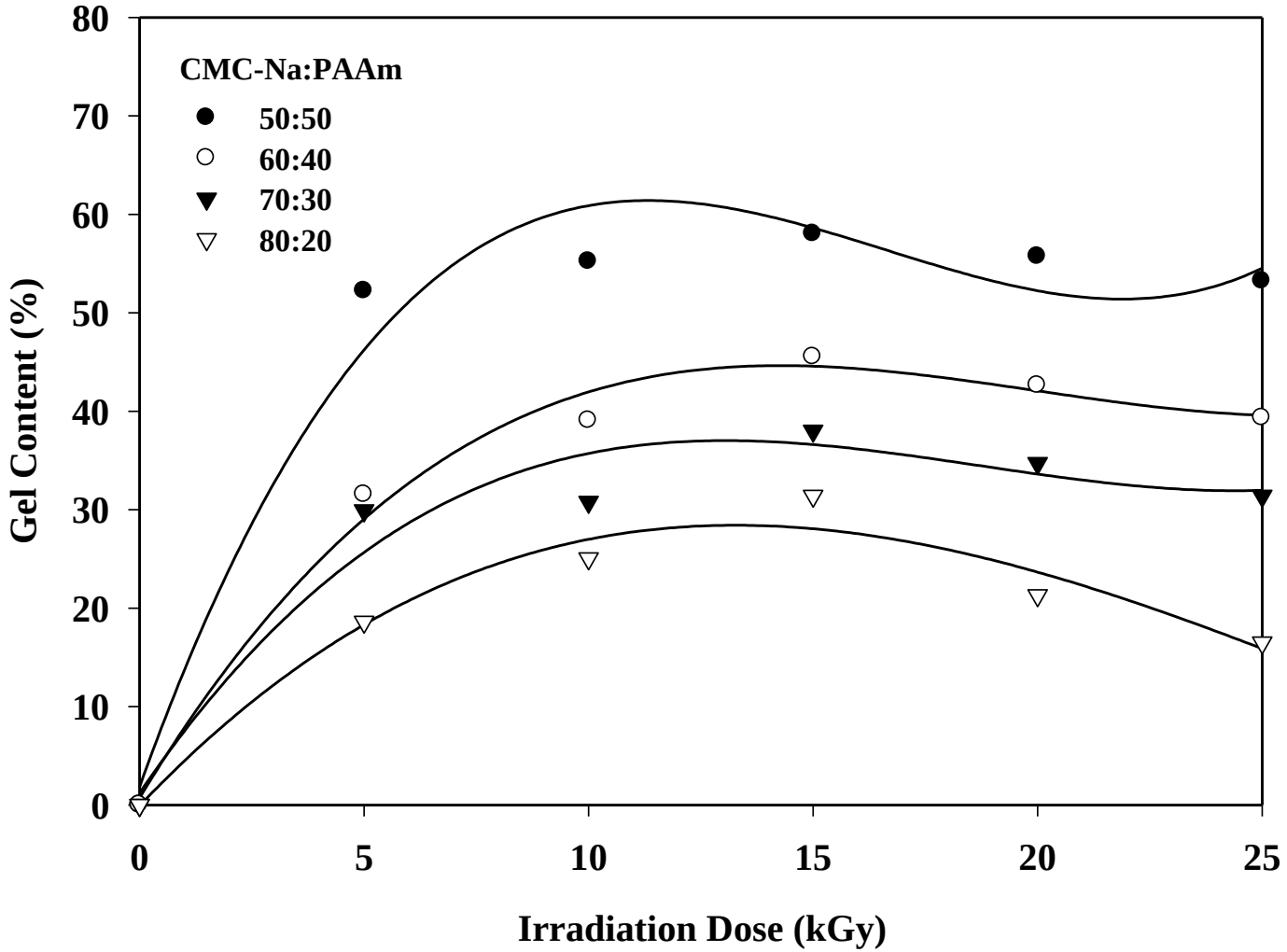
- **Degraded Na-alginate and chitosan could be used as a growth promoter for plants in agriculture purposes. The growth and other responses of zea maze plant treated with irradiated Na-alginate or chitosan of different MWts were studied.**
- **The test field results showed that the treatment of the zea plant with irradiated Na-alginate at 120, 160, and 200 kGy in the presence of APS resulted in increasing the growth in plant. Meanwhile, the use of chitosan under the same conditions enhances the plant growth and productivity as well.**
- **The increase in plant performance by using degraded alginate or chitosan suggested its acceptable use in agriculture field as growth promoter.**



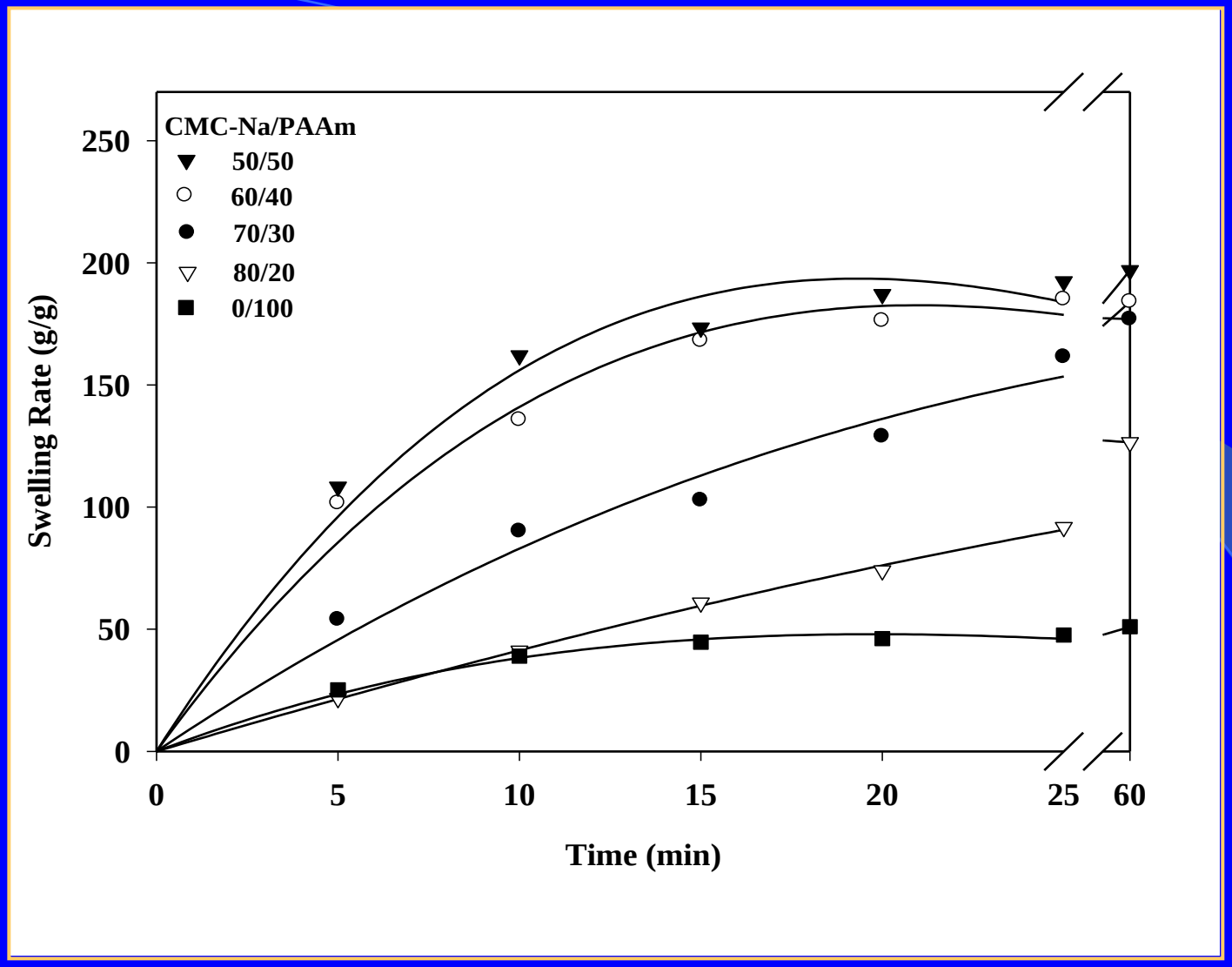
The growth and other responses of zea maze plant treated with irradiated Na-alginate of different MWts in APS

Radiation Cross-linking of Natural Products/ PAAm For the Use as Super Adsorbent Hydrogels

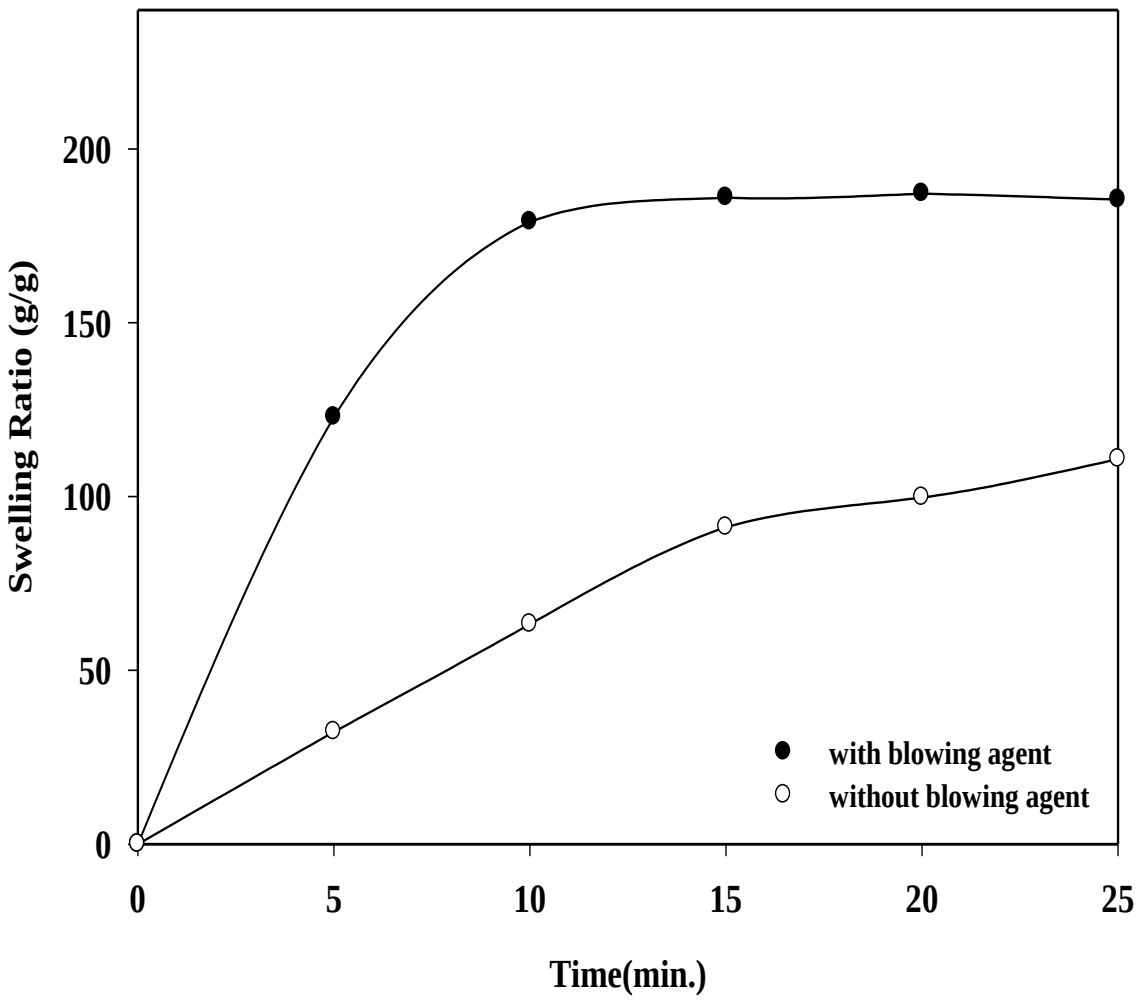
- Super Adsorbent Hydrogels are used in various fields including bandages and wound dressing, controlled drug delivery, humidity-controlled products, soil conditioners, controlled release of fertilizers, aqueous waste management and gelling agents, medical health care products..etc.



Gel content of crosslinked CMC-Na:PAAm as a function of irradiation dose extracted at 50°C after 24hr.

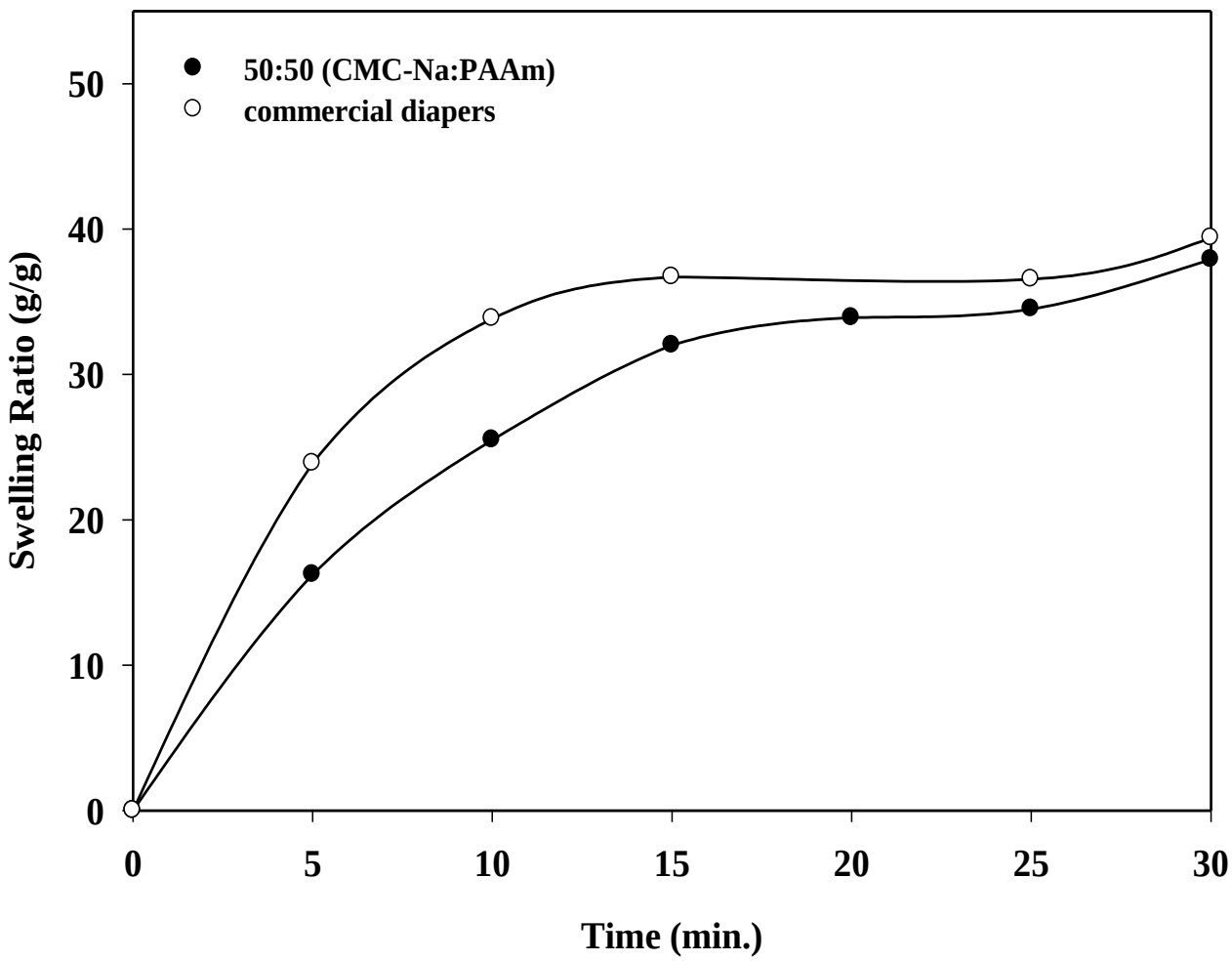


Effect of polymer composition on the swelling ratio of crosslinked CMC-Na:PAAm hydrogel, Polym. conc. 30 wt%. Irrad. dose 10kGy



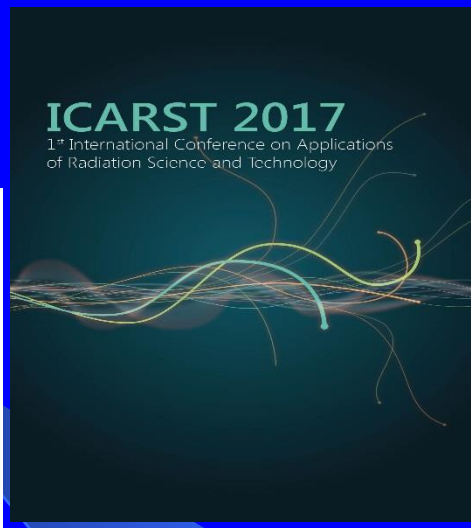
Swelling ratio of CMC-Na:PAAm hydrogels (50:50) in distilled water.Polym.conc. 30 wt% Irrad. dose 10kGy in Am Carbonate.

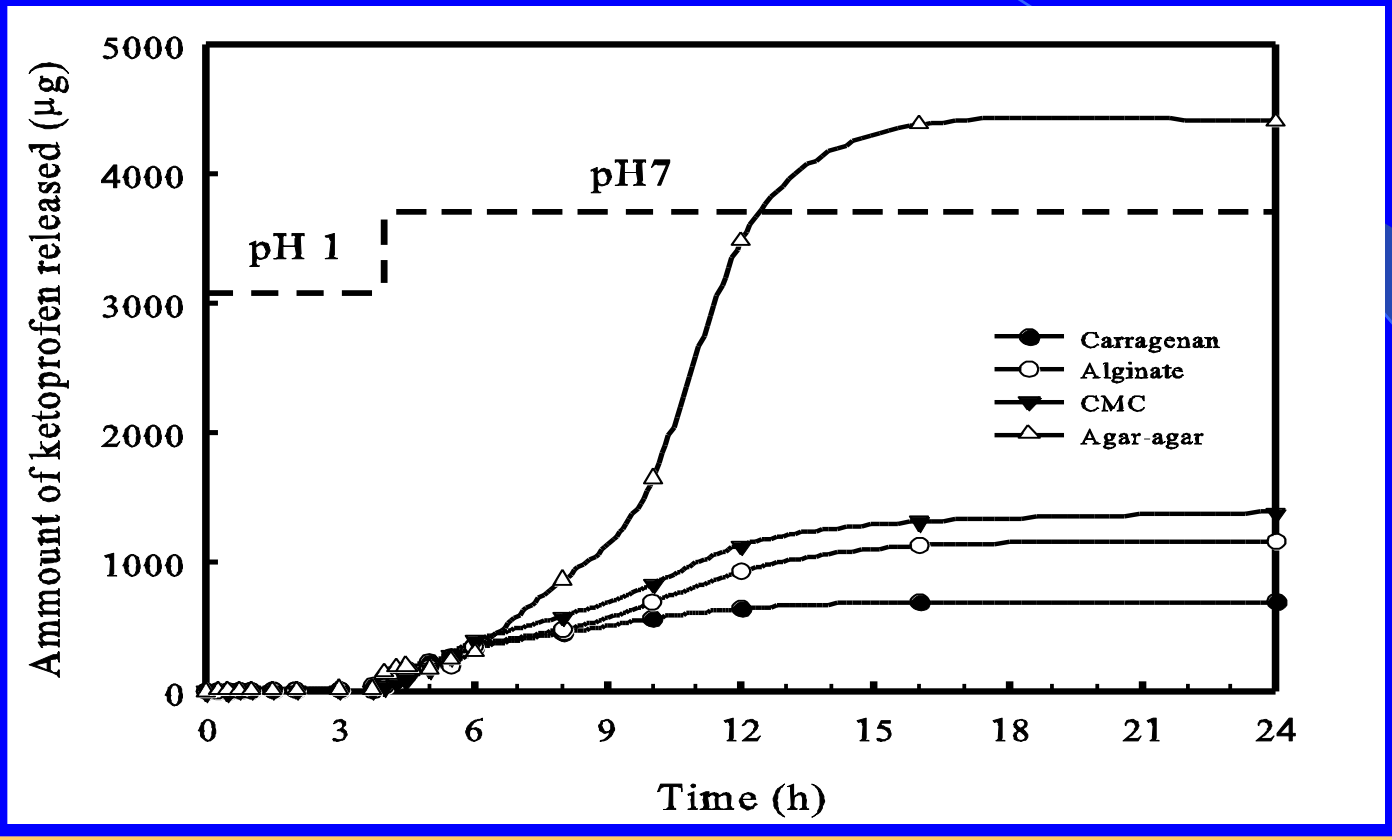
**Bean plant cultivated in soil after 9 weeks:
(A) Untreated (control), (B) Treated with PAAm and (C) treated with PAAm/Na-alginate.**



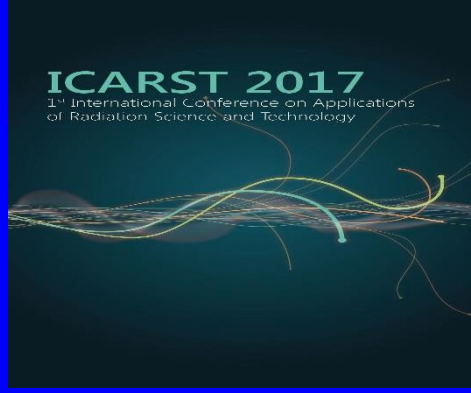
Swelling ratio of CMC-Na/PAAm superabsorbent hydrogel and commercial diaper in simulated urine solution.

Application of PNIPAAm grafted with some natural polymers



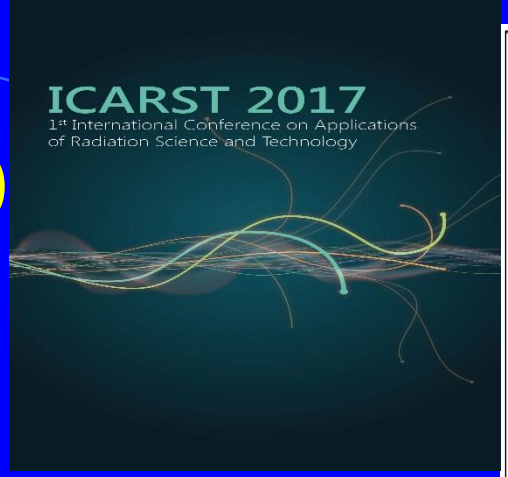


Effect of natural polymer on the release of ketoprofen from its corresponding copolymer with PNIPAAm at pH 1 and 7.



Radiation synthesis of nano-sized hydrogel particles based on the interpolymer complexation between polyvinylpyrrolidone and polyacrylic acid by gamma radiation

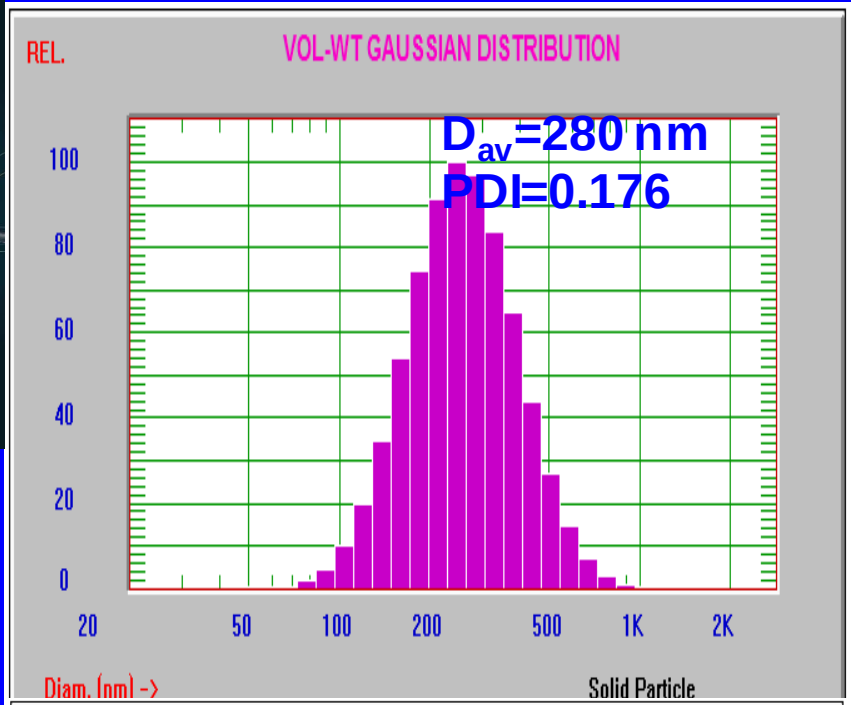
DLS Results of irradiated (40 kGy) PVP/PAAC

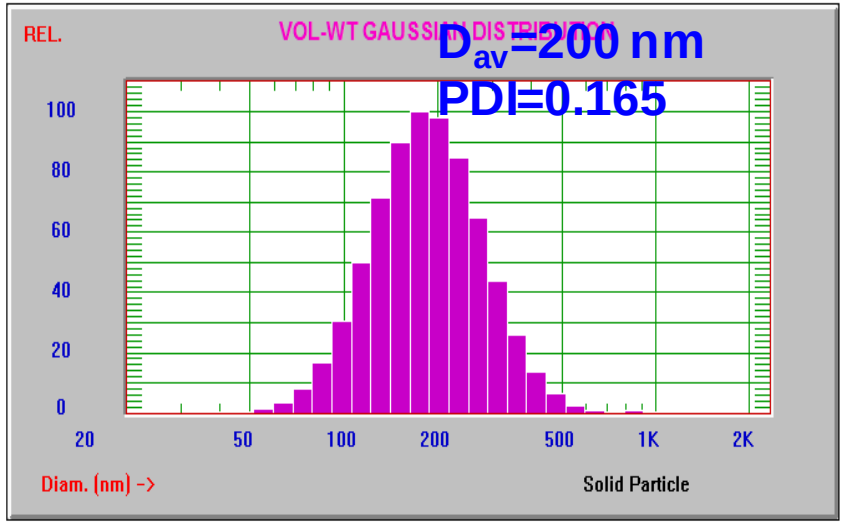


(a) pH 4

Synthesis of PVP/PAAc nanogels by gamma irradiation in air atmosphere:

(b) pH 7





Volume-weighted Gaussian distribution analysis for irradiated (40 kGy) PVP/PAAC at pH 4 and 7. Feed composition: PVP/PAAc (35/65 mol/mol %); total conc. 0.5%; PVP 1300000.

Multimodal distribution for the particles obtained from PVP/ PAAc polymers

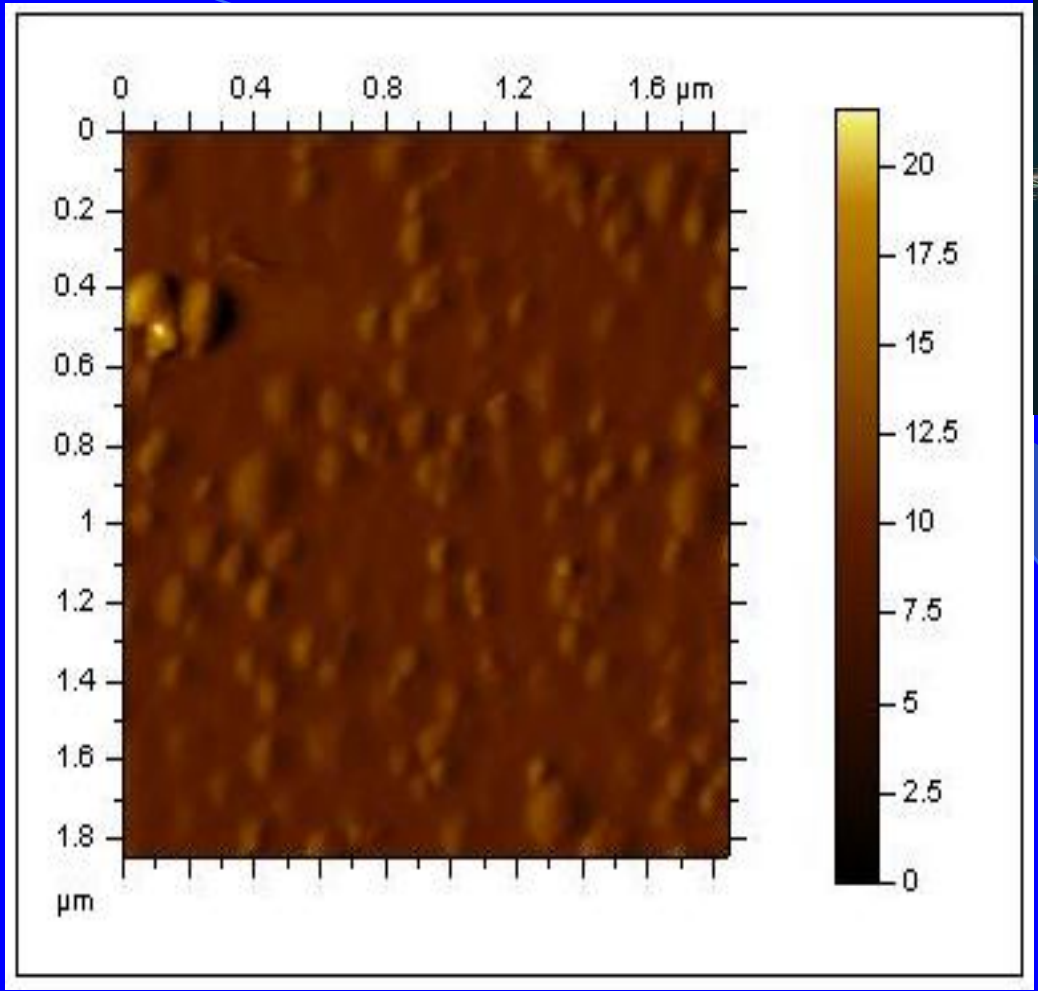
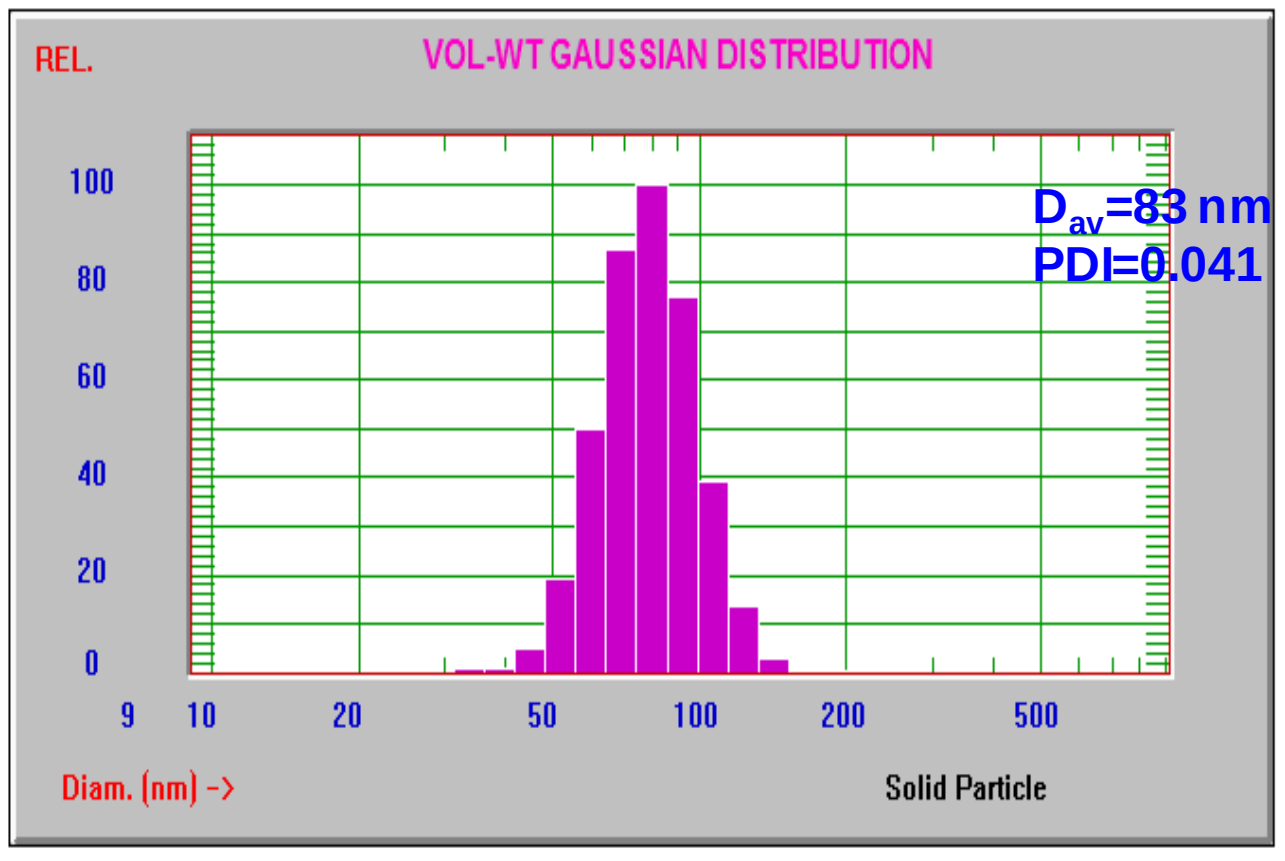


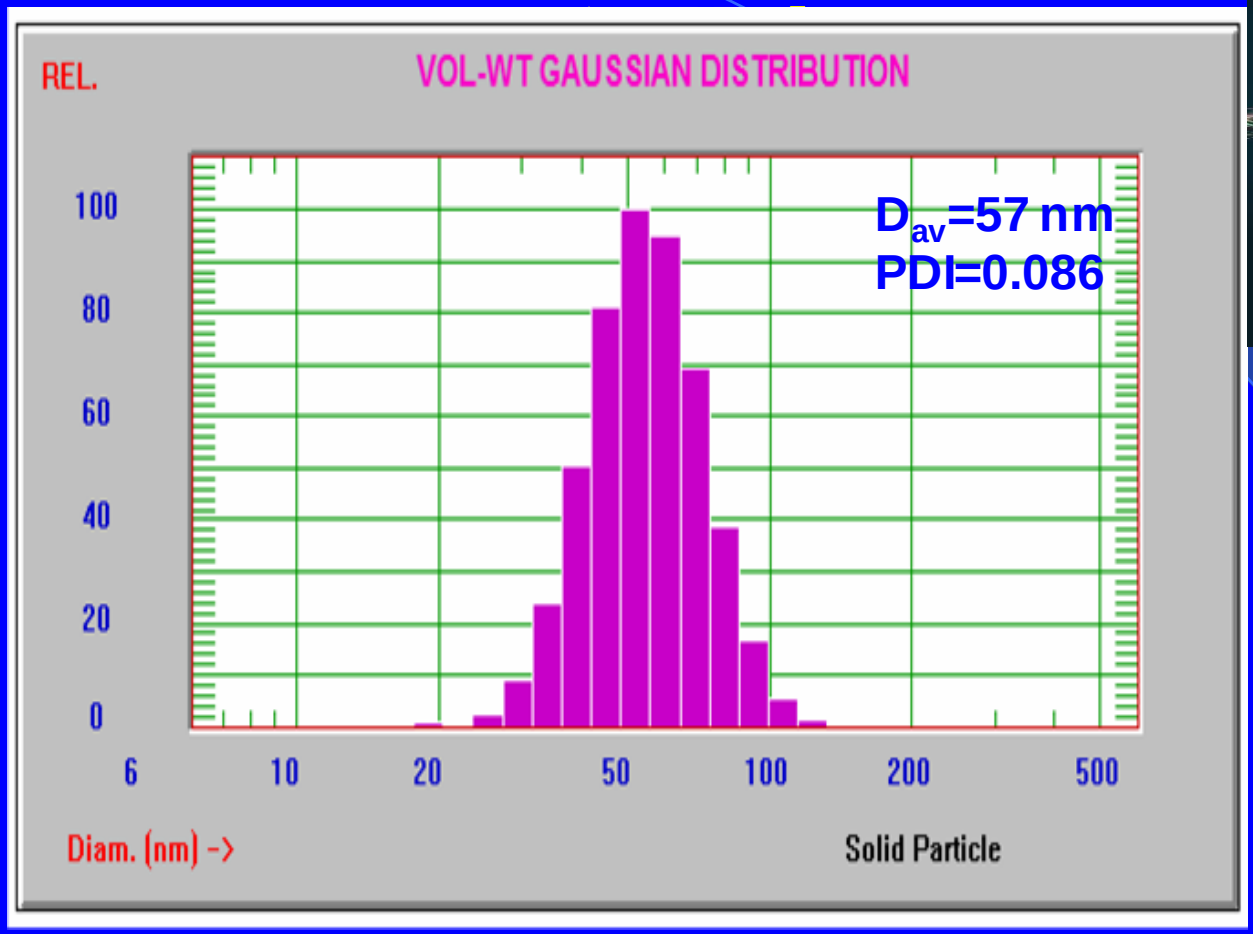
Figure (3) AFM image for PVP and PAAc polymers

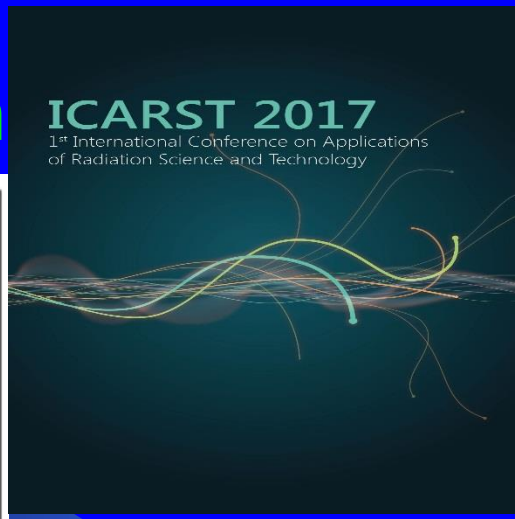
DLS results for PVP/AAc aqueous solution at pH 4



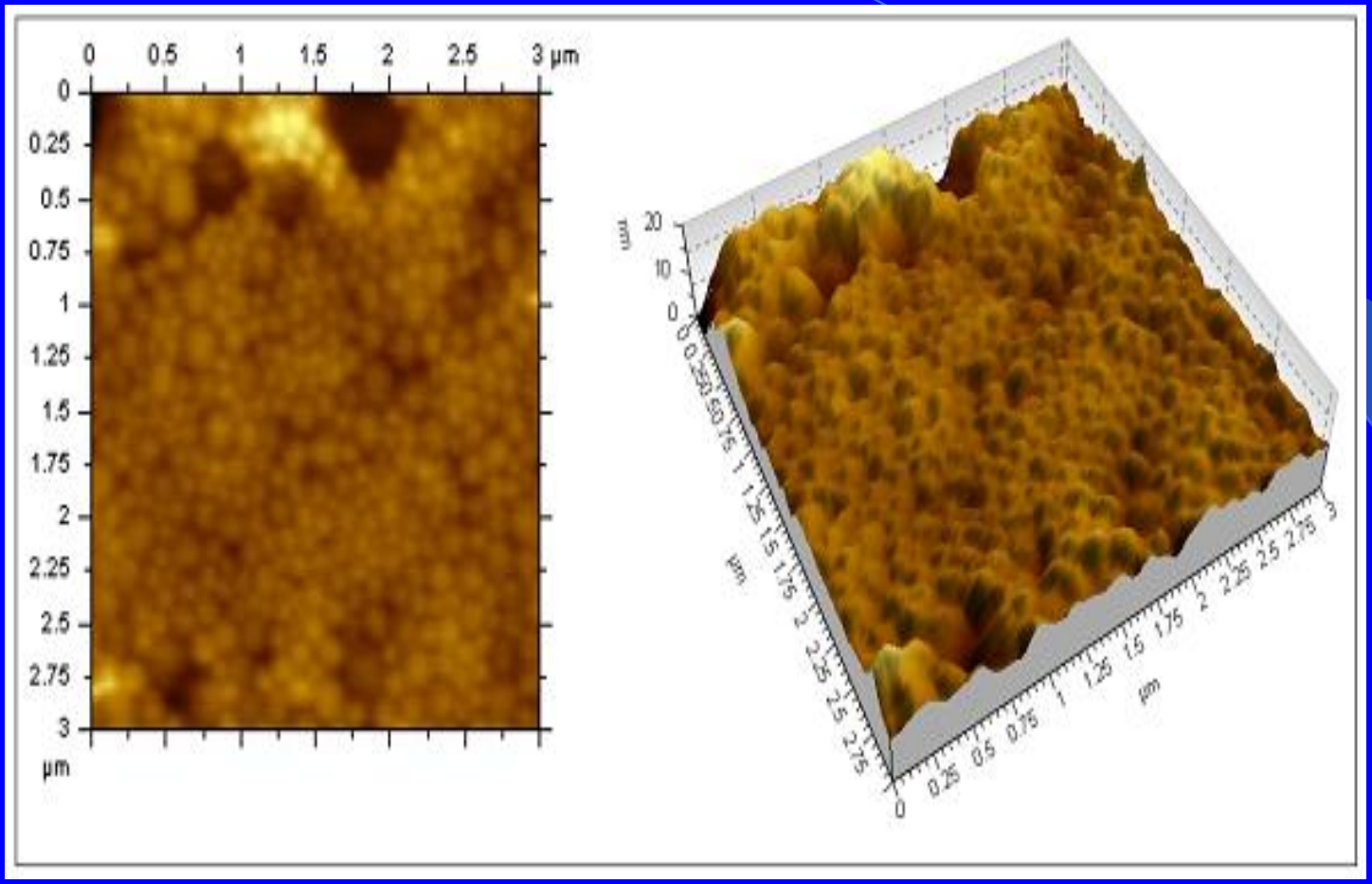
DLS results for system (B): PVP/AAc in deionized water at pH 4. PVP/AAc: 35/65 mol/mol %; Total conc.: 1.5%; PVP *Mw* = 1300000; 20 kGy.

DLS results for N-VP/PAAc aqueous solution

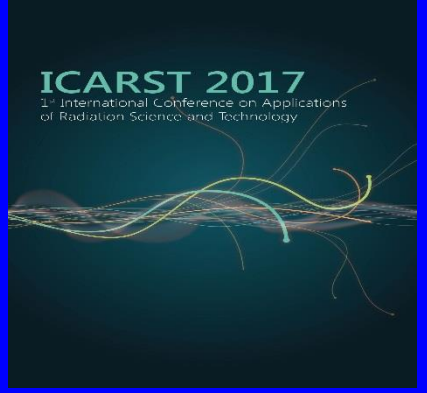




DLS results for system (C): N-VP/PAAc in deionized water at pH 4. N-VP/PAAc: 35/65 mol/mol %; Total conc.: 1.5%; PAAc *Mw* = 497000; 20 kGy.



AFM image (topography and three dimensional) of PVP/PAAc nanogel particles investigated in deionized water.



Possible Bio-medical Applications of PVP/PAAc Nanogels

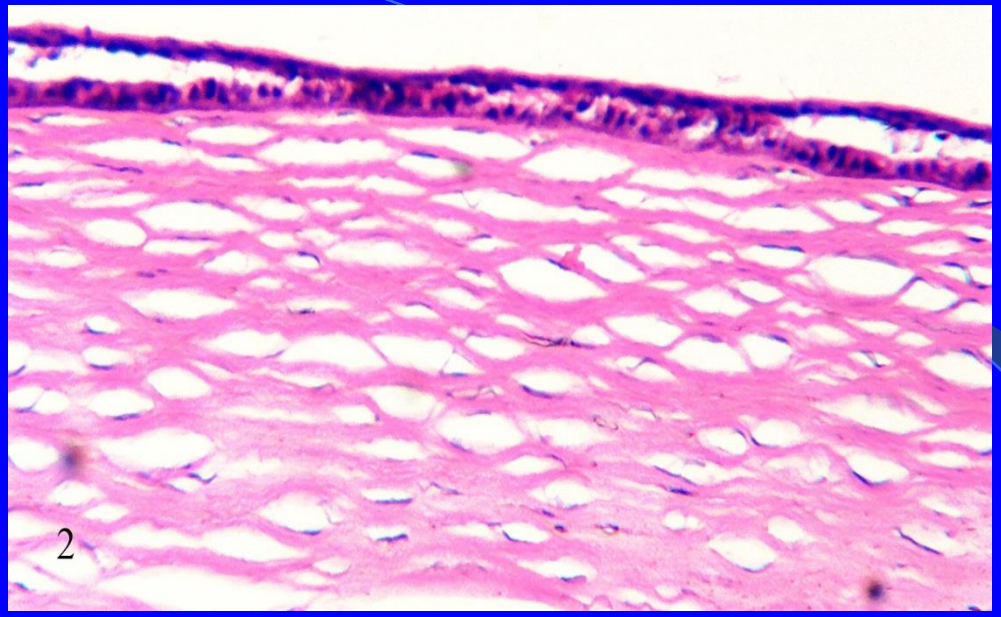
Treatment of dry eye syndrome Topical application of PVP/PAAc nanogel dispersions in an experimental dry eye model in albino rabbits

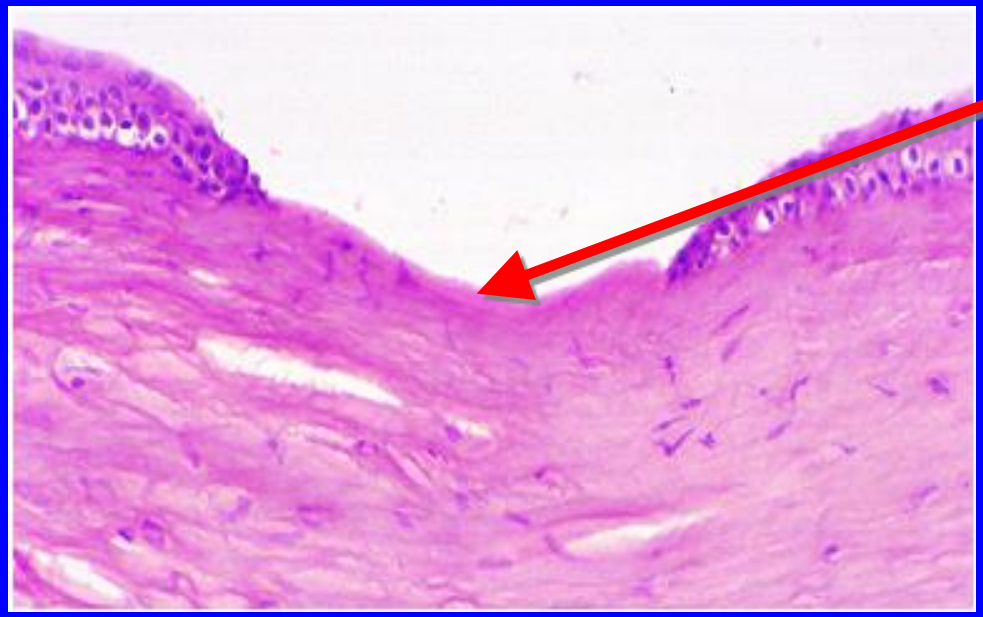
- Dry eye syndrome is a chronic eye disease which is associated with symptoms of discomfort, visual disturbance and abnormal tear film from either tear deficiency or excessive tear evaporation

Topical application of PVP/PAAc nanogel dispersions in an experimental dry eye model in albino rabbits

- An experimental dry eye model in albino rabbits was carried out using atropine sulfate 1% eye drops
- The model produces some typical dry eye symptoms such as a significant reduction in the tear volume and tear break-up time (TBUT), corneal staining, and histopathological signs of dryness and inflammation.
- The prepared PVP/PAAc nanogels (1.5 w/v%, pH 7.4) were used for the treatment of the dry eye model, and the obtained results were compared with that of commercial carbomer gel “Vidisic, 0.2%”

Untreated dry eye model





Ulcer

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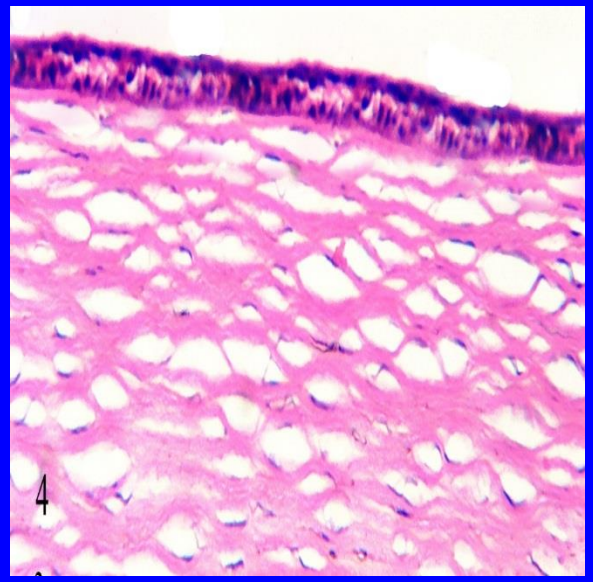
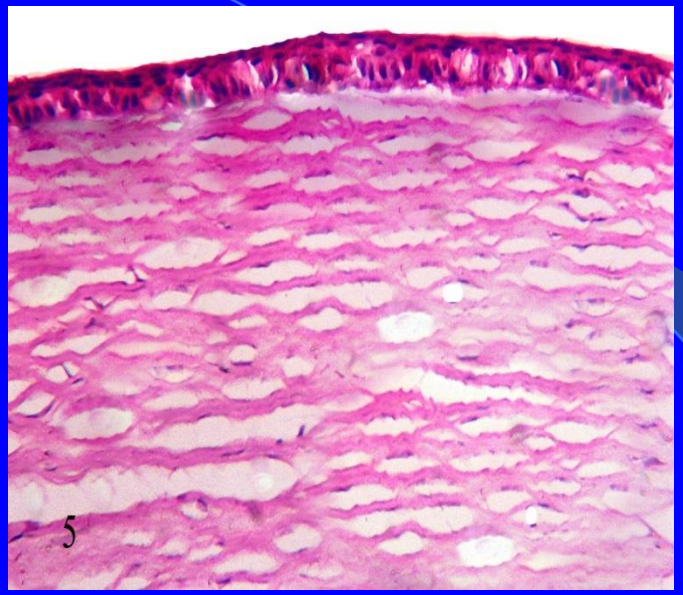
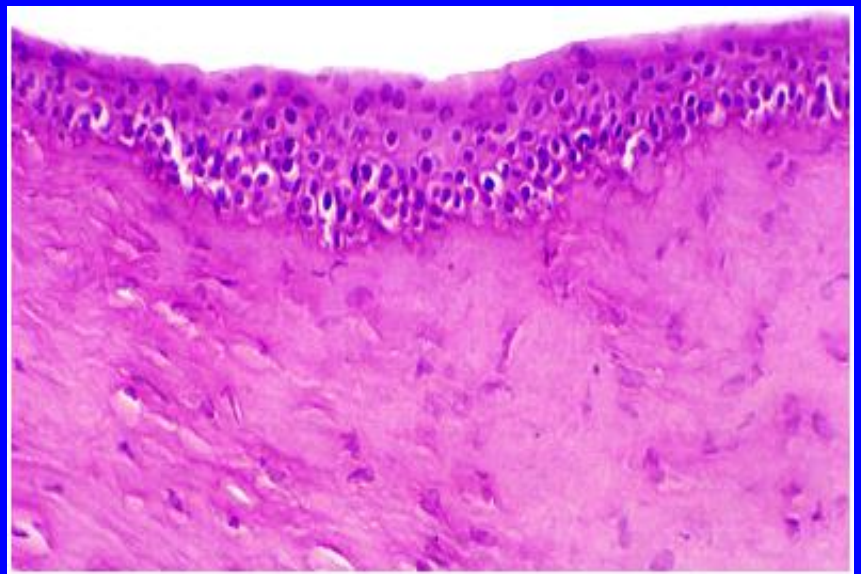
Treated dry eye model







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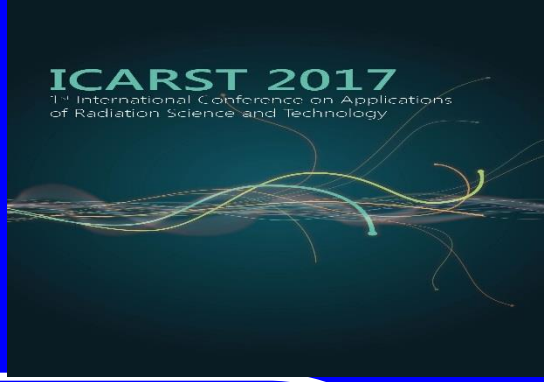
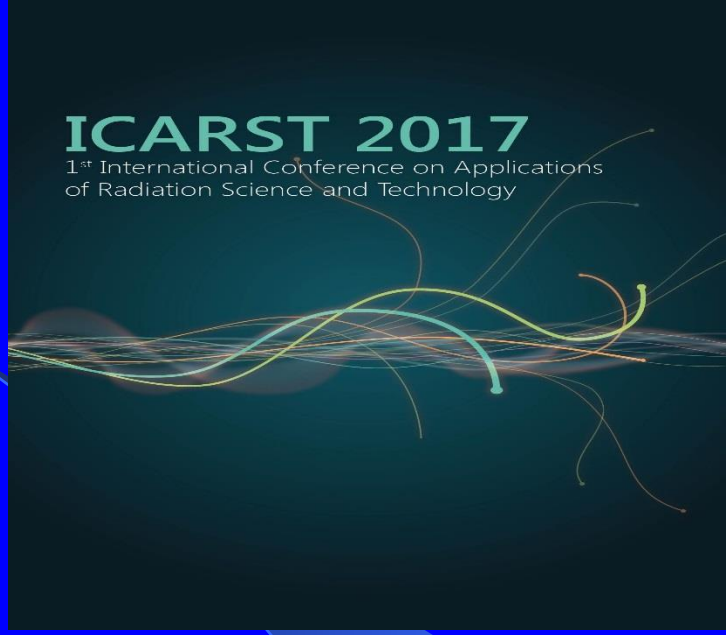


Conclusion

It can be concluded that radiation is a very effective tool for controlling the degradation and cross-linking of natural occurring polymers and the synthesis of relative economic, environmentally friendly super-absorbent hydrogels which may potentially be used in personal care products industry, in agriculture as a growth promoter, and in medical uses as drug delivery under control release to specific sites.



Many Thanks
for your kind attention