RADIATION FORMATION OF HYDROGEL BIOMATERIALS

JANUSZ M. ROSIAK*

INSTITUTE OF APPLIED RADIATION CHEMISTRY,
FACULTY OF CHEMISTRY,
LODZ UNIVERSITY OF TECHNOLOGY,
WROBLEWSKIEGO 15, 93-590 LODZ, POLAND
*E-MAIL: ROSIAKJM@MITR.P.LODZ.PL

[ENGINEERING OF BIOMATERIALS 143 (2017) 7]

Abstract

One of indispensable requirements related to biomaterials is their sterility. Ionizing radiation seems to be a very convenient and useful tool to achieve that, especially in relation to polymeric components of medical devices and their packaging. However, in parallel to destruction of living microorganisms radiation treatment causes changes in physicochemical properties of irradiated materials. Both electron beam and gamma radiation used for sterilization may initiate all types of fundamental polymer reactions in biomaterials, i.e. polymerization, degradation, crosslinking, grafting, oxidation, gases formation, etc. The presence of water in irradiated systems enhances the observed changes by indirect effect of radicals formed in water at high yield. Some of such changes are undesirable from the point of view of properties of biomaterials and have to be suppressed, e.g. by introducing into composition of materials selected additives, as it is done for polypropylene syringes or UHMW polyethylene applied for total joint arthroplasty.

On the other hand, such "additional" reactions during terminal sterilization of biomaterials can be utilized for achieve their final, desired properties.

In the last 30 years, our research group has created a number of radiation technologies of polymeric biomaterials. Some of them have been commercialized and are used, modified and developed by other laboratories and companies all over the world, some of them still await industrial investments. The comprehensive review of such biomaterials will be presented including hydrogels dressings, hydrogel systems for induction of childbirth, hydrogel-based dietary product, hydrogel-based hybrid artificial organs, hydrogel implants for intervertebral discs, hydrogel dosimeter for radiotherapy, hydro-nanogels, degradable and/or non-degradable scaffolds for regeneration of peripheral nerve and formation of animal neural tissue in 3D, thermoresponsive surfaces for cultivation of skin cells as well as the method for preservation of biological activity of peptides undergoing radiation sterilization in aqueous solution.

The developed technologies as well as the area of their applications have formed a new direction of research – radiation engineering of polymeric biomaterials – see Report for the IAEA [1].

Conclusions

The above mentioned biomaterials and new methods have been achieved using a typical radiation chemistry methodology and experimental techniques, e.g. sol-gel analysis, molecular weight measurements, pulse radiolysis with spectrophotometric and light scattering detection methods (LSI) as well as specific tests recommended for biomaterials by ISO 10993.

Human-friendly hydrogel systems, due to the rising trend to prolong life span and to improve the results of medical care, seem to be one of the most expected and required products. The unique advantages of radiation technology can be successfully utilized for the preparation of new commercial products, with designed functions that satisfy expectations of patients and physicians. Implants, wound dressings, drug delivery systems, artificial organs, and bioengineering generally are the domains in which radiation formed polymer materials begin to play an increasingly significant role. Despite a great number of investigations on radiation processes which allow for clarification of some mechanisms of reactions and elaboration of some general rules governing those phenomena, there are still some doubts and needs of further studies, both fundamental and applied. Despite many patents devoted to radiation bioengineering there are continuing needs for new products and more sophisticated biomaterials. The use of ionizing radiation in the production of human-friendly products seems to be the most promising way to broaden the range of commercial applications of radiation technology.

Acknowledgments

The author thanks all co-workers and former PhD students who have made a significant contribution to the presented technologies, especially to Prof. P. Ulanski, the first of them and the current head of our Research Team.

References

[1] http://mitr.p.lodz.pl/biomat/old_site/overview.html