Available online at www.sciencedirect.com
ScienceDirect
Nuclear Instruments and Methods in Physics Research B 265 (2007) 51–57
NIM B
Beam Interactions with Materials & Atoms
www.elsevier.com/locate/nimb

The role of IAEA in coordinating research and transferring technology in radiation chemistry and processing of polymers

M. Haji-Saeid [a,*], M.H. Sampa [a], N. Ramamoorthy [a], O. Güven [b], A.G. Chmielewski [c]

[a] International Atomic Energy Agency (IAEA), Wagramer Strasse 5, A-1400 Vienna, Austria
[b] Hacettepe University, Department of Chemistry, Ankara, Turkey
[c] Faculty of Chemical and Process Engineering, Warsaw University of Technology, Warsaw, Poland

Available online 2 September 2007

Abstract

The IAEA has been playing a significant role in fostering developments in radiation technology in general and radiation processing of polymers in particular, among its Member States (MS) and facilitate know-how/technology transfer to developing MS. The former is usually achieved through coordinated research projects (CRP) and thematic technical meetings, while the latter is mainly accomplished through technical cooperation (TC) projects. Coordinated research projects encourage research on, and development and practical application of, radiation technology to foster exchange of scientific and technical information. The technical cooperation (TC) programme helps Member States to realize their development priorities through the application of appropriate radiation technology.

The IAEA has implemented several coordinated research projects (CRP) recently, including one on-going project, in the field of radiation processing of polymeric materials. The CRPs facilitated the acquisition and dissemination of know-how and technology for controlling of degradation effects in radiation processing of polymers, radiation synthesis of stimuli-responsive membranes, hydrogels and absorbents for separation purposes and the use of radiation processing to prepare biomaterials for applications in medicine.

The IAEA extends cooperation to well-known international conferences dealing with radiation technology to facilitate participation of talented scientists from developing MS and building collaborations. The IAEA published technical documents, covering the findings of thematic technical meetings (TM) and coordinated research projects have been an important source of valuable practical information.

PACS: 47.85.m; 81.40.Wx; 61.82.−d

Keywords: IAEA; Radiation chemistry; Radiation processing; Gamma radiation; Electron beam

1. Introduction

Radiation processing is being applied in many fields of the national economies of developed and developing countries. Sterilization, polymer crosslinking, tire belt vulcanization, art objects' conservation, selected food items' irradiation are among the well-established technologies in this field. Both types of irradiators, gamma sources and electron accelerators are being applied in the process [1,2]. In the last few years, considerable success has been achieved in modifying the natural polymers through radiation processing to meet specific applications. It has been demonstrated that processing of natural polymers through radiation is simple, effective and commercially attractive. During a short span, many of these research and development activities have successfully progressed demonstrating their commercial utility in the areas of health care, agriculture and environment in some countries [3,4].

The IAEA has been helping the developing Member States (MS) during the last several years towards capacity building in radiation processing of polymeric materials. A number of coordinated research projects (CRP) have been implemented for the above purpose. The CRP brings together typically 10–15 groups of participants to share and complement core competencies and work on specific

* Corresponding author. Tel.: +43 1 2600 21748.
E-mail address: M.Haji-Saeid@iaea.org (M. Haji-Saeid).

0168-583X/$ - see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.nimb.2007.08.024

areas of development needed to benefit from an emerging radiation technique and its applications. A number of technical cooperation projects (TC) have been implemented in this field to strengthen the capability of developing Member States and to create awareness in the industries about the technical benefits of radiation processing of polymers. TC builds national capacities through training, expert advice and delivery of equipment [5].

Thematic technical and consultancy meetings have been held to review the status and prepare technical documents on specific topics of interest for developing Member States (MS). The impact of the IAEA's efforts is visible by the progress noticeable in adoption of radiation technology and/or growth in the range of activities in several MS in different regions. This paper covers the highlights of such activities implemented recently by the IAEA for the benefit of developing MS.

2. Coordinated research programme

A number of coordinated research projects on radiation processing of synthetic and natural polymers have been implemented. The Agency run CRPs have helped in regional and interregional networking of scientists and coordinating the research carried out in the participating countries, to ensure that different research programmes complement one another and the information benefit is available to all. Many of the CRPs also resulted in demands for further capacity building through national or regional TC projects.

2.1. Radiation synthesis and modification of polymers for biomedical applications

The main objective of the related CRP (1996–2000) was to expand the use of ionizing radiation in two major areas: synthesis of polymers and gels for medical and biotechnological applications, and modification of surfaces to achieve a specific functionality and/or to immobilize bioactive materials. The results of the studies carried out in participating centres helped better understanding and control of radiation effects on synthetic and natural polymers in the preparation of biomaterials. Some of the results which found industrial or pilot scale applications have been transferred to interested end users in some Member States through technical cooperation projects [6].

The major achievements reported from the CRP include:

- Mechanisms of radiation-induced crosslinking of some selected hydrophilic polymers [poly acrylic acid, poly ethylene oxide, some polysaccharides] in aqueous solutions were described. Results on the promising biomedical applications such as wound dressings, controlled drug delivery systems and implants were presented.
- New injectable drug delivery systems were developed using poly ethylene glycol. Stimuli-responsiveness of poly electrolyte hydrogels were established and intelligent release and permeation devices were constructed using radiation prepared micro-porous films.
- Copolymeric hydrogels containing diprotic acids were synthesized to be used as specialty adsorbents for biomolecules such as bovine serum albumin, amylase, invertase and some model drugs. Their release behaviour was investigated under different environmental conditions.
- Radiation grafting conditions for various monomers onto polypropylene were optimized to enhance adsorption capacity of the substrate for some enzymes and bovine serum albumin.
- Hydrogels prepared from blends of natural polymers (kappa-carrageenan) and synthetic polymers were characterized for their suitability in biomedical applications.
- Hydrogels based on vinyl ethers were prepared and their use as drain materials in ophthalmologic surgery tested.
- Functional microspheres with uniform and narrow size distribution were prepared, immobilization and binding capacities towards bioactive molecules such as histidine and lysosyme were determined. Surface of ELISA plates were radiation modified to improve the adsorption characterisation and in turn, the sensitivity for early detection of tropical diseases (e.g. schitosoma).
- Patterned surfaces were prepared by combination of gas discharge and lithographic processes to control cell attachment and growth.

2.2. Radiation synthesis of stimuli-responsive membranes, hydrogels and absorbents for separation purposes

Stimuli-responsive hydrogels and membranes have emerged in recent years as a unique class of materials that can offer many advantages over the conventional ones in a number of applications of radiation processing techniques. A coordinated research project on this subject was initiated in 2000 and completed in 2004, with the overall objective of developing new materials using radiolytic methods for practical applications in various fields, and in particular: development of new functionalized hydrogels, partly by using natural polymers for collecting hazardous heavy metals, dyes and other organic compounds from wastewaters; synthesis of polymers with high selectivity for collecting uranium from wastes and also from sea water; synthesis of new polymeric materials (nanogels, membranes) for separation of biomolecules or biopolymers, such as amino acids, nucleic acids and proteins; synthesis of stimuli-responsive nano- and microgels, hydrogels for controlled drug delivery; and production of polymers with special properties for biomedical applications.

Under this project new synthesis and characterization methods were developed and areas for applications, where such materials can be beneficially utilized, were explored. Accordingly, the participating groups engaged in this project have carried out the development of radiation processed materials in different forms such as hydrogels, grafted membranes, ion track membranes, beads, mono-