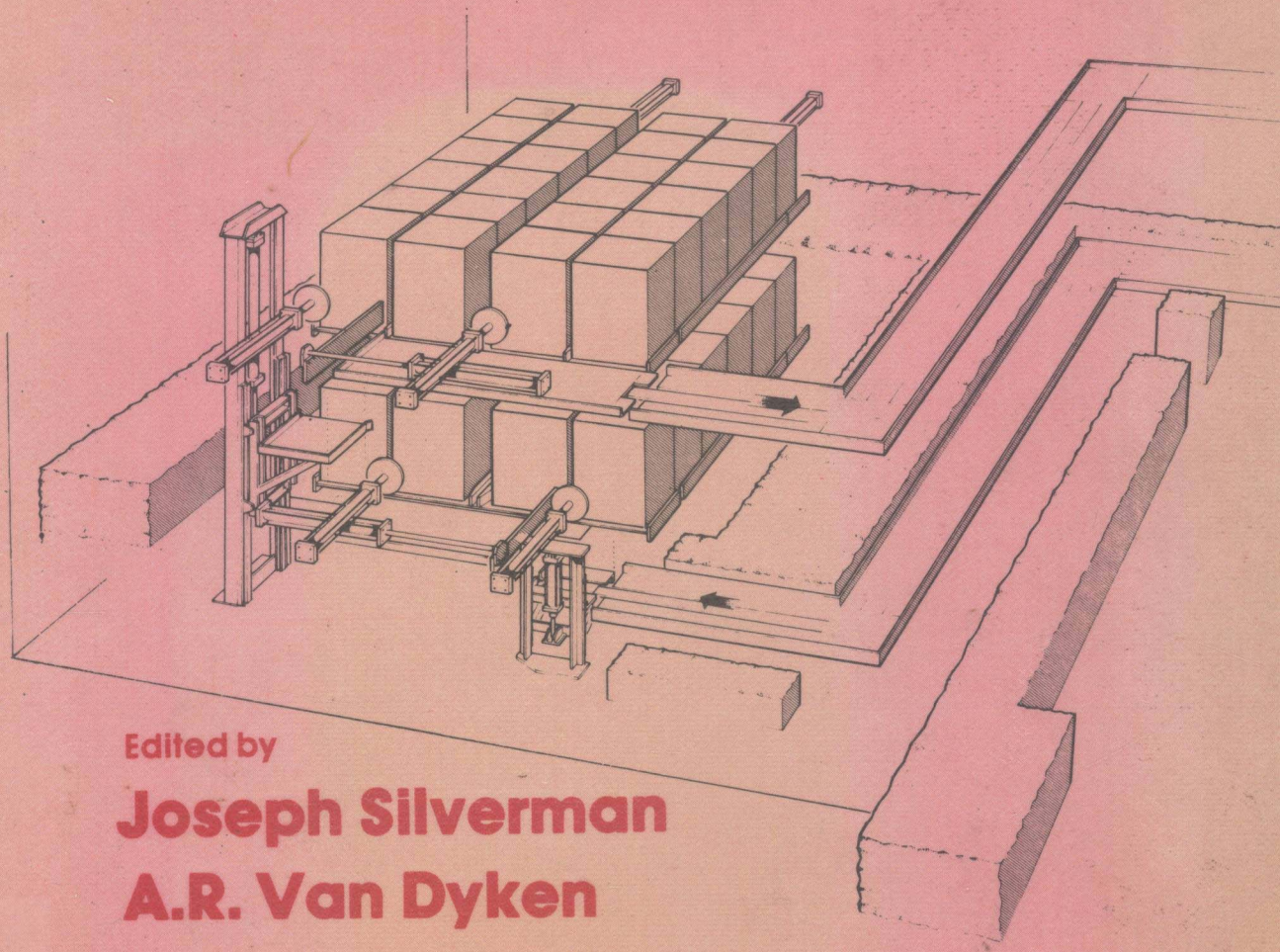
Radiation Processing

Transactions of the First International Meeting held at Dorada Beach, Puerto Rico, May 1976

Volume 2: Contributed Papers



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University of Maryland

Pergamon Press

RADIATION PROCESSING

Editors

JOSEPH SILVERMAN and A. R. VAN DYKEN

Transactions of the
First International Meeting on Radiation Processing

A CONFERENCE JOINTLY SPONSORED BY
POLYMER CHEMISTRY DIVISION, AMERICAN CHEMICAL SOCIETY
ISOTOPES AND RADIATION DIVISION, AMERICAN NUCLEAR SOCIETY
ELECTRONICS DIVISION, SOCIETY OF PLASTICS ENGINEERS

Held at Dorado Beach, Puerto Rico, 9–13 May 1976

VOLUME II

Contributed Papers

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PREFACE

This two volume work contains most of the papers delivered at the First International Meeting on Radiation Processing held in Dorado Beach, Puerto Rico during May 9 - 13, 1976.

The first volume consists of a series of invited papers which cover almost all aspects of radiation processing. It can serve as a reference volume summarizing the present status of radiation processing as well as the opportunities and problems associated with this technology. Since it contains a comprehensive analysis of the basic elements of the field, it can also be used as text material in courses in applied radiation chemistry and radiation engineering. This work should therefore prove useful to technical management, practicing engineers, and university students in applied science and engineering programs. The careful reader will find it to be a reliable guide in assessing the role ionizing radiation can play in existing industrial processes. This volume can also assist him in evaluating the processes that will be suggested in the future.

Volume II consists of papers reporting recent research on new and old process applications, radiation source technology, processing techniques that compete with ionizing radiation (e.g. ultraviolet light), dosimetry and quality control, etc. The papers are aimed at readers with a reasonable grasp of radiation science and engineering.

Together, the two volumes give an excellent survey of the extent and variety of applications of radiation technology. While the research aspects are not ignored, the papers were written in the main by applied scientists, engineers, and industrial processors. In consequence, these volumes are devoted to the work of people with a practical outlook, and they are directed at readers with similar attitudes.

The two volumes are dedicated to the three hundred conferees who provided the substance and spirit of this successful meeting. It is their papers that formed the basic framework, their probing questions and thoughtful responses that illuminated the dark corners, and their stellar accomplishments and reputations that give luster to the conference and to the science we serve.

While it is the speakers, authors and other conferees who are the principal basis for the success of the meeting, it is the financial backing of three organizations that made the meeting possible. They are the U. S. Energy Research and Development Administration, the Johnson and Johnson Company, and the W. R. Grace Comapny. We are grateful for their generosity and hope that the combined efforts of all concerned justified their kindness.

We also extend our compliments and thanks to Caprice McCann and Judy Whipstock for the skillful secretarial work they performed on all the publications of the meeting. Editorial work is not always pleasant; neither are editors. It is gratifying to report that these fine young ladies survived the experience of working with us with their excellent temperaments still intact.

Joseph Silverman
A. R. Van Dyken

University of Maryland
College Park, MD 20742

September, 1976

ORGANIZATION

OF THE

FIRST INTERNATIONAL MEETING ON RADIATION PROCESSING

General Chairman	Dr. K. H. Morganstern
Banquet: Honorary Chairman	Dr. E. Munekata
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	American Nuclear Society Isotopes and Radiation Division
	Society of Plastics Engineers Electronics Division
Supporting Institutions	U. S. Energy Research and Development Administration Johnson & Johnson Co. W. R. Grace Co.

PROGRAM

A. Invited Papers

Monday, May 10, 1976

Introduction - Dr. K. Morganstern
General Chairman

Welcome - Dr. Jaime Benitez
Resident Commissioner
Commonwealth of Puerto Rico

Session I: Applied Radiation and Technology

Professor V. T. Stannett
Program Committee Chairman

Chairman's Remarks

"Basic Concepts"
Professor Joseph Silverman

"Crosslinking and Degradation of Polymers"
Professor A. Charlesby

"Radiation Initiated Polymerization"
Professor Y. Tabata

"Radiation Grafting"
Dr. A. Chapiro

Informal discussion sessions with invited speakers

Contributed Papers

Session IIa: Applied Radiation Grafting
Session IIb: Radiation Grafting
Session IIc: General

Reception

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Session IIc: General

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Dr. Klaus Singer, Chairman

Chairman's Remarks

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Mr. W. Ramler

"Gamma Irradiation Facilities"
Mr. R. Harrod

"Radiation Process Control and Equipment"
Mr. R. Derbyshire

"Shielding and Safety Requirements"
Mr. C. Hoffman

"Radiation Measurements and Quality Control"
Dr. W. L. McLaughlin

Informal Discussion Sessions with Invited Speakers

Contributed Papers

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Session IVb: Crosslinking of Polymers

Wednesday, May 12, 1976

Session V: Successful and Promising Applications

Session Va: Biological Applications

Dr. A. Brynjolfsson, Chairman

Chairman's Remarks

"Sterilization of Medical Supplies"
Dr. C. Artandi

"Preservation of Food"
Dr. J. F. Diehl

"Bioengineering Applications"
Professor A. S. Hoffman

"Sterility Assurance of Medical Products"
Dr. W. Dierksheide

*Manuscript not available in time for publication

Monday, May 10, 1976

"Comparison of Irradiation Crosslinking and Chain Scission in Extended Chain and Bulk Film Samples of Linear Polyethylene"
Malcolm Dole & V. M. Patel

"Radiation Stability of Polypropylene"
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Professor J. L. Garnett, Chairman

"Radiation Treatment of Natural Fibers"
A. Rodriguez S., Ma. Esther Martinez P. & J. Reyes L.

"Radiation Flameproofing of Polyester/Cotton Blends"
R. Liepins, J. R. Surles, V. T. Stannett & R. H. Barker

"Radiation Induced Crosslinking of Polyethylene in the Presence of Bifunctional Vinyl Monomers"
Mukund S. Joshi, Klaus Singer & Joseph Silverman

"Terpolymeric Membranes Obtained by Radiation Grafting of Styrene-Acrylonitrile Mixtures onto Polyethylene Films"
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"Monomer Exponent in Radiation Grafting Polymerization"
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"Characterization of Gamma-Ray Graftcopolymers of Fibrous Cotton Cellulose-Acrylamide System"
Ung-Ping Wang

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Dr. Meyer Steinberg, Chairman

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Meyer Steinberg

"Synthesis of Copolymers Suitable for the Storage and Slow Release of Reactants - Cases of Copper Salts for Intra-Uterine Devices"*
G. Gaussens & J. Duchemin-Berthet

"Shielding and Safety Requirements -- Shielding Criteria for Neutron and Gamma Radiation Facilities"*
Martin A. Welt

*Manuscript not available in time for publication

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Session IVb: Crosslinking of Polymers

Professor Malcolm Dole, Chairman

"Preparation of Hydrogels by Radiation Technique"
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"The Improvement of Polyethylene Prostheses through Radiation Crosslinking"
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"Radiation Curing of Chlorinated Polymer/Vinyl Monomer Mixtures by High Dose Rate Electron Beam"
M. Gotoda & T. Yagi

"Compounding for Radiation Crosslinking"
R. F. Grossman

"Application of Irradiation Process for the Production of Thin Wall Wires"
Eisuke Saito

"New Applications for Irradiated Polyethylene Insulation"*
Robert A. Bellino

"Radiation Processing of Polyolefins and Compounds"
A. Barlow, J. Biggs and M. Maringer

"Problems Concerning the Thermal-Oxidative Stability of Radiation Crosslinked Polyethylene-Compounds for Wire and Cable Insulations"
R. Wiedenmann

"Radiation Processed PAA Composites for Endosseous Implants"
Ihab Kamel

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Dr. Vitomir Marković, Chairman

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Jacques Laizier & Constantin Oproiu

"Radiachromics: A Radiation Monitoring System"
K. C. Humpherys & A. D. Kantz

"Measurements of Dose Distributions in Various Materials Irradiated by 10 MeV Electrons"
J. C. Humphreys, S. E. Chappell, W. L. McLaughlin & R. D. Jarrett

Session Vb: Bulk Polymer Applications

Dr. J. R. Puig, Chairman

Chairman's Remarks

"Applications in Plastic Sheet and Film"
Mr. W. Baird

"Applications in Elastomers"*
Dr. G. A. Böhm

"Applications in Wire and Cable"
Mr. D. Loan

"Applications in Foam Plastics"
Mr. D. A. Trageser

"Applications in Wood Plastics"
Dr. A. Witt

Session Vc: Surface Applications

Dr. Jesse Hwa, Chairman

Chairman's Remarks

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Dr. Clifford Coppinger

"Textile Applications"
Dr. W. K. Walsh

"Ultraviolet Applications"
Dr. R. Mesrobian

"Low Voltage Applications"
Dr. S. Nablo

Session VI: New Horizon Applications of Radiation

Dr. D. S. Ballantine, Chairman

Chairman's Remarks

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Dr. I. A. Suss

"Radiation Treatment of Combustion Gases"
Dr. S. Machi

"Radiation Treatment of Solid Waste"
Professor W. Brenner

*Manuscript not available in time for publication

Wednesday, May 12, 1976

"N-Vinyl-2-Pyrrolidone as a Reactive Diluent in Radiation Curing"
D. H. Lorenz, J. L. Azorlosa & R. S. Tu

"A Comparative Study of Electron Beam and Ultraviolet Curing of Epoxy Acrylate"
J. Kumanotani, T. Koshio, T. Yagi & M. Gotoda

"Electron-Beam Curing of Paints and Varnishes on Wood Panels"
P. R. Grosmaire

"Electron Beam Curing of Coatings - The Influence of the Voltage on the Curing Process"
A. Rosenberg

"The Utilization of Partial-Impregnation Techniques to Improve the Economic Viability of Wood-Polymer Composites"
T. A. du Plessis & G. S. du Toit

INTRODUCTION

The First International Meeting on Radiation Processing ended with a panel session charied by Dr. Kennard H. Morganstern of Radiation Dynamics, Inc. (Westbury, N.Y.) and some concluding comments by Professor V. T. Stannett, Dean of the Graduate School and Vice Provost of the North Carolina State University (Raleigh, N.C.). Dr. Morganstern served as General Chairman of the meeting; Dean Stannett was Chairman of the Program Committee.

Their remarks summarized the purpose and history of the meeting, and some of the highlights of the proceedings. They are presented here as an introduction.

A. Dr. K. H. Morganstern

The First International Meeting on Radiation Processing is now history. The meeting took place at the Cerromar Beach Hotel in Puerto Rico, May 9 through 13, 1976. From every vantage point the meeting was deemed a resounding success.

It was my pleasure to have had the opportunity to chair this meeting and I am also pleased to provide this introduction to the publication of the papers that were presented at our many technical sessions.

The idea for a meeting on radiation processing was generated initially at an Executive Committee Meeting of the Isotopes and Radiation Division of the American Nuclear Society. At this meeting, held in the latter half of 1973, suggestions for ANS topical meetings were being discussed. Because of my familiarity with the radiation processing industry and my feeling that this industry was entering a substantial growth period, I suggested that a meeting on radiation processing would be most timely. Shortly thereafter I discussed the concept with Professor Vivian Stannett at North Carolina State University, and Professor Joseph Silverman at the University of Maryland, and they reinforced my feeling with respect to the advisability and timeliness of such a meeting. I asked these two distinguished professors and close friends to assist me in its organization and to serve on the program committee.

It was decided relatively early in the planning stage that because many radiation activities were taking place outside of the United States as well as inside, we should think more broadly than the typical topical ANS meeting and make it international in scope. Further, we felt that since other disciplines were involved, we should broaden the sponsorship; consequently, the American Chemical Society and Society of Plastics Engineers were contacted and graciously added their support to that of the ANS.

Our program committee also felt that it would be desirable to choose a location not in the continental United States (in order to give meaning to the international scope) and a location isolated enough so there would not be major distractions to the educational and technical content of the program. Frankly, we were desirous of having a "total immersion" of participants in a radiation environment, and Puerto Rico and the Cerromar Beach Hotel appear to have served our purposes admirably.

Although there were many other distinguished conferees at the meeting whose names should be mentioned, lack of space prevents me from enumerating them. To them I apologize.

While development of the radiation processing industry was influenced heavily by the efforts of many of our participants, the increased use of radiation as a processing tool was brought about primarily by a substantial reduction in radiation costs, due in large part to the increasing power levels of radiation devices. Recognition on the part of industry that radiation could compete economically with more conventional processing techniques, the recent increase in energy costs, the inherent energy efficiency of radiation processing, and the awareness that there are finite limits to our energy resources have brought the advantages of radiation processing into still sharper focus.

I feel the net result is summarized in the theme of the meeting: "Radiation's Time Has Arrived".

In spite of the relative newness and small size of our industry, we should all recognize that it is based on a new technology that has the potential of enormous impact on pressing world problems. What other industry offers simultaneously the possibility of

- extending the world's supply of food
- cleaning up its dirty air and water
- recovering valuable products from its wastes
- conserving energy in practical production applications?

We should all be proud of the position we have played and are playing in furthering the growth of the radiation processing industry.

In conclusion, I should again like to personally thank all those who contributed to the organization of this meeting, Professor Stannett, Dr. Ballaneine, Dr. Chapiro, Professor Charlesby, Dr. McLaughlin, Professor Okamura, Professor Silverman, and Professor Tabata. My secretary, Corinne Weber, has earned gratitude for her diligent assistance and for her organization of the Hospitality and Ladies' Program. A special thanks goes to my wife, Lee, for her help in coordinating all our efforts, and a final thanks to the attendees who made the Firs International Meeting on Radiation Processing a successful reality.

B. Dean Vivian T. Stannett

Ken Morganstern in his admirable introduction has shown a justifiable pride in the undoubted success of this meeting. The invited papers were well selected, well presented, and well received. They constitute an excellent basic reference and instructional volume for the entire field. Particularly gratifying was the large amount of discussion which the papers engendered and the wide participation by the audience. There appears to be an easing of the reluctance of industrial attendees to add their own questions and comments without fear of revealing too much. Hopefully, this was a sign of the growing confidence we all feel in our field. The contributed papers were very numerous and covered an extraordinarily large number of topics.

There were many "firsts" at this meeting. Major manufacturers such as W. R. Grace and Raychem gave clear presentations of many details of their own highly successful activities. Furthermore, there were excellent presentations on the engineering aspects of radiation processing including highly practical aspects such as conveyor systems, process control, dosimetry and economic and regulatory considerations. The invited and contributed papers also covered ultraviolet and plasma treatments in addition to the more standard radio isotope and accelerator processes.

The delegates were an unusually healthy blend of academicians, chemical and equipment suppliers and present and prospective users of radiation. The large percentage of foreign attendees and contributors was also unique and they added greatly to the success of the conference. The range of subjects covered was also unusually broad ranging from the more standard crosslinking, polymerization and grafting processes to food irradiation, sterilization and the use of radiation in finding solutions to various environmental problems including sewage and combustion gas treatments.

It became clear from the conference that the cost of radiation was no longer the prime consideration nor was the reliability factor. Radiation processing has truly taken its place among other forms of energy to be considered on an equal basis. This alone made the conference highly worthwhile. We all look forward to a second meeting of this kind.

The title for the meeting, the "First International Meeting on Radiation Processing", tells the story.

It certainly was the first of its kind. Although there have been many other meetings in the past discussing radiation applications, I do believe this truly was the first of its kind in the calibre, extent, and orientation of the meetings' participants.

Approximately 300 individuals participated. The vast majority of them represented industry -- some already using radiation, many others interested in its possible application to their industry. In addition, we had many of the world's experts both from academic and governmental agencies who helped bridge the gap between the fundamental and the applied.

It is my belief that this kind of meeting could not have taken place much earlier than this year and indicates to me that our industry, the radiation processing industry, has finally come of age.

The meeting was certainly international in scope with 22 countries represented by various participants. This is indicative of the world-wide interest in, and scope of, radiation processing. The fact that we had "radiation processing" in the title rather than "radiation applications" means that the technology has progressed beyond the thinking stage -- possible application areas; and has arrived at the more important stage -- making products and profits. Obviously, this is what the business of radiation processing is all about and this is what attracted, I believe, the large number of industrial participants.

To those of you who have been involved in the growth of the radiation processing industry, it is obvious that this did not just happen; it is the result of the efforts of many people over an extended period of time.

We were fortunate in having in attendance at our meeting many of the early radiation chemists who were so instrumental in laying the foundation for this industry...individuals such as Dr. David Ballantine, Professor Arthur Charlesby, Professor Adolphe Chapiro, Professor Malcolm Dole, Professor Joseph Silverman, Professor Vivian Stannett and Professor Yoneho Tabata.

We were also fortunate in bringing together for the first time at this kind of meeting some of the very early industrial users of radiation, the "brave ones", who were willing to climb out on a limb because they had the vision, the imagination, and the fortitude to pioneer...individuals such as Dr. Charles Artandi from Ethicon, William Baird from W. R. Grace, and Paul Cook from Raychem. Let me pause here to compliment Paul in behalf of the conferees for his brilliant banquet address.

We are proud to acknowledge the participation of Dr. E. Munekata, Chairman of the banquet. It was Dr. Munekata's leadership that brought the Takasaki Laboratory of the Japan Atomic Energy Institute to the forefront in applied radiation science.

Also participating in this meeting were many of the people who helped in the development of radiation equipment and source technology such as Dr. Marshall Cleland, Don Gantt, John Masefield, and David Trageser.