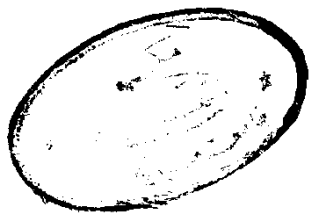
THESIS ENTITLED
EFFECT OF 8-IRRADIATION ON SOME POLYMERIC MATERIALS

SUBMITTED TO
AIN SHAMS UNIVERSITY

IN PARTIAL FULFILMENT
OF THE REQUIREMENTS
FOR THE DEGREE OF (M.Sc.)
IN
(Chemistry)

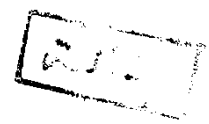
B y

Manal Mohamed Abdel-Fattah Shaker
(B. Sc.)



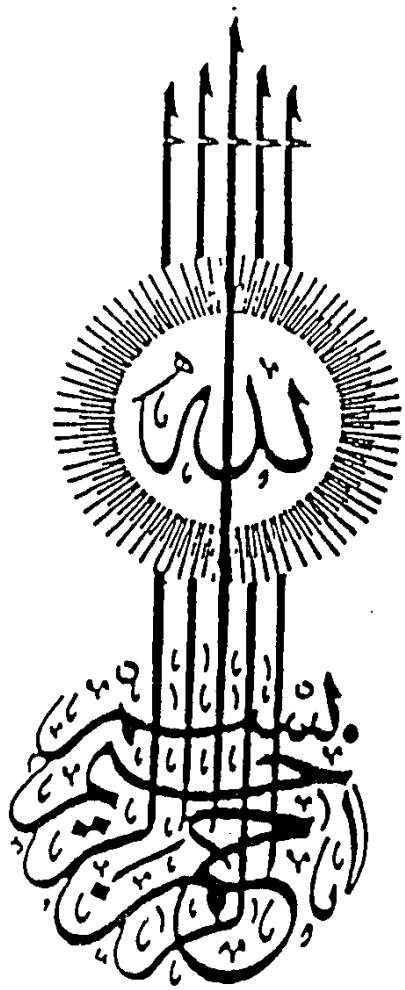
National Centre For Radiation
Research & Technology

(CAIRO)



1986

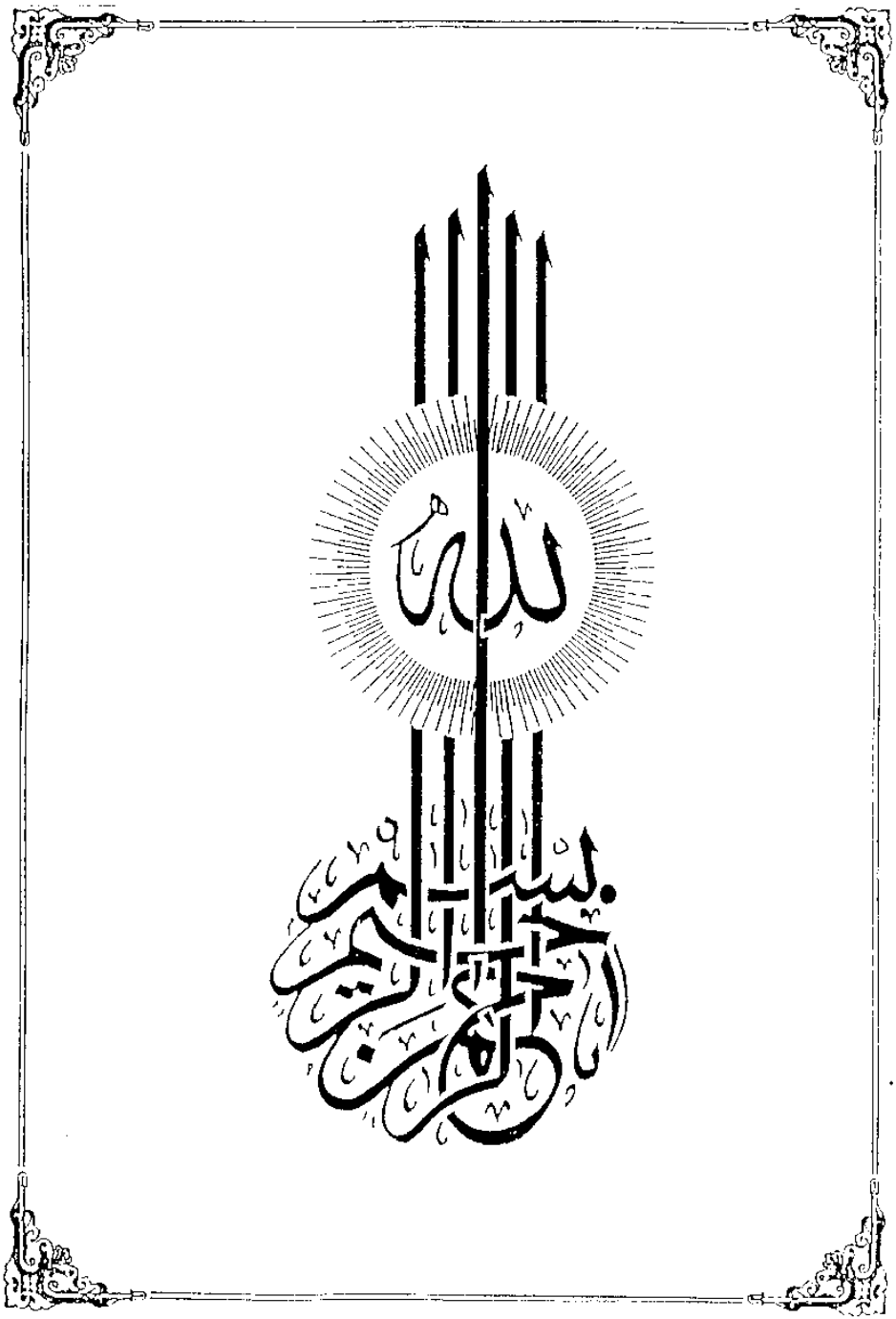
Women



سبحانك

لا علم لنا إلا ما علمتنا إنك أنت العليم الحكيم

صدق الله العظيم سورة البقرة آية ٣٢



ACKNOWLEDGMENT

I wish to express my deepest thanks and gratitude to Prof. Dr. Abo El-Khair B. Mostafa, Chemistry Department, University College for Women, Ain Shams University for supervision, and his great interest throughout this work.

My sincere thanks and deepest gratitude to Assistant Prof. Dr. A.M. Dessouki, Head of Radiation Research of Polymer Chemistry Department, and to Dr. El-Sayed A. Hegazy, Head of Synthetic Membranes and Bipolymers Laboratory, National Centre for Radiation Research and Technology(NCRRT), Cairo, for suggesting the topic of this work, supervision, continuous guidance, and helpful discussions throughout this work.

The author wishes gratefully to thank Prof. Dr. Hamed Roushdy, The Chairman of National Centre for Radiation Research and Technology for his continued interest and valuable helps throughout this work.

Many thanks are due to Assist. Prof. D.N.El-Assy and Dr. M. Mansour for their valuable helps in different measurements, and to all colleagues for their interest and valuable helps throughout this work.

EFFECT OF γ-IRRADIATION
ON SOME POLYMERIC MATERIALS

Thesis Advisors :

Prof. Dr. Abo-El- Khair B. Mostafa. A. Khair

Assist Prof. Dr. Ahmed M. Dessouki A. M. Dessouki

Dr. El-Sayed A. Hegazy. El-Sayed A. Hegazy

S. A. Awad

Prof. Dr. S.A.Awad.
Head of chemistry Dept.

NOTE

Besides the work carried out in this thesis, the candidate has attended postgraduate courses in the following topics:-

1- Photochemistry
2- Microanalysis
3- Polymer chemistry
4- Quantum Chemistry
5- Spectroscopy
6- Chemical kinetics
7- Thermodynamics
8- Germany language

She has successfully passed a written examination in these courses, in partial fulfillment for the degree of Master of Science.

Approved,

Prof. Dr. S.A. Awad
Head of Chemistry Department

CONTENTS

AIM OF WORK

Water is an essential commodity of everyday life. Although it is nature's abundant gift,water has attracted considerable attention during the last two decades owing to serious shortages felt in certain parts of the world. With the advent of rapid industrilization and growing population, this common and abundant commodity is becoming insufficient even though attempts have been made for full utilization of the available natural water resources and it has become necessary to adopt different desalination techniques to convert saline water resources including sea water into good water quality.

Radiation-induced graft copolymerization is a versatile technique which can be used to alter the surface and/or bulk characteristics of a polymeric substrate. This technique utilizes electron beam, gamma, or UV radiation to form radicals or ions in the polymer substrate,which then can attack monomers to initiate polymerization, which results in grafting.

The increasing interest on membrane problems in these recent years testifies that this topic will play an important role in the future, both from the point of view of the applied and fundamental sciences. Membranes obtained by radio-induced grafting in polymers seem to meet all the requirements

to become the protagonists or at least the co-stars in this story, due to the fact that grafting can induce peculiar properties to natural and synthetic polymers (1).

In this connection, a study has been made for the preparation of ion-containing reverse osmosis membranes by the radiation grafting of acrylic acid onto low density polyethylene films followed by alkaline treatment to confer ionic character in the prepared membranes. The suitable preparation conditions, at which the grafting proceeded successfully and the grafted films possessed membrane quality, were determined. To elucidate the possibility of applicability of such prepared membranes in the reverse osmosis desalination of saline water, some selected properties of the membranes were investiagted. Swelling behaviour, mechanical properties, electrical conductivity, and reverse osmosis properties (water flux and salt rejection) were studied. The effect of operation time, applied pressure, degree of grafting, and feed concentration, on the membrane quality for water flux and salt rejection, was determined.

Thermal and chemical stability of the grafted membranes were also studied at various elevated temperatueres and in different acidic solutions. The gelled part in the graft copolymers was also determined. The practical uses of such grafted membranes were suggested.

SUMMARY

In this study the preparation and properties of ion-containing reverse osmosis membranes obtained by the direct radiation grafting of aqueous acrylic acid onto low density polyethylene films followed by alkaline treatment to confer ionic character in the prepared membranes were investigated. The appropriate reaction conditions at which the graft polymerization was carried out successfully were selected. In this grafting system, ammonium ferrous sulphate (Mohr's salt) was used as inhibitor to minimize the homopolymerization of acrylic acid and the suitable concentration of the inhibitor to be added to the reaction medium was found to be 2.5 wt.%. The effect of aqueous monomer concentration on the rate and degree of grafting was studied. The dependence of grafting rate on the monomer concentration was found to be 0.8 order, i.e. almost first order dependence. It was also found that the irradiation atmosphere (air or nitrogen gas) had no significant effect on the grafting yield at a given reaction condition . The prepared graft copolymer films showed good thermal and chemical stability. Gel determination in the grafted films was also investigated and the results indicated that a crosslinked network structure may be formed. The extent of gelled part in the graft copolymer increased as the degree of grafting increased.

The swelling behaviour for the alkali -treated and untreated grafted films was investigated.It was observed that the swelling percent depends mainly on the amount of hydrophilic groups introduced into the polymer substrate. The alkalin -treatments for the graft copolymer resulted in the improvement of their electrical conductivity and swelling properties and the films became flat, smooth and swell in water to higher extent as compared with those of the untreated grafted films. The irradiated and grafted polyethylene films showed good and acceptable mechanical properties.

Reverse osmosis properties of the polyethylene-g-poly (acrylic acid) membrane revealed that such membrane has a high water flux and good salt rejection. The effect of parameters influencing the reverse osmosis of the grafted membranes, such as operation time, degree of grafting,applied pressure, and feed concentration, was determined.

It can be concluded that the grafted membranes showed a good swelling behaviour, good mechanical properties acceptable for handling and uses, good thermal and chemical stability, high water flux and salt rejection. This may make them acceptable for practical uses as reverse osmosis membrane for desalination of sea water.

CHAPTER I

INTRODUCTION

INTRODUCTION

Reverse osmosis is a membrane permeation process for separating relatively pure water (or other solvent) from a less pure solution. The solution is passed over the surface of an appropriate semipermeable membrane at a pressure in excess of the effective osmostic pressure of the feed solution. The permeating liquid is collected as the product and the concentrated feed solution is generally discarded. It is immediately obvious that the membrane must be highly permeable to water, highly impermeable to solutes, and capable of withstanding the applied pressure without failure.

There are other equally important constraints on the membrane but these do not obvious until the details of the process and, most importantly, the costs of the process are introduced. Consider the example of water desalination, all of salt solution must be pressurized but only a fraction can be recovered as product because the osmotic pressure of the concentrated feed solution exceeds practical operating pressures at some points. However, the pressure-volume work put into the feed solution represents the principal operating cost, and the cost of disposal of concentrated brine can also be significant under some circumstances,both factors favour high water recovery. In order to achieve high recovery and maintain acceptable quality

of the produced water, it is necessary to use membranes of high permselectivity Completely solute-impermeable membranes would, in fact, be optium for most applications. Because the membrane represents a significant fraction of the capital cost of the process, it is essential that water flux be maximized. This means that the membrane material must be highly water permeable and that the fabricated membrane, or more precisely speaking the solute-impermeable barrier,must be as thin as possible, consistent with strength requirements.

Further,because membrane replacement is an important operating cost, membrane life must be maximized. This means that membrane must be resistant to chemical and microbiological attack, and that its transport and mechanical characteristics should be invariant after long exposure to high pressure. Finally, the fact that the cost of the pressure vessel used to define the membrane is a significant fraction of the capital cost adds another constraint. The membrane should be capable of being fabricated into shapes that offer high packing densities, i.e., high surface-to-volume ratios. We can summarize these criteria as follows:

1- The membrane material must be highly permeable to water and highly impermeable to solutes.

2- The membrane barrier must be as thin as possible consistent with strength requirements.