
Sudan University of Science and Technology

College of Graduate Studies

Management of Polymer Waste Using Gamma Irradiation Technique

معالجة النفايات البوليميرية باستخدام تقنية التشعيع بأشعة قاما

A thesis submitted for the fulfillment of the PhD degree in medical physics

By:

Nuha Salih Mustafa Abd almotalab

M. Sc. in Medical Radiation Physics

B. Sc. in Radiotherapy

Supervisor:

Dr. Mohammed Elfadil Gar Alnabi

Co-Supervisor:

Dr. Mohammed Ahmed Ali Omer

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To my father Salih Mustafa, Who was sincerely encourage and foster me throughout my study-hood, I dedicate the benefits of this humble work. My deeps gratitude and special appreciation extended to my mum Amna Abd Rahman, To my Brothers and sister, To the staff members of College of Medical Radiologic Sciences and RICK friends at RICK, whose generous help and sincere encouragement motivated me to go ahead for further study, to my husband Hamed Abdallah Ismail, our sons Mohammed and Mohaned my daughters Mawahib and Malaz those who are sincerely pray for my success.

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Abstract

The aim of this work was to study the using gamma irradiation technique to manage polymer waste in Sudan- Khartoum during period from 2012 to 2016. The plastic waste was collected randomly from the environmental and differentiated according to color then packed and compressed to be in a bulk form with a diameter of 5*5 cm and thickness of 6 cm and sand witted between 0.5cm of buildup material, then the samples were irradiated at different doses in range of 0 - 800 kGy at room temperature using Co⁶⁰ gamma cell model 220 with dose rate of 6.05Gy/min, then the sample was characterized using Hounsfield Tensometer ASTM D412, compression set machine Zwick Roell E Type, Hardness machine A Durometer Type Zwick Roell. The γ -irradiation of polymer plastic and rubber led to remarkable changes in the mechanical properties of the material due to chain scission and cross-linking activities. These changes result in the mechanical properties such as the compression set, elongation at break, hardness, elastic modulus and strength. It was observed that the polymer compression, hardness, elastic modulus and strength were increases as radiation doses increases. Likewise,

there were decreased in polymer elongation as dose increases. It was concluded that irradiation rate is an important parameter and it is well known that the irradiation rate lead different effects for the same polymer with equal amount of total absorbed dose. If the irradiations are made open to the atmosphere, the diffusion limited oxidation became a critical factor for the radiation-induced effects on the polymers.

المستخلص

الهدف من هذه الدراسة معالجة النفايات البوليمرية باستخدام تقنية التشعيع باشعة قاما في السودان - الخرطوم خلال الفترة من 2012 إلى 2016 وذلك للحد من الاثار الصحية والبيئية الضارة لنفايات البوليمر. تم جمع النفايات البلاستيكية عشوائيا من البيئة علي حسب لونها ثم تشكيلها وضغطها لتكون في شكل مكعب يبلغ طوله 5 * 5 سم وسمكه 6 سم , تم تشعيع العينات بجرعات اشعاعيه مختلفة من 0-800 كيلو قرأى من اشعة قاما في درجة حرارة الغرفة باستخدام Co-60 gamma cell موديل 220, بمعدل جرعة 6.05قري / دقيقة، تمت دراسة العينات باستخدام مقياس هاونسفيلد ASTM D412، مجموعة ضغط آلة زويك نوع Roell E ، مقياس التحمل نوع زويك Roell. نستطيع ان نقول ان تشعيع قاما للبوليمرات البلاستيكية والمطاطية ادي لتغيرات ملحوظة في الخواص الميكانيكية للمواد بسبب انفصال سلسلة الربط. هذه التغيرات نتيجة لتغير الخواص الميكانيكية مثل الضغط، والاستطالة ، والصلابة، ومعامل المرونة، وقوة الشد . ولوحظ من خلال هذه الدراسة أن ضغط البوليمر، والصلابة، ومعامل المرونة وقوة الشد كانت تزيد مع زيادة الجرعات الإشعاعية. وبالمثل، لوحظ هناك انخفاض في استطالة البوليمر مع زيادة الجرعة. وخلص إلى أن معدل الإشعاع هو معيار مهم لدراسة الخواص الميكانيكية للبوليمر ومن المعروف جيدا أن معدل الإشعاع يؤدي تأثيرات مختلفة لنفس البوليمر مع كمية مساوية من مجموع الجرعة الممتصة. إذا تم إجراء التشعيع في درجة حرارة الغرفة.

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List of Abbreviations

BBPIB:	Bis(t-butylperoxy isopropyl)benzene
CS:	Compression Set
DMA:	Dynamic Mechanical Analysis
D _{ri} :	Initial dose rate
DSC:	Differential scanning calorimetry
E:	Elastic modulus
ENB:	Ethylidene norbornene
EPDM:	Ethylene propylene diene ter-polymer
FTIR:	Fourier Transform Infrared Spectroscopy

Gy:	Gray
HDR:	High dose rate
k:	Decay constant
LDR:	Low dose rate
NBR:	Acrylonitrile butadiene rubber
PBEH:	Poly(bisphenol-a-epichlorohydrin)
PCU:	Poly(carbonate urethane)
PMMA:	Poly(methyl methacrylate)
PVC:	polyvinyl chloride
SEM:	Scanning Electron Microscopy
TD:	Total dose
TGA:	Thermal gravimetric analysis
TGA-FTIR:	Thermogravimetric Analysis Fourier Transform Infrared
TS:	Tensile strength
XRD:	X-Ray Diffraction Analysis