UNIVERSITI PUTRA MALAYSIA

RADIATION – INDUCED POLYMERIZATION OF POLYMETHACRYLIC GEL FOR DOSIMETRY

ISKANDAR SHAHRIM MUSTAFA

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RADIATION-INDUCED POLYMERIZATION OF POLYMETHACRYLIC GEL FOR DOSIMETRY

By

ISKANDAR SHAHRIM MUSTAFA

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

March 2006

To:

My beloved mom, Siti Ishah bt Md. Hanafi

Thanks for the encouragement, love and support in fulfilling my endeavour…

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

RADIATION-INDUCED POLYMERIZATION OF POLYMETHACRYLIC GEL FOR DOSIMETRY

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ISKANDAR SHAHRIM MUSTAFA

March 2006

Chairman : Associate Professor Elias Saion, PhD

Faculty : Science

The aim of the present work is to investigate the effect of radiation on methacrylic acid (MAA) crosslinked with N, N'-methylene-bisacrylamide (BIS) for the purpose of developing a polymer gel dosimeter, namely, polymethacrylic gel (PMAAG). PMAAG of different concentrations of MAA and BIS were irradiated with the absorbed doses ranging from 0 Gy to 19 Gy. Using Raman spectrophotometer, five peak intensities were identified and represents the assigned bonding for C=C (2238 cm^{-1}) of MAA, C=C (1634 cm^{-1}) of BIS, C-C (2110 cm^{-1}) of PMAA, C=O (1795 cm^{-1}) of PMAA, CH_2 (2905 cm^{-1}) of PMAA, which have strong modes of vibration in the band positions. The Raman peak intensity y as a function of absorbed dose D was found to have a

monoexponential expression in the form; $y = y_0 + A\left(1 - e^{-D/D_0}\right)$. The dose sensitivity D_0 and half dose $D_{1/2}$ were obtained and found to increase with the concentrations of MAA monomer and BIS crosslinker. The dose correlation factor of BIS, k_{BIS} is always higher than k_{MAA} of MAA ($k_{BIS} > k_{MAA}$) for all C-C, C=C, C=O and CH_2 stretching modes, indicating BIS is a very significant parameter in the polymerization process. Additionally, a Nuclear magnetic resonance (NMR) spectrometer was used in order to measure the relaxation time of polymethacrylic (PMAA) gel dosimeters. The relaxation rate (ΔR_2) dose sensitivity value (12.5 $\pm$ 0.1 Gy) of MAA monomer by Lepage, et al 2001 is comparable with PMAAG experimental value gained which are 12.6 $\pm$ 0.1 Gy. A comparison between and indirect measurements of polymer formed along with consumptions of monomer and crosslinker are also obtained from this experimental work. Finally, a UV-Vis spectrophotometer was used to records PMAAG degree of absorption in order to determine the accuracy of PMAAG. The PMAAG has a mean value of absorption of 0.614 at 375 nm. The dose derived from PMAAG is comparable to Fricke dosimeter and ionization chamber readings between 4.7 ± 0.1% and 11.6 ± 0.1%. The dose errors of less than 10 ± 0.1% are considered acceptable in radiation processing, an improvement of accuracy less than 5.0 ± 0.1% is acceptable in radiotherapy.

Abstrak tesis ini yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

RADIASI MENGARUH PEMPOLIMERAN GEL POLIMETAKRILIK UNTUK DOSIMETRI

Oleh

ISKANDAR SHAHRIM MUSTAFA

Mac 2006

Pengerusi : Professor Madya Elias Saion, PhD

Fakulti : Sains

Matlamat kajian pada masa ini adalah untuk menyiasat kesan terhadap asid metakrilik (MAA) yang bertaut-silang dengan "N,N'-methylene-bisacrylamide" (BIS) dengan tujuan untuk pembangunan meterdos gel polimer, gel polimetakrilik (PMAAG). PMAAG dengan berlainan kepekatan MAA dan BIS disinarkan dengan dos terserap dari 0 Gy hingga 19 Gy. Dengan menggunakan spektrofotometer Raman, keamatan lima puncak dikenalpasti dan mewakili ikatan terhadap C=C (2238 cm^{-1}) dari MAA, C=C (1634 cm^{-1}) dari BIS, C-C (2110 cm^{-1}) dari PMAA, C=O (1795 cm^{-1}) dari PMAA, CH_2 (2905 cm^{-1}) dari PMAA, yang mempunyai getaran mod kuat di dalam kedudukan ikatan. Keamatan puncak Raman y sebagai fungsi dos terserap D didapati mempunyai ungkapan monoeksponen dalam bentuk

$y = y_0 + A\left(1 - e^{-D/D_0}\right)$. Kepekatan dos D_0 dan dos separa $D_{1/2}$ diperolehi dan didapati meningkat dengan kepekatan monomer MAA dan taut-silang BIS. Faktor sekaitan dos dari BIS, k_{BIS} sentiasa lebih tinggi daripada k_{MAA} dari MAA ($k_{BIS} > k_{MAA}$) untuk semua mod regangan C-C, C=C, C=O dan CH_2, menunjukkan BIS adalah parameter yang sangat bererti di dalam proses pempolimeran. Secara tambahan, sebuah spektrometer salunan magnet nuklear (NMR) telah digunakan, bertujuan untuk mengukur masa santaian meterdos gel polimetakrilik (PMAA). Nilai kepekaan dos (12.5 ± 0.1 Gy) kadar santaian (ΔR_2) dari monomer MAA oleh Lepage, et al 2001 adalah setanding dengan nilai yang diperoleh dari uji kaji PMAAG iaitu 12.6 ± 0.1 Gy). Perbandingan antara pengukuran langsung dengan tidak langsung pembentukan polimer dengan penggunaan monomer dan taut-silang juga diperolehi dari kerja uji kaji ini. Akhirnya, sebuah spektrofotometer UV-Vis digunakan untuk merekod darjah serapan PMAAG untuk mengenalpasti ketepatan PMAAG. PMAAG mempunyai nilai penyerapan min 0.614 pd 375 nm. Dos yang diperoleh dari PMAAG adalah setanding dengan bacaan meterdos Fricke dan kebuk pengionan di antara 4.7 ± 0.1% dan 11.6 ± 0.1%. ralat dos yang kurang daripada 10.0 ± 0.1% adalah dipertimbangkan kebolehterimaan di dalam pemprosesan sinaran, pembaikan ketepatan kurang dari 5.0 ± 0.1% adalah boleh diterima di dalam radioterapi.

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I certified that an Examination Committee has met on 16th March 2006 to conduct the final examination of Iskandar Shahrim bin Mustafa on his Master of Science thesis entitled "Radiation-Induced Polymerization of Polymethacrylic Gel for Dosimetry" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledge. I also declare that it has not been previously of concurrently submitted for any other degree at UPM or other institutions.

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ISKANDAR SHAHRIM MUSTAFA

Date:

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LIST OF ABBREVIATIONS/SYMBOL

γ-ray	Gamma Ray
BIS	N, N'-methylene-bisacrylamide
MAA	methacrylic acid
PMAAG	polymethacrylic gel
Gy	Gray
MINT	Malaysian Institute for Nuclear Technology Research
IAEA	International Atomic Energy Research
NMR	Nuclear Magnetic Resonance
UV-Vis	Ultraviolet - Visible
T_1	Spin-lattice relaxation time
T_2	Spin-spin relaxation time
R_1	Spin-lattice relaxation rate
R_2	Spin-spin relaxation rate
N_A	6.022×10^{23} mol^{-1} (Avogadro's number)
ΔA	the change in absorbance at peaks
ρ	the density of the dosimetry solution
ε	molar extinction coefficient
ζ	temperature coefficient of the molar extinction coefficient
G	G-value of the radiation yield, which is valid for electrons or photons of energy 0.5 to 16 MeV at absorbed dose rates $< 2 \times 10^7$ Gy/s.