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Development and Evaluation of Surface Modified Poly (lactic acid) Microsphere via Irradiation Techniques for Drug Delivery System

Z.H.A. Ninaya[a,b], Z.A Abdul Hamid[a*], Z. Ahmad[a], M. Jaafar[a], B. H Yahaya[c]

[a]*School of Material and Mineral Resources Engineering, Universiti Sains Malaysia, Pulau Pinang 14300 , Malaysia*
[b]*Medical Device Authority, Putrajaya 62675, Malaysia*
[c]*Cluster for Regenerative Medicine, Advance Medical and Dental Institute, Universiti Sains Malaysia, Pulau Pinang 13200, Malaysia*

Abstract

Poly (lactic acid) (PLA) has been used in medical field because it is biocompatible, biodegradable and has good mechanical properties. However, its surface characteristic which is hydrophobic and chemically inert is not suitable as a carrier in drug delivery system. Purpose of this study is to modify and improve PLA microspheres surface by grafting hydrophilic monomers onto its surface via irradiation techniques. Two sets of PLA microspheres with and without hydrophilic monomers were irradiated using high energy irradiations which are electron beam and Gamma (γ) rays respectively. Although dose used in irradiating samples were same for both electron beam and γ-rays, but the dose rate were different where electron beam has the higher dose rate. Free radicals will be formed when a matter is irradiated with ionising radiation and these radicals will interact with monomers and initiate grafting. Three hydrophilic monomers were used in this study i.e. Acrylic Acid (AA), Acrylamide and Maleic Anhydride (MAH). Surface modified PLA microspheres were characterised using Fourier Transform Infrared (FTIR) and Scanning Electron Microscopy (SEM). PLA microspheres surface were successfully modified and grafted with selected monomers and confirmed by FTIR results. The degrees of grafting were found to be dependent on irradiation dose and dose rate of irradiation as well as monomer used in the grafting. SEM shows surface of PLA microsphere after surface modification is rougher compared to before surface modification.

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* Corresponding author. Tel.: +6-045-995-999; fax: +6-045-941-011.
Email address: srzuratulain@usm.my

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1. Introduction

Drug delivery refers to approaches, formulation, technologies and systems for transporting a pharmaceutical compound in the body as needed in a safe manner to achieve its therapeutic effect[1].

The challenge has been on three fronts: finding the proper target for a particular disease state; finding a drug that effectively treats this disease; and finding a means of carrying the drug in a stable form to specific sites while avoiding the immunogenic and nonspecific interactions that efficiently clear foreign material from the body.

PLA has been used in medical field quite sometimes and has gained FDA approval because it is biocompatible, biodegradable and has good mechanical properties[2]. However, it surface characteristics which is hydrophobic and lack of readily reactable[3] side-chain groups is not suitable to be used in drug delivery system. Thus, pure PLA may cause a mild inflammatory response if it is implanted into human tissues[2]. Therefore, surface modification strategies will be developed to modified PLA surface chemical functionalities[3], hydrophilicity, roughness, surface energy and topography.

There are different techniques that are used to modify its surface chemical functionalities, hydrophilicity, roughness, surface energy and topography such as surface coating, entrapment, plasma treatment, laser, irradiation and chemical[4]. Amongst all techniques, irradiation is one of the least techniques that are being studied.

Radiation is often categorised as ionising or non-ionising depending on the energy of the irradiated particles. Ionising radiation is able to ionise atom and molecules and break chemical bonds while the energy of non-ionising radiation is not enough to ionise atom and molecules[4]. Radiation can initiate chemical reaction of any material without the use of initiator[5, 6] and catalysts[5]. The irradiation of polymeric materials with high energy radiation will caused the emergence of very reactive intermediates or radicals[7] which rearrangements and/or formation of new bonds may be occurred and eventually oxidized products, grafts, scission of main chains (degradation) or cross-linking will be formed[7]. This process is illustrated in Fig. 1. Radiation sources that are used in this study are electron beam and γ-rays from Cobalt-60. Although both radiations are in the same ionising radiation category, there are differences with regards to penetration and dose rate[8]. γ-rays will give deep penetration into a material but at slow rate and electron beam will give less penetration has higher dose rate[9].

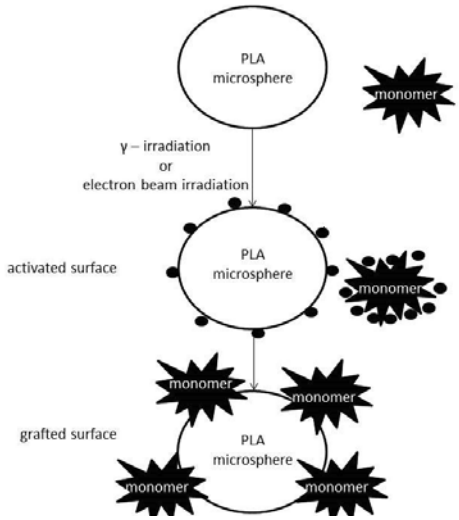

Fig. 1. General scheme proposed in surface modified PLA microsphere