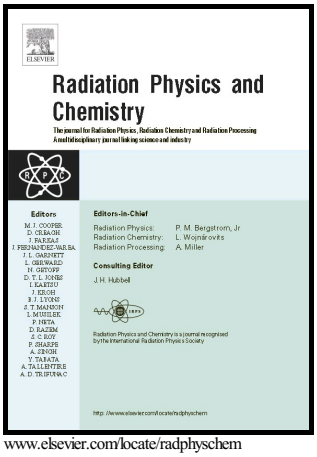
Author's Accepted Manuscript



www.elsevier.com/locate/radphyschem

Gamma Radiation Effects On Random Copolymers Based On Poly(Butylene Succinate) For Packaging Applications

M. Negrin, E. Macerata, G. Consolati, F. Quasso, L. Genovese, M. Soccio, M. Giola, N. Lotti, A. Munari, M. Mariani

PII: S0969-806X(16)30585-0
DOI: http://dx.doi.org/10.1016/j.radphyschem.2017.05.011
Reference: RPC7540

To appear in: *Radiation Physics and Chemistry*

Received date: 2 November 2016
Revised date: 4 May 2017
Accepted date: 12 May 2017

Cite this article as: M. Negrin, E. Macerata, G. Consolati, F. Quasso, L Genovese, M. Soccio, M. Giola, N. Lotti, A. Munari and M. Mariani, Gamma Radiation Effects On Random Copolymers Based On Poly(Butylene Succinate For Packaging Applications, *Radiation Physics and Chemistry* http://dx.doi.org/10.1016/j.radphyschem.2017.05.011

Gamma Radiation Effects On Random Copolymers Based On Poly(Butylene Succinate) For Packaging Applications

M. Negrin[1]*, E. Macerata[1], G. Consolati[2], F. Quasso[2], L. Genovese[3], M. Soccio[3], M. Giola[1], N. Lotti[3], A. Munari[3], M. Mariani[1]

[1] Department of Energy, Politecnico di Milano, Piazza L. da Vinci, 32, 20133 Milano, Italy.
[2] Department of Aerospace Science and Technology, Politecnico di Milano, Piazza L. da Vinci, 32, 20133 Milano, Italy.
[3] Department of Civil, Chemical, Environmental and Materials Engineering, Università di Bologna, Viale Risorgimento 2, 40136 Bologna, Italy.

*Corresponding author. Tel.: +39 2399 6395. E-mail address: maddalena.negrin@polimi.it

Abstract

Within the context of new bioplastic materials, poly(butylene succinate) (PBS) and four novel poly(butylene/thiodiethylene succinate) random copolymers (PBS-PTDGS), in sheets as well as in films, were exposed to gamma radiation, in air and in water, and their behaviour along with the effect on their biodegradability was investigated. The molecular weight data obtained from Gel Permeation Chromatography indicate that the sensibility to radiation increases with the amount of sulphur-containing co-unit (TDGS). At 200 kGy the average molecular weight of PBS film halves, while for P(BS60TDGS40) the residual molecular weight is about 20%. The calculated intermolecular crosslink G_x and scissioning G_s yields confirmed that degradation is predominant over crosslink for all the aliphatic systems. As shown by thermal analyses, gamma radiation affects the thermal properties, leading to an increased crystallinity of the systems, remarkable for PBS, and lower decomposition temperatures. Variations of crystallinity with the increasing absorbed dose were confirmed also by PALS analyses. Water contact angle measurements revealed post-irradiation wettability alterations that could positively affect polymer biodegradability. In particular, when irradiated in water at 100 kGy PBS film exhibits a water contact angle decrease of about 17%, indicating an enhanced wettability. After degradation in compost, changes in the surface morphology were observed by means of SEM and sample weight losses were determined, at different extent, according to the irradiation environment. Interestingly, after 52 days in compost PBS films, both pristine and irradiated in air at 25 kGy, showed a residual weight of about 60%, while the ones irradiated in water at 25 kGy of about 44%. Experimental data confirmed that gamma irradiation could represent a viable treatment to enhance biodegradation in compost of PBS and PBS-based copolymers.

Keywords

Poly(butylene succinate), biodegradable polymers, PBS copolymers, degradation in compost, gamma irradiation, radiation-induced modifications.

1. Introduction

During the last 60 years, polymers have started to substitute natural materials in every aspect of life. Their outstanding properties have led them to find many uses in areas as diverse as household appliances, packaging, construction, medicine, electronics, automotive and aerospace components (Hamad et al., 2013). More than one third of plastic production involves disposable materials, which become wastes within one year from manufacture. The increasing plastic pollution issue, due to the extremely long durability of the traditional fossil-based plastic, has risen the necessity to substitute materials with biodegradable ones and to optimize the use and disposal of conventional plastic. Among the class of new biodegradable polymers, poly(Butylene Succinate) (PBS), polycaprolactone (PCL) and poly(Lactic Acid) (PLA) have attracted considerable interest, due to their economically competitiveness. In particular, PBS is an aliphatic biodegradable polymer commercially available since 1993, under the trade name of Bionolle® (Showa Denko). It is characterized by interesting physical and mechanical properties, good processability and biodegradability (Ichikawa and Mizukoshi, 2012). Recently, great efforts have been made to tailor its properties and many works have been published on PBS-based copolymers and composites for different kinds of applications (Gigli et al., 2016; Soccio et al. 2012; Siracusa et al, 2015; Jamaluddin et al. 2016; Supthanyakul et al. 2016; Bautista et al. 2016). In particular, the