Radiation Physics and Chemistry 110 (2015) 67–71

Contents lists available at ScienceDirect

Radiation Physics and Chemistry

journal homepage: www.elsevier.com/locate/radphyschem

Short Communication

The effect of gamma irradiation on the fluorescence properties of 1,4,5,8-naphtalisoimides

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HIGHLIGHTS

- The fluorescence intensity of γ irradiated naphtalisoimides is subject to change.
- These changes occur in three phases: increase, stabilisation. and decrease.
- E–Z structural isomerisation causes the greatest increase in fluorescence intensity.

ARTICLE INFO

Article history:
Received 27 December 2014
Received in revised form
16 January 2015
Accepted 21 January 2015
Available online 22 January 2015

Keywords:
Naphtalisoimides
E–Z-isomers
Absorbed dose
Isomerisation

ABSTRACT

The subject of our investigation was the intensity of the fluorescence of 1,4,5,8-naphtalisoimides subjected to gamma radiation (the absorbed doses were 242 Gy, 1 kGy and 2.242 kGy). Dynamic changes of fluorescence intensity have been observed; the greatest relative increase of fluorescence intensity (and simultaneously, the least durable increase) occurs as a result of structural isomerisation.

1. Introduction

It has been shown (Hamel et al., 2008) that 1,8-naphtalimides can work as liquid scintillators of gamma radiation. Because of their possible uses as new cytotoxic agents (Brana and Ramos, 2001; Constantinova et al., 2003; Li et al., 2011; Grzesiak and Brycki, 2012), it is necessary to investigate the influence of irradiation on their properties, particularly on fluorescence (Noel et al., 2006). As a result of ionisation, some reactions in polymers, such as synthesis, degradation, modification, chain scission, oxidation and cross-linking, occur. Photo- (He et al., 2014; Bushan et al., 2001), electron beam irradiation- (Verma et al., 2012) and gamma irradiation-induced (Arkinar et al., 1994; Kozuma et al., 2002) structural isomerisation have been studied extensively, and this article cites just several of the many papers that have appeared on this subject. We have verified whether gamma irradiation may have caused structural isomerisation of the studied samples. In our earlier paper (Mazurak et al., 2015), we presented the fluorescence properties of several 1,4,5,8-nahthalisoimides, particularly fluorescence decay curve analysis. All chemical, NMR, UV–vis, FTIR, and fluorescence results for these samples are shown in our earlier paper (Mazurak et al., 2015). This article uses the same numbering order of the samples as our previous paper.

2. Experimental

NMR analysis: A Bruker Avance II 600 MHz spectrometer was used. $CDCl_3$-3d was used as a solvent. As for the analysis and digital preparation of the NMR spectra, ACDLabs 12.0, 1 D NMR Processor software was used for the stretching and enlarging of the most important parts of the spectra. A Varian VXR-300 (300 MHz) spectrometer and a DMSO–d6 solvent were used in an auxiliary experiment demonstrating the location of the acid proton. The isomer composition of all studied samples – natural and

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http://dx.doi.org/10.1016/j.radphyschem.2015.01.023
0969-806X/

Table 1
The contents of Z- and E-isomers for natural and radiated samples (*).

Sample	Σ Z	Σ E	1,5-Z	1,4-Z	1,5-E	1,4-E
142 n.p.	62.9	37.1	35.2	27.7	37.0	0.0
142* n.p.	73.6	26.4	73.6	0.0	26.4	0.0
166 n.p.	33.1	66.9	27.4	5.7	33.0	33.9
166* n.p.	42.6	57.4	42.6	0.0	23.5	33.9
173 w.p.	35.8	64.2	28.9	6.9	30.5	33.7
173* n.p.	37.1	62.9	37.1	0.0	29.2	33.7
183 p.	0.0	100.0	0.0	0.0	98.3	1.7
183* n.p.	0.0	100.0	0.0	0.0	100.0	0.0
185 n.p.	45.9	54.1	38.5	8.1	24.2	29.2
185* n.p.	60.8	39.2	60.8	0.0	10.0	29.2
186 w.p.	31.6	68.4	26.2	6.5	29.2	38.1
186* n.p.	35.0	65.0	35.0	0	26.9	38.1
187 n.p.	41.6	58.4	33.3	8.3	30.0	28.4
187* n.p.	45.0	55.0	45.0	0.0	26.6	28.4

irradiated – is included in Table 1. The chemical structures of E- and Z-isomers are presented in Fig. 1.

Fluorescence steady-time measurements: They were performed using a Jobin-Yvon (SPEX) spectrofluorimeter FLUORLOG 3–12 at room temperature using a 450 W xenon lamp, a double-grating monochromator, and a Hamamatsu 928 photomultiplier. The wavelength range for emission and excitation spectra is 250–900 nm, and the resolution is no lower than 1 nm. The samples were prepared as a solution 1×10^{-4} mol/L in chloroform $CHCl_3$. The changes of the integral intensity of the studied samples are presented in Fig. 2 and Table 2.

2.1. Irradiation procedure

Samples no. 166, 173, 183, 185, 186 and 187 were gamma-irradiated (^{137}Cs). The irradiation was conducted in three series – 2 Gy, 40 Gy, and finally 200 Gy; therefore, the total absorbed dose by each sample was 242 Gy.

For sample 142, the absorbed dose was 1 kGy, and for sample 183-an additional 2 kGy (designated in Figs. 2 and 3 as sample no. 183 A) of X-ray radiation by using a Clinac TrueBeam linear

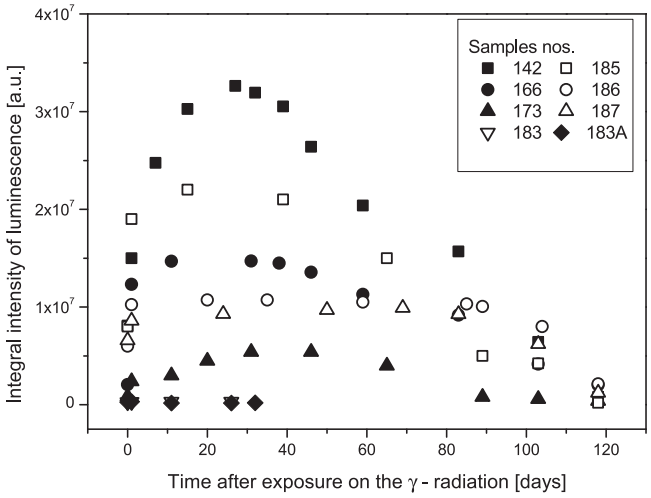

Fig. 2. The changes of the integral intensity of the irradiated samples over the 120 days immediately following irradiation.

medical accelerator dedicated to the standard radiotherapy.

All measurements and laboratory operations were performed at room temperature, and the samples were stored in room temperature.

3. Results and discussion

It has been observed that as a result of irradiation, the character of emission spectra and the position of the emission bands do not change. The only exception is sample 183 – after absorbing a heavy dose (2.242 kGy). The intensity of fluorescence of the irradiated samples was measured on the next day after the absorption of the whole radiation dose and several times afterwards (Fig. 2 and Table 2).

We have observed that the changes of fluorescence intensity occur in three distinct phases: **Phase 1**: The increase of

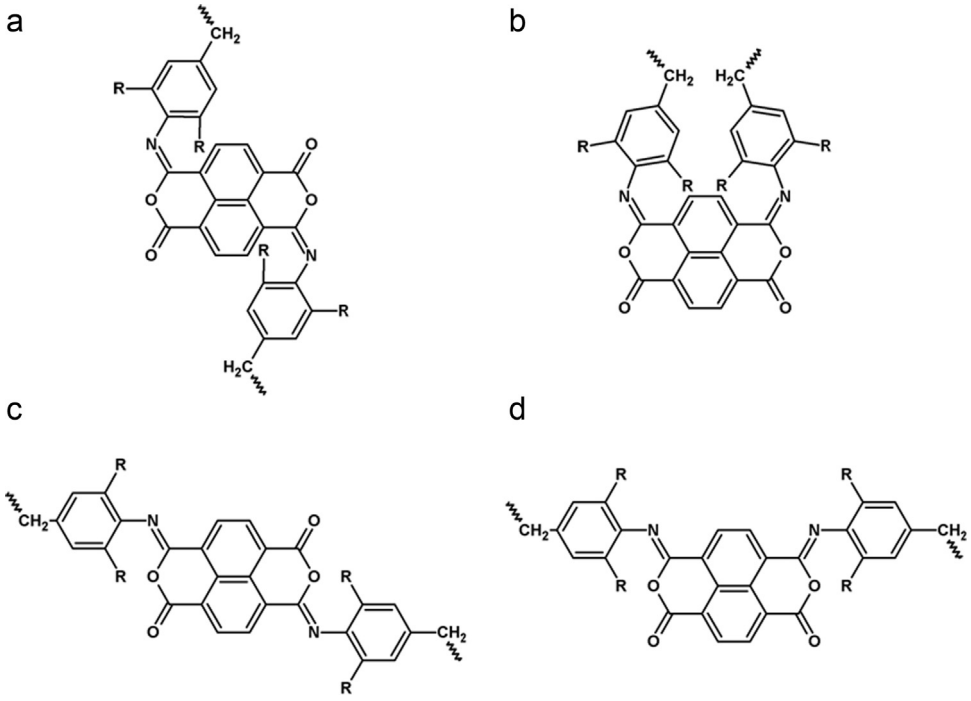

Fig. 1. The chemical structures of E- and Z-isomers: (a) 1,5-Z isomer; (b) 1,4-Z isomer; (c) 1,5-E isomer; and (d) 1,4-E isomer.