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Development of plastic scintillator with thermal polymerization

Tonguç Özdemir *1, Isıl Yıldırım 1

1Mersin University, Chemical Engineering Department, Mersin, Türkiye, tonguc.ozdemir@gmail.com, isilyldrm181@gmail.com

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Abstract

In this study, development of a lastic scintillator based on polystyrene and doped with 1,4-bis[2-(phenyloxazole)]-benzene (POP) and 2,5 diphenyloxazole (PPO) was produced using the thermal polymerization process is studied. Plastic scintillators are used for the detection of radiation and they are vital for the radiation safety and protection. Thermal polymerization was used and the monomer were used after removal of retarder via alumina. The scintillation was confirmed with the radiation detector.

Introduction

Plastic scintillators are homogeneous and amorphous materials containing scintillating substances (mostly organic fluorescent compounds) dissolved in a polymer matrix consisting of aromatic [1]. They convert the energy of the incoming ionizing radiation into visible or UV light [2].

The emission spectrum of the polymer matrix in the ultraviolet region (300-350 nm) does not fit the spectral sensitivity region of photodetectors (425 nm) and cannot be used as a scintillator due to low scintillation efficiency [3-4]. Therefore, scintillator additives are added into the polymer matrix.

Scintillator substances are generally divided into two groups primary and secondary scintillators. Primary scintillators are enabled to carry out two main functions that are (1) converting captured energy to light emission and (2) wavelength shifters. Since the light emission does not comply with the sensitivity of the photomultiplier tube (PMT), that is, the emission wavelength cannot reach the desired level (425 nm), the secondary scintillator (wavelength shifter) is inevitably added.

The studies conducted by Zaitseva et. al. that the maximum light output is obtained at relatively lower dye concentrations of about 1 wt% of 2,5-diphenyloxazole (PPO). The increasing of dye concentration above the optimum value can decrease the light output and also the fluorescence intensity due to the effect of concentration quenching [5].

Material and Method

Plastic scintillators were produced by thermal polymerization method in a mold. The plastic scintillator was prepared by using styrene as the polymer base matrix, 2,5-diphenyloxazole (PPO) as the primary scintillator and 1,4-bis[2-(phenyloxazolyl)]-benzene (POPOP) as the wavelength shifter or secondary scintillator.

The inhibitory substance contained in the styrene monomer was absorbed by activated alumina granules for the production of plastic scintillators. PPO content was up to 3% by weight and that of POPOP was 0.15% by weight were added to the purified styrene monomer. The resulting mixture was mixed continuously in a magnetic mixer for 6 hours and at a constant temperature of 40°C (Figure 1). The rotation speed was adjusted regularly depending on the viscosity of the mixture. When a homogeneous solution was obtained, it was placed in vacuum.

First, the air bubbles that were dissolved were removed. After that, the temperature of the oven was gradually increased to 120°C and kept constant for the polymerization reaction to occur. After the polymerization reaction was completed, the temperature was gradually cooled to prevent the formation of air bubbles that may occur inside the polystyrene material. Figure *2* shows the temperature profile during the polymerization process.

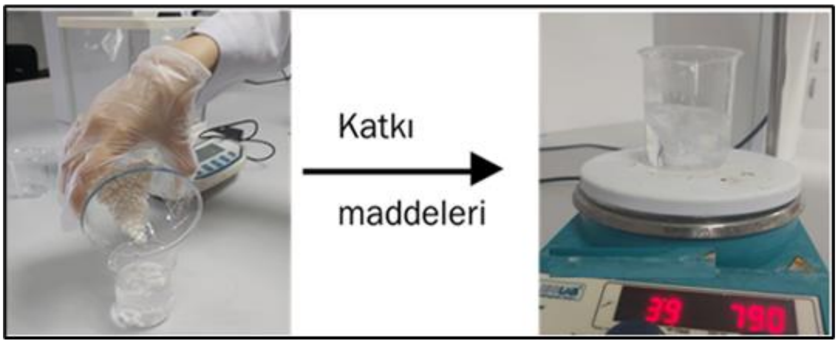


Figure 1. Dissolving additives.

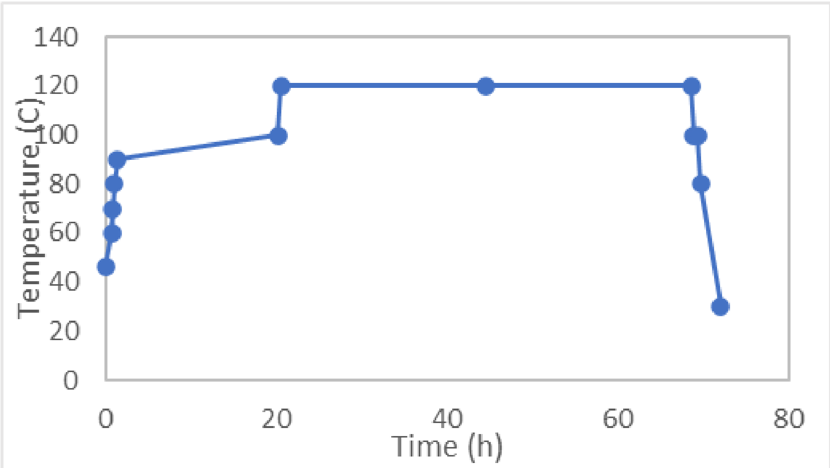
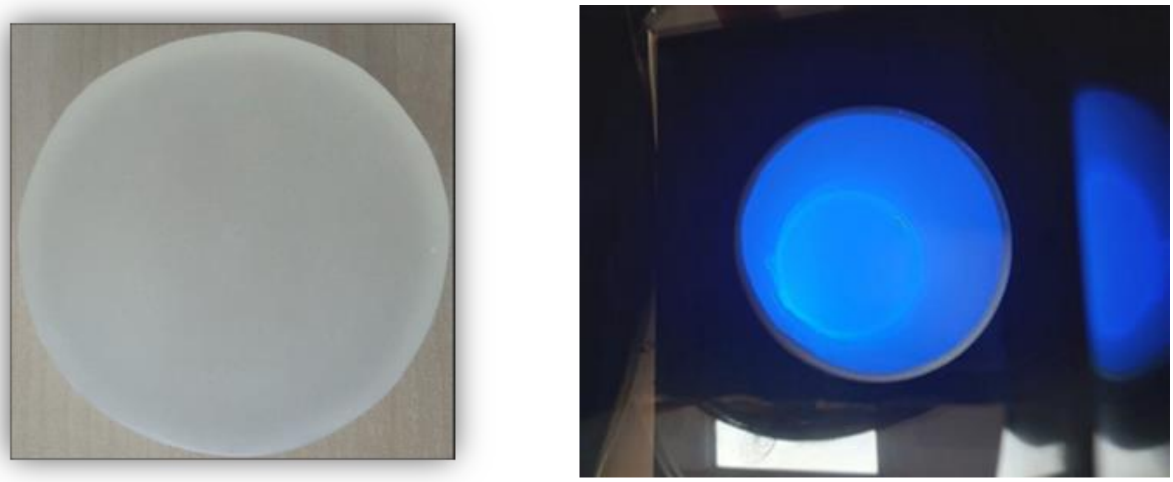


Figure 2. Temperature profile of the polymerization process.

Results and Discussion

Photographs of the produced polystyrene-based plastic scintillator taken under white and UV light are shown in **Figure 1**Figure 3(a) and 3(b). When these plastic scintillators are excited with UV, the blue color could be seen. In the secondary scintillator, it absorbs the light emitted by the primary scintillator and consequently produces photons in the visible range. As a result of the production process, scintillation under UV is performed using plastic scintillators.



(a) (b)

Figure 3. Polystyrene based plastic scintillator under white (a) and UV illumination (b) (color online).

Conclusion

Plastic scintillator with thermal polymerization with a unique thermal history has been developed. The scintillation of the materials was observed via the UV. The scintillator could be used for the detection of radioactivity.

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