Polymer Testing 93 (2021) 106929

Contents lists available at ScienceDirect

Polymer Testing

journal homepage: http://www.elsevier.com/locate/polytest

Lifetime estimation of epoxy based composite materials on irradiating with gamma radiation for shielding applications

Mamta Saiyad [a,*], N.M. Devashrayee [b]

[a] *Chemical Engineering Department, Institute of Technology, Nirma University, India*
[b] *VLSI Technology, EC Department, Institute of Technology, Nirma University, India*

A R T I C L E   I N F O

Keywords:
Lifetime estimation
Epoxy composites
Gamma radiation
Decomposition kinetics
Thermogravimetric analysis

A B S T R A C T

The extensive application of polymer composites in the ionizing radiation conditions leads to durability issues where performance for a long run under the radiation environment is related. For the products, such as space applications; it is expected to have about 20 to 30 years of durability. In the case of polymer composites, the reactive intermediates like free radicals present in the polymers are capable of initiating chemical reactions resulting in scission and cross-linking on irradiation. It may result in the failure of material under the application. In the current work, polymer composites are developed to withstand such chemical reactions prepared by using different fillers and stabilizers and carried out decomposition studies to predict the stability of developed materials under ionizing radiation conditions. The lifetime is estimated by studying decomposition kinetics. The lifetime estimated for all developed samples is found around 20 to 45 years at 50 °C which is desired for a device under the nuclear environment.

1. Introduction

1.1. Objective

The extensive application of composites in the ionizing environment leads to durability issues where performance for a long run under the radiation environment is related. For applications, such as space, in a radiation environment, it is expected to have about 20 to 30 years of durability. The present work intends to carry out decomposition studies [1–3] to predict the stability of developed composites prepared by using modified epoxy with different fillers and stabilizers. Details of the preparation of such composites with different stabilizers and fillers are given in the following sections. The results are used to estimate approximate lifetime by assessing the relative stabilities of these developed composites likely to be used under gamma radiation conditions.

1.2. Introduction

Product lifetime is the desired quality to be specified for newly developed polymer or composite materials, along with other quality assurance. It is going to be even more important for situations where onsite inspection is not feasible or chances of failure during the severe operating conditions. Traditionally for such products, based on the previous experiments and experience, life expectancy is used to predict. Understanding failure mechanisms at the micro-level and predicting long term performance or use under critical applications require a far better understanding of failure mechanisms to predict the life of the material using decomposition conditions. This method is useful for reliable lifetime predictions to be made.

Various types of radiations like x-rays, gamma rays, neutrons, alpha particles, and beta particles are ionizing radiations. On irradiating such rays, free radical forms degrade the polymer. Free radicals generated by ionization are highly reactive and it results in scission as well as cross-linking reactions. Free radicals, which are present in the material after irradiation, are responsible for changes in properties for a long time after exposure [4,5]. Near the earth's surface, the intensity of the radiation waves is not very high due to which polymer behavior may not change significantly. Hence radiation exposure tests are required only in applications where high radiation sources are in use, like nuclear plants; space applications; defense applications, etc [6].

Looking at the above conditions it is critically important to

Abbreviations: HALS, Hindered amine Light stabilizer; UV, Ultra Violet; TVP, Trivalent Phosphate; BNNP, Boron nitrided nanopowder.

* Corresponding author.
E-mail address: mamta.saiyad@nirmauni.ac.in (M. Saiyad).

https://doi.org/10.1016/j.polymertesting.2020.106929
Received 25 June 2020; Received in revised form 6 October 2020; Accepted 22 October 2020
Available online 5 November 2020