Polymer Degradation and Stability 184 (2021) 109476

Contents lists available at ScienceDirect

Polymer Degradation and Stability

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

Accelerated Photodegradation of Solid Phase Polystyrene by Nano TiO_2-Graphene Oxide Composite under Ultraviolet radiation

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ARTICLE INFO

Article history:
Received 16 January 2020
Revised 25 September 2020
Accepted 29 December 2020
Available online 31 December 2020

Keywords:
Nano TiO_2-GO composite
Hydrothermal method
Polystyrene
UV radiation
photodegradation
Chain scission

ABSTRACT

Nano TiO_2-graphene oxide (TiO_2-GO) composites with varying weight percentages of GO were successfully developed by ultrasonication assisted hydrothermal approach and characterised. HRTEM analysis revealed that the GO sheets associated with TiO_2 have broken down into nano dimensions. Photodegradation of polystyrene (PS), PS-TiO_2 and PS-TiO_2-GO composites were studied under UV irradiation of wavelength 253 nm. Nano TiO_2-GO loaded solid phase polystyrene (PS) underwent an accelerated photodegradation compared to Pristine PS and PS-TiO_2 composite as evident from various monitoring techniques. Gel permeation chromatography (GPC) revealed that the degradation proceeded through random chain scissions decreasing the average molecular weights. PS and PS composites followed the mechanism of photo oxidative degradation as evident from FTIR. Maximum degradation percentage was observed in PS-TiO_2-30%GO compared to the other specimens under study. Mechanical properties including tensile and flexural strengths which were found to be higher for the PS composites compared to pristine PS, decreased appreciably upon UV irradiation due to deterioration of polymer chain. Dielectric strength of the PS composites also decreased as a consequence of photodegradation revealing the formation of charge centers within the polymer chain. Dielectric permittivity of the polymer specimens under study increased upon UV irradiation suggesting the formation of more polar centers. The improved thermal stability of PS composites compared to pristine PS decreased due to photodegradation of the polymer chain. The glass transition temperature (Tg) and decomposition temperature lowered as a consequence of chain scission of polymer specimens caused by photodegradation. Photocatalytic activity of nano TiO_2 was enhanced upon its surface modification using GO for the photodegradation of PS under UV radiation.

1. Introduction

Increased consumption of plastic commodities worldwide has led to a steep rise in the total amount of plastic debris. The uncontrollable spread of plastic wastes which have adverse effects on the environment has become one of the primary concerns of most of the countries. Only a very few percentage of plastic debris are being recycled or incinerated. Incineration of plastics further produces several hazardous secondary side products [1]. Most of plastic debris ends up in land filling. The objective of our work is to demolish such plastic debris without much environmental issues.

Polystyrene (PS) - one of the most widely used plastic was chosen for our investigation. PS undergoes degradation when exposed to sunlight [2]. The process – termed as photodegradation deteriorates the polymer rendering it as a useless material with degraded properties. Chain scission, mass loss, brittleness etc. are consequences of photodegradation [3,4]. The process of photodegradation is however quiet slow and depends upon the intensity of UV radiation to which the plastic is exposed. Studies have shown that the rate of photodegradation could be enhanced by the aid of various photocatalysts loaded into the PS matrix [5].

Transition metal oxide semiconductors exhibit appreciable photocatalytic activity for the degradation of PS. Nano TiO_2 (anatase phase) was found to be the best out of other metal oxide photocatalysts due to its high efficiency, nontoxicity, photostability, cheapness, reusability and easy synthetic approach. TiO_2 absorbs UV radiations from the sunlight as its optical band gap energy range between 3.2-3.5 eV (depending upon the particle size) [6]. Electron- hole pair generated upon interaction of TiO_2 with UV light further interacts with adsorbed oxygen, water and hydroxyl groups (-OH) to produce various active species which are trans-

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https://doi.org/10.1016/j.polymdegradstab.2020.109476
0141-3910/