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EPDM recycling assisted by γ-processing

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Abstract The integration of waste ethylene–propylene–diene terpolymer (EPDM), containing carbon black into pristine EPDM can be achieved by γ-irradiation as a versatile procedure to process ethylene–propylene elastomers. The presence of acrylic acid in the material formulation allows the formation of intermolecular bridges by threefold increase in gel content. The possibility of achieving greater stability by the addition of acrylic acid in EPDM systems was analyzed. The start materials were EPDM containing 30 and 50 phr of EPDM powder loaded with 40 phr of carbon black aged by pre-exposure to electron beam irradiation. The advanced γ-irradiation exceeding 100 kGy represented the optimal radiation processing condition. Two procedures of chemiluminescence under isothermal and non-isothermal regimes for the evaluation of radiation stability were applied on γ-irradiated samples. The thermal strength of irradiated samples was characterized based on the radiolysis mechanism of EPDM. The variation in the activation energy required for the thermal oxidation of these samples and the modification in gel contents due to the gelation action of acrylic acid were presented for the validation of proposed recycling radiochemical technique. Charlesby–Pinner representation provided different values for the ratios between radiochemical yields of cross-linking and scission, proving that the presence of acrylic acid promoted the conversion of EPDM wastes into valuable materials.

Keywords EPDM · Radiation compatibilization · Recycling

Introduction

The recycling process through which the waste materials are reclaimed to achieve an economically feasible route allows the recycling of polymer materials under various formulations [1]. The classical compatibilization of two polymers becomes effective under the thermodynamic conditions of miscibility and follows Flory–Huggins relationship [2]. Several examples of polymer mixtures verify the possibility of blend homogenization for further applications [3–5]. The high energy irradiation (exposure to electron beams or gamma rays) is a proper procedure by which the materials are turned onto desired products to be available for other technologies [6, 7]. In essence, the polymer recycling by radiation processing is based on the possibility to break chemical bonds followed by the addition of desired structures existing in different appropriate formulations or on the transformation into useful and stable materials.

The radiation effects on ethylene–propylene–diene rubber (EPDM) have been reported earlier. Rivaton et al. [8] demonstrated that the radical mechanism generally adopted for polyolefins would lead to random chain breaking, but the larger proportion of radical generation was provided by tertiary carbon atoms. According to Ito [9] and Zaharescu et al. [10], the chain degradation preferentially starts on propylene and so far the dominant feature that influences oxidation of irradiated EPDM is the constitutive ethylene/propylene ratio [11]. Davenas et al. [12] analyzed

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