

# Preparation and rheology characterization of branched polypropylene during reactive extrusion process

Kimia Mohebbi<sup>1</sup> · Nadereh Golshan Ebrahimi<sup>1</sup>

Received: 16 June 2014 / Accepted: 1 March 2015 / Published online: 17 March 2015  
© Iran Polymer and Petrochemical Institute 2015

**Abstract** The aim of this study was to compare the rheological behavior of branched polypropylene and linear PP by reactive extrusion process. Samples were modified in the presence of a peroxide initiator, i.e., 2,5-dimethyl-2,5(tert-butyl peroxy) hexane which was dispersed at 45 wt% in CaCO<sub>3</sub> (DHBP45), multi-functional monomer trimethylol propane triacrylate (TMPTA) as a graft monomer, and co-agent tetraethyl thiuram disulfide (TETDS) as a co-reactant, in an internal mixer. Rheological measurements and thermal analysis were used to characterize the structure of the modified PP samples. Using PP powder instead of PP granule, it was concluded that the elastic response of branched PP at low frequency was enhanced in comparison with linear PP. Rheological properties, such as increasing the  $G'$  at low frequency, plateau in  $\tan\delta-\omega$  plot, deviating from linear PP in Han plot and upturning at high viscosity in Cole–Cole plot, promoted the branching in PP backbone. Moreover, the results showed that by decreasing the amount of initiator, the chain scission can be controlled. TETDS could efficiently control side reactions, decrease the concentration of active free radicals simultaneously in system and improve the branching. When the quantity of TETDS decreased from moderate quantity, the functionality remained unchanged and failed to improve the branching.

**Keywords** Branched polypropylene · Degradation · Co-agent · Reactive extrusion process

✉ Nadereh Golshan Ebrahimi  
ebrahimn@modares.ac.ir

<sup>1</sup> Polymer Engineering Department, Chemical Engineering Faculty, TarbiatModares University, P.O. Box 14115-114, Tehran, Iran

## Introduction

Polypropylene is used in thermoplastic processes due to its desirable properties such as low cost, low density, high melting point, stiffness and good chemical resistance [1–3]. However, PP exhibits low melt strength and weak strain hardening behavior which limits its applications in foaming, blow molding and thermoforming. High melt strength PP can be produced by introducing long chain branching into linear PP. Thus, long-chain branched polypropylene (LCB-PP) can provide the melt strength and extensional properties that are lacking in. As a result, methods of producing and characterizing these materials have attracted considerable interest [4–6].

Several approaches have been developed to make branched PP. Some include post-reactor treatments such as reactive extrusion process, electron beam irradiation and melt grafting, whilst others involve in situ polymerization in a reactor (direct synthesis) [7, 8]. Difficulties in synthesis have encouraged the researchers to do chemical modification. Reactive extrusion process and electron beam irradiations are the most popular post-reactor methods because of their convenient use in industry. As compared with electron beam irradiation, the reactive extrusion process has many merits some of which are simplicity, low cost and high productivity operation [9].

As mentioned, a simple method for preparing LCB-PP is reactive extrusion, in which three reactants; PP, multi-functional monomer (as a graft monomer) and free radical initiator (usually peroxide) are used to form LCB-PP via radical reaction. Preparation of LCB-PP occurs through several reactions [10, 11]. The first step involves the thermal decomposition of peroxide to form primary radicals. The next step encompasses the abstraction of H-atom from PP backbone by primary radicals leading to the formation