THERMOPLASTIC POLYURETHANE-GRAPHENE MICROCELLULAR FOAMS: PRODUCTION & CHARACTERIZATION

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ABSTRACT

Foams are multiphase porous structures in which one phase is in the gaseous state and they are found in a plethora of applications including thermal insulation, tissue engineering, drug release, packaging etc [1]. The polymer foams, in particular, represent a major part of the overall market and their share is expected to present a growth rate of 4.9% in the next five years [2]. Among the existing technologies, batch foaming with supercritical fluids as physical foaming agents, especially carbon dioxide, is distinguished for its simplicity, reduced environmental footprint and improved safety while it also allows an ultimate control of the processing variables. The foaming process involves two crucial steps: (a) sorption or diffusion of a foaming agent in the polymer matrix under pressure for the formation of a polymer/gas solution and (b) bubble nucleation upon a reduction in ambient pressure or an increase in temperature [1]. In the recent years, the presence of graphene as filler in polymer nanocomposite foams is widely discussed in the literature, as it provides improved mechanical, thermal, and electrical proprieties [3].

In this study, the production of microcellular thermoplastic polyurethane (TPU) / graphene (Gr) foams using the procedure of sc-CO_2 batch foaming is reported (Figure 1a). Pure TPU and TPU elastomeric masterbatches (MBs) with incorporated graphene based nanofillers up to 15 wt% (multilayer graphene, few layer graphene and reduced graphene oxide) are used as raw materials. As opposed to the oldest existing methods for synthesis of polymer nanocomposites such as the solution blending and melt mixing techniques [4], industrially produced MBs are examined, resulting in a more homogeneous and potentially more affordable final product. Gas concentration, foaming temperature during pressurization, diffusivity of blowing agent in the polymeric matrix and pressure drop rate are the most important processing parameters and their careful control is essential for homogeneous multifunctional foams with advanced specific properties and density reduction. After their production, microstructure of foams is observed (Figure 1b) with a scanning electron microscope (SEM) while their mechanical, electrical and sensing properties are investigated.

KEYWORDS: Nanocomposites, Batch foaming, Supercritical CO_2, Graphene, Masterbatches

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Figure 1a: *Bulk and foamed TPU/Gr* granules
(from left to right: Pure TPU, TPU/0.1%Gr, TPU/1%Gr).

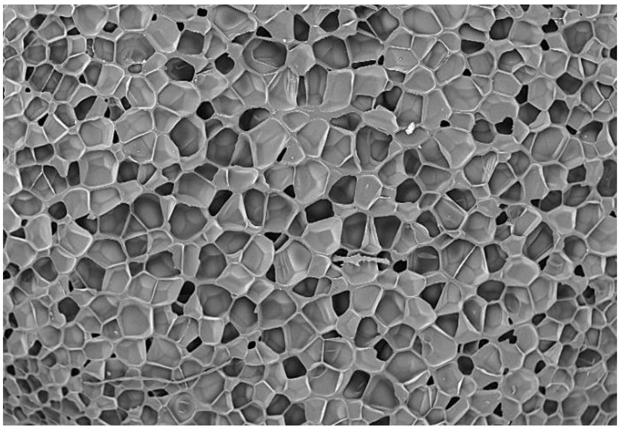

Figure 1b: *SEM micrographs of foamed pure TPU*

(Processing conditions: T=115^{o}C, P_{CO2}=100bar, t_{CO2}=10min).