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Effect of the Molecular Structure of TPU on the Cellular Structure of Nanocellular Polymers Based on PMMA/TPU Blends

Ismael Sánchez-Calderón [1,*], Victoria Bernardo [2], Mercedes Santiago-Calvo [1], Haneen Naji [3], Alberto Saiani [3] and Miguel Ángel Rodríguez-Pérez [1,4]

[1] Cellular Materials Laboratory (CellMat), Condensed Matter Physics Department, University of Valladolid, Campus Miguel Delibes, Paseo de Belén n°7, 47011 Valladolid, Spain; mercesc@fmc.uva.es (M.S.-C.); marrod@fmc.uva.es (M.Á.R.-P.)
[2] CellMat Technologies S.L., Paseo de Belén 9-A, 47011 Valladolid, Spain; v.bernardo@cellmattechnologies.com
[3] School of Materials, The University of Manchester, Oxford Road, Manchester M13 9PL, UK; haneen.naji@postgrad.manchester.ac.uk (H.N.); a.saiani@manchester.ac.uk (A.S.)
[4] BioEcoUVA Research Institute on Bioeconomy, University of Valladolid, 47011 Valladolid, Spain
* Correspondence: ismaelsc@fmc.uva.es

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Abstract: In this work, the effects of thermoplastic polyurethane (TPU) chemistry and concentration on the cellular structure of nanocellular polymers based on poly(methyl-methacrylate) (PMMA) are presented. Three grades of TPU with different fractions of hard segments (HS) (60%, 70%, and 80%) have been synthesized by the prepolymer method. Nanocellular polymers based on PMMA have been produced by gas dissolution foaming using TPU as a nucleating agent in different contents (0.5 wt%, 2 wt%, and 5 wt%). TPU characterization shows that as the content of HS increases, the density, hardness, and molecular weight of the TPU are higher. PMMA/TPU cellular materials show a gradient cell size distribution from the edge of the sample towards the nanocellular core. In the core region, the addition of TPU has a strong nucleating effect in PMMA. Core structure depends on the HS content and the TPU content. As the HS or TPU content increases, the cell nucleation density increases, and the cell size is reduced. Then, the use of TPUs with different characteristics allows controlling the cellular structure. Nanocellular polymers have been obtained with a core relative density between 0.15 and 0.20 and cell sizes between 220 and 640 nm.

Keywords: nanocellular polymer; poly(methyl-methacrylate); thermoplastic polyurethane; gas dissolution foaming

1. Introduction

Nowadays, modern society needs specific materials for each application, so there is a need to develop new and advanced materials as technology evolves. In this framework, a new generation of cellular polymers with enhanced properties was developed during the last decade: the so-called nanocellular polymers [1].

Nanocellular polymers are porous materials characterized by cell sizes in the nanoscale. These materials have aroused great attention owing to their very interesting combination of properties. As a result of their nanometric cell size, nanocellular materials present a reduced thermal conductivity of the gas phase due to the Knudsen effect [2–4]. Moreover, enhanced mechanical performance has been demonstrated in nanocellular polymers [5–7]. Furthermore, it is possible to produce semi-transparent nanocellular polymers [8,9], among other interesting properties [10,11].

The fabrication of nanocellular polymers is still a challenge, especially in the low-density range, because it requires a specific production technique to produce and stabilize cells in the nanoscale [1]. Among the diverse technologies employed for this purpose [3,12], one of the most promising methods is the so-called gas dissolution foaming process [13], which allows the bulk part production with a significant density reduction. To create a