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Morphological characterization of foamed natural filler-reinforced styrene maleic anhydride (SMA) composites

Deniz Aydemir · Alper Kiziltas · Douglas J. Gardner · Yousoo Han · Gokhan Gunduz

Abstract The aim of this study is to investigate the foaming of styrene maleic anhydride (SMA) matrix composites with a physical foaming agent, created during the reactive extrusion of natural fillers and SMA. The effect of lubricant on the foaming of SMA composites was also investigated. Whether particle's crystallinity and hydroxyl number had any effect on cell size and cell density was also studied. The results showed that the greatest cell size and expansion occurred in the starch reinforced SMA composite which also exhibited the highest hydroxyl number and water by-product from reactive extrusion. Whereas microcrystalline cellulose-SMA composite exhibited the least cell number and expansion after extrusion because of the high crystallinity of MCC and the low hydroxyl number. Scanning electron microscopy results revealed that the cell distribution in foamed samples was heterogeneous and cell density increased from the core to skin layer. The results showed that hydroxyl number has an important effect on foaming and cell nucleation of the composites, and cell properties changed with filler's percentage crystallinity.

Keywords Foaming · Styrene maleic anhydride · Reinforced composites · Hydroxyl number · Polymer composites

D. Aydemir (✉) · A. Kiziltas · G. Gunduz
Department of Forest Industry Engineering, Faculty of Forestry, University of Bartin, 74100 Bartin, Turkey
e-mail: denizaydemir@bartin.edu.tr

A. Kiziltas · D. J. Gardner · Y. Han
Advanced Structures and Composites Center, University of Maine, Orono, ME 04469, USA

1 Introduction

Natural filler-based composites are widely used in many industries such as construction, automotive, aerospace, and electronics. The composites are generally reinforced using various forms of fillers in polymer matrices to improve the physical and mechanical properties and thermal behavior, but the resulting composites typically exhibit high densities. To eliminate the high density of composite materials, composites can be foamed to decrease their density by using different blowing agents such as chemical and physical agents [1–3]. Foamed composites are defined as materials consisting of voids surrounded by the denser polymer matrix. These composites have attracted the attention of researchers because of their wide applications in insulation, cushions, absorbents, and weight-bearing structures [3–6]. Many polymers such as PS, PVC, polyester, polyolefins, etc. have been used to produce polymeric foams. For the foaming process, blowing agents are generally used to create the porous structures [7, 8]. Various techniques can be used to produce polymeric foams. For large-scaled production, the utilization of blowing agents is the most practical method. For thin film foams, other methods such as phase inversion, bleaching and thermal decomposition are commonly used [9, 10].

The foaming system is composed of polymer, blowing agent, nucleating agent and other necessary additives [7]. Generally, there are two types of blowing agents which are physical blowing agents and chemical blowing agents. Chemical blowing agents are reactive species that can produce gases by certain chemical reactions or thermal decomposition. Physical blowing agents are typically volatile chemicals such as chlorofluorocarbons, hydrocarbons/alcohols, and inert gases (CO_2, N_2, Argon, and Water). Of

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