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Influences of particle sizes and contents of chemical blowing agents on foaming wood plastic composites prepared from poly(vinyl chloride) and rice hull

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ABSTRACT

This research aims to investigate the effects of chemical blowing agent (CBA) contents and particle sizes on the properties of foamed poly(vinyl chloride) (PVC)/rice hull (RH) composites. Fine particles of azodicarbonamide (AC) at 5, 8, 11 and 22 μm were modified with 20% by weight of ZnO and used at 0–3.0% by weight. The average cell size and density of the PVC/RH foamed profiles were reduced as the content of modified azodicarbonamide (mAC) increased. Larger mAC particles lowered the density more effectively. Maximum reduction of density by 46% was achieved when mAC 22 μm was applied at 2.0% by weight. Larger blowing particles led to PVC/RH foam with greater flexural modulus and strength. Greater impact strength, observed when 5 μm mAC was applied, resulted from the rather thick cell wall created abundantly when fine mAC was applied.

1. Introduction

Recent increase in environmental awareness has drawn many current researchers to concentrate their studies on natural fiber reinforced polymer composites, and prompted the wood plastic composite (WPC) industry to expand significantly over the last two decades. Environmental regulations [1,2], relatively low cost of the WPC coupled with favorable strength to weight ratio are the main driving forces for the industry's rapid growth. The roles of wood-fiber as an inexpensive filler in thermoplastics have been studied extensively in recent years due to the various benefits they offer, such as high strength per unit weight and modulus, abundant availability, biodegradability, renewability, recyclability and good processability [3–6]. Natural fiber such as rice hulls had been investigated as an alternative filler for the production of WPC [7–10]. Chemically, the organic constituents in rice hulls are mainly cellulose, hemicellulose and a large amount of the phenyl propanoid structural polymer known as lignin, which are also compounds found in softwood and hardwood.

Several shortcomings still exist in most WPCs used as a substitute of solid wood. The problems of heavy weight, low ductility, low impact strength, poor nailing and screwing ability and high flammability have limited the use of WPC in many applications [11]. Many of these drawbacks can be remedied by incorporating a blowing agent in the WPC. In fact, foaming WPC can lead to many advantages, e.g. lower material consumption and better insulation [12]. While the use of a blowing agent in the production of WPC is aimed primarily at reducing weight and density, many mechanical properties are tacitly altered. Hence, it is vital that an appropriate amount of blowing agent be incorporated during the foaming process.

To date, most of the research performed on foamed WPCs are experimental and to some extent analytical. Bledzki and Faruk [13] suggested that exothermic chemical blowing agents were more effective in lowering the density and enhancing the tensile strength than the endothermic ones and their mixture. Endothermic foaming agent was reported to have reduced the surface roughness by nearly 70%. Matuana et al. [14] found that the cellular morphologies of the foamed PVC/wood-fiber composites were a strong function of the content of plasticizer and the surface treatment of wood-fiber as well as the gas saturation and foaming conditions. Blair [15] indicated that when the cell size was increased, the compressive and tensile strength of plastic foams decreased.

In this work, the foaming of wood plastic composites prepared from PVC and rice hulls was investigated by studying the effects of foaming process variables on the physical, mechanical properties and the cell morphology of the foamed composites. The foaming process variables understudied include the particle sizes of the chemical blowing agents and their concentrations.

2. Experimental

2.1. Materials

PVC compound (W5103 BRA) produced by Thai Plastic and Chemicals Company Limited, Thailand, was used. Its melting

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