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Effects of industrial scale production on the chemical composition of novel coupling agents and its relationship to the mechanical properties of chopped glass fibre mat reinforced thermoset composites

Cs. Varga [a,*], N. Miskolczi [a], H. Szakács [a], G. Lipóczi [b]

[a] University of Pannonia, Faculty of Engineering, Institute of Chemical and Process Engineering, MOL Institutional Department of Hydrocarbon & Coal Processing, H-8200 Veszprém, Egyetem u. 10, Hungary
[b] BalatonPlast Ltd., H-8227 Felsőörs, Petőfi u. 26, Hungary

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ABSTRACT

Previously successfully applied polyalkenyl-poly(maleic-anhydride)-ester/amide type additives synthesized in laboratory scale have gone through selection steps then the selected coupling additives were produced in industrial scale process. Additives have been applied for treating the surfaces of glass fibres with and then mechanical properties of the laminated polyester and vinyl–ester based composites have been determined. Results have been focussed on the effect of the size increasing of additive production on the final properties of the laminates. The structures of the additives have been compared based on their FT-IR spectra. Improvement of mechanical properties of composites treated by coupling additives has been found manufactured in industrial scale either. Tensile properties could be improved by 3.2–51.3% with additives from industrial scale related to the same properties of untreated laminates. The Charpy impact strength of laminates treated with coupling agents from industrial scale was higher than that of from lab scale. Fibre–matrix interaction has been studied on SEM micrographs of the fractured faces of the composites. Similarly, the unfavourable results had been caused by the fibres slipping out of the ester matrix.

1. Introduction

Polymer composites offer numerous advantages for applications relying on high strength/weight ratios due to their high modulus and strength coupled with low density [1,2]. Epoxy and polyesters are the most widely used thermosetting resins and are usually applied for reinforced composites [3,4]. They are generally formed by a condensation reaction between a glycol and an unsaturated dibasic acid. Polyesters, vinyl-esters and epoxy could not be applied for technological purposes without reinforcing because of low strength and brittleness but they are intensively used for composite matrices [5]. If chemical resistance is the most important point of view vinyl-esters are to be applied [6]. The glass fibres, especially E- and S-type, as reinforcing materials are the most widespread applied in fibre reinforced thermoset composites due to their favourable mechanical and economical characteristics [7,8]. Unfortunately weak link in their broader applicability continues to be a not suitable fibre–matrix connection. Not only the properties of the reinforcing material and the matrix are important in any composite systems but also the strength of the interfacial interactions and the mechanisms of the load transfer at the interphase [1,9]. The role of the fibre–matrix interaction is complex. For high tensile strength strong bond is needed but that makes the composite brittle, for a tough composite weak bond is required but in that case the loads can not be transferred efficiently from the matrix to the fibres [8,10]. The optimised fibre–matrix compatibility has to be found for the selected end-use [11,12]. In most cases different types of coupling additives are used for establishing a strong but flexible interphase between the matrix and the fibres [8]. Main types of additives are commonly used polymers, such as polypropylene, polyethylene grafted with polar chemicals like maleic-anhydride or acrylic acid [13]. Another important group is the silane type chemicals with different side chains depending on the composition of the fibre and the matrix. Silanes are widely applied both for natural fibre reinforced composites and for glass fibre reinforced thermoset composites, because their–OR–functional groups can react with the –OH groups on the fibre surface [14]. Effectiveness is dependent on the type of the silane, the thickness of the silane layer and the methods of the treatment. Silanes couple the polymers with covalent or hydrogen-bonds to the surface of the glass fibres, but literature data differ whether the siloxane bonds are established before or after the connection to the surface [15].

The aim of our experimental work was to produce the successfully applied polyalkenyl-poly(maleic-anhydride) based coupling

* Corresponding author. Tel.: +36 88 624187; fax: +36 88 624520.
E-mail address: vcsilla@almos.uni-pannon.hu (Cs. Varga).

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