



Mild-thermal fabrication and phase conformation of chopped glass fiber-reinforced low-density unsaturated polyester resin with NH_4HCO_3

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Received: 28 May 2018 / Accepted: 20 October 2018 / Published online: 28 October 2018
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Abstract

Chopped glass fiber-reinforced low-density unsaturated polyester resin product (CFR-LDUPRP) was fabricated utilizing chopped glass fiber and ammonium bicarbonate through an innovative mild-thermal process featuring an ideal phase conformation. Based on the mild-thermal mechanism and preliminary experiments, an orthogonal experiment was conducted to obtain the optimal conditions of CFR-LDUPRP fabrication. The optimal fabrication temperature of 76.0 °C, 20.00 phr of 3 mm chopped glass fiber, 2.50 phr of NH_4HCO_3 and 1.50 phr of *tert*-butylperoxy benzoate (TBPB) comprised the optimal conditions for CFR-LDUPRP fabrication. Under this condition, the density (ρ), compressive strength (P), and specific compressive strength (P_s) of CFR-LDUPRP specimen were $0.63 \pm 0.02 \text{ g cm}^{-3}$, $24.29 \pm 0.73 \text{ MPa}$, and $38.56 \pm 1.02 \text{ MPa g}^{-1} \text{ cm}^3$, in the given order. The analyses of nonisothermal DSC and semi-quantitative FTIR revealed that NH_4HCO_3 neutralized the residual acid in the resin, leading to an early polymerization of resin and a prolonged curing process of UPR. The endothermic decomposition of NH_4HCO_3 and the vaporization of water enabled a mild-thermal mechanism, which was beneficial for the growth of bubbles and for the distribution of chopped glass fiber in the resin. Proper phase conformation of the resin, bubbles, chopped glass fiber together with cracks and microvoids in the resin matrix, characterized by SEM and ^1H NMR, facilitated the polymerization of UPR and improved properties of CFR-LDUPRP. Bubbles diameter ranged from 0.27 to 0.61 mm without linking or destroyed bubbles.

Keywords Low-density unsaturated polyester resin · Chopped glass fiber · Ammonium bicarbonate · Mild-thermal · Phase conformation

Abbreviations

UPR	Unsaturated polyester resin
LDUPRP	Low-density unsaturated polyester resin product
CFR-LDUPRP	Chopped glass fiber-reinforced low-density unsaturated polyester resin product
FRP	Fiber-reinforced plastics
AIBN	Azodiisobutyronitrile
ABVN	Azobisisoheptonitrile
TEA	Triethanolamine
OBSh	4,4'-Oxibis-(benzenesulfonyl hydrazide)
AC	Azodicarbonamide
DSC	Differential scanning calorimetry

FTIR	Fourier transform infrared
SEM	Scanning electron microscope
^1H NMR	^1H nuclear magnetic resonance
TBPB	<i>Tert</i> -butylperoxy benzoate
DOP	Diocetyl phthalate
BBO	Broad band observe

Introduction

Fiber-reinforced plastic (FRP) present in the matrix of unsaturated polyester resin (UPR) and reinforced by glass fiber is one of the most widely used composite materials in practice, due to its high mechanical strength, excellent corrosion resistance, and anti-fatigue specialties. The density of the FRP (polyester resins as a matrix material) is between 1.5 and 2.1 g cm^{-3} [1–3]. Previous research works in FRP focused on solid materials, for example, Janusz et al. [4] investigated the influence of different inorganic particles on

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