Iranian Polymer Journal (2018) 27:207–216
https://doi.org/10.1007/s13726-018-0601-1

ORIGINAL RESEARCH

Sodium bicarbonate/azodiisobutyronitrile synergistic effect on low-density unsaturated polyester resin fabrication

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Received: 27 April 2017 / Accepted: 2 December 2017 / Published online: 23 January 2018

Abstract
The combination of sodium bicarbonate ($NaHCO_3$) and azodiisobutyronitrile (AIBN) is an innovative idea for the fabrication of low-density unsaturated polyester resin (LDUPR). At 100 °C, acetic acid (HAc) was added to the polyester resin glue to facilitate the decomposition of $NaHCO_3$ for the synergy between the gas releasing of $NaHCO_3$ and that of AIBN in the foaming process. Regular and homogeneous cell distribution in LDUPR specimen was characterized by electron microscopy to clarify the foaming efficiency of $NaHCO_3$ and AIBN combined. The LDUPR specimen containing AIBN/$NaHCO_3$ and the LDUPR specimen containing AIBN/$NaHCO_3$/HAc were demonstrated by X-ray diffractometry (XRD) to analyze the decomposition of $NaHCO_3$. Heat balancing resulted from the combination of $NaHCO_3$ and AIBN during the foaming process and it was realized through the endothermic heat of reaction of $NaHCO_3$ and HAc, balanced by the exothermic heat of UPR curing process. This combination tempered the curing process of UPR, and was conducive to the foaming process of LDUPR. At 100 °C, the optimal contents of AIBN, $NaHCO_3$ and HAc were all 1.5 phr, which were obtained from an orthogonal experiment, and the appropriate addition time of HAc was 18 min following the addition of AIBN/$NaHCO_3$ mixture into the resin glue. The lowest apparent density of 0.34 ± 0.02 g^{-1} cm^{-3} and the highest specific compressive strength of 36.18 ± 1.02 MPa g^{-1} cm^3 were obtained for LDUPR specimen.

Keywords Low-density unsaturated polyester resin · Sodium bicarbonate · Azodiisobutyronitrile · Acetic acid · Foams

Introduction

With the growing requirements for energy saving and the development of green materials, light-weight and high-strength materials are becoming one of the hotspots in the development of industrial and civilian materials [1, 2]. Low-density unsaturated polyester resin (LDUPR) materials, with low apparent density, high specific compressive strength, and fine heat and sound insulation performance, are available for the body of ships and vehicles, sandwich plates of shower enclosures, and buildings and desktops. Therefore, LDUPR materials have received growing interest in the application and development of unsaturated polyester resin (UPR) [3–5].

Chemical foaming was a commercial foaming technique in the manufacture of foamed materials [6, 7]. The current chemical foaming methods in foamed materials include using azodicarbonamide to prepare flexible epoxy foam with reactive liquid rubber and starch [8], using toluene sulfonyl hydrazide blowing agent to prepare epoxy composite hollow microspheres [9], and hydrogen-bond activation between triethanol amine and azodiisobutyronitrile in LDUPR fabrication [10]. However, the above methods are based on an organic foaming agent, which takes an exothermic decomposition in the foaming process. As for UPR, the heat released by an organic foaming agent accelerates the curing process of UPR, which is adverse to the nucleation or the growth of bubble in LDUPR fabrication [11–13]. On the other hand, the decomposition process of an inorganic foaming agent, such as carbonate, bicarbonate or nitrite compounds, is endothermic [14, 15]. The endothermic process of an inorganic foaming agent can counteract the curing heat, released by UPR, and this is favorable for the nucleation and the growth of bubble in LDUPR fabrication. Therefore, it is necessary to introduce inorganic foaming agent in LDUPR fabrication.

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