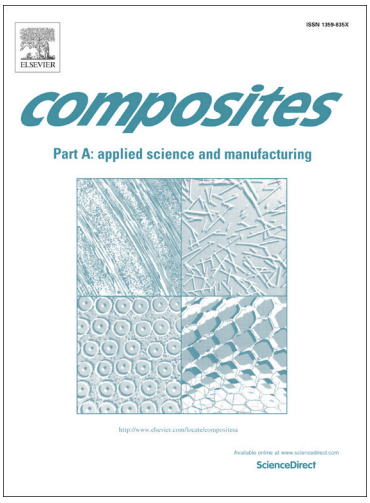

Kinetics and temperature evolution during the bulk polymerization of methyl methacrylate for vacuum-assisted resin transfer molding

Yasuhito Suzuki, Dylan Cousins, Jerred Wassgren, Branden B. Kappes, John Dorgan, Aaron P. Stebner

PII: S1359-835X(17)30380-9
DOI: https://doi.org/10.1016/j.compositesa.2017.10.022
Reference: JCOMA 4811

To appear in: *Composites: Part A*

Received Date: 16 August 2017
Revised Date: 19 October 2017
Accepted Date: 21 October 2017

Please cite this article as: Suzuki, Y., Cousins, D., Wassgren, J., Kappes, B.B., Dorgan, J., Stebner, A.P., Kinetics and temperature evolution during the bulk polymerization of methyl methacrylate for vacuum-assisted resin transfer molding, *Composites: Part A* (2017), doi: https://doi.org/10.1016/j.compositesa.2017.10.022

Kinetics and temperature evolution during the bulk polymerization of methyl methacrylate for vacuum-assisted resin transfer molding

Yasuhito Suzuki,[1,2,*] *Dylan Cousins*[2], *Jerred Wassgren*[2], *Branden B. Kappes*[1], *John Dorgan*[2], *Aaron P. Stebner*[1]

1. Mechanical Engineering Department, Colorado School of Mines, Golden, CO USA
2. Chemical and Biological Engineering Department, Colorado School of Mines, Golden, CO USA

Keywords: Thermoplastic resin, cure behavior, vacuum infusion

Abstract

Curing reactions of Methyl methacrylate (MMA) are comprised of an induction time of gradual temperature change over tens of minutes, followed by a sudden temperature rise within tens of seconds because of auto-acceleration known as the Trommsdorff effect. These curing effects were investigated as initial initiator and polymer concentrations were varied. A mathematical model combining the reaction kinetics with heat transfer was developed and verified in its ability to simulate the processing kinetics and temperature evolutions throughout thick MMA-based parts. It was further demonstrated that the processing conditions at specific points within a part during manufacture could be actively controlled via the Trommsdorff effect by locally varying the initial concentration of poly(methyl methacrylate) (PMMA) solution. Together, these advancements provide an enhanced ability to design and optimize the manufacture of thick, large scale PMMA fiber reinforced composites, taking advantage of auto-acceleration instead of avoiding it.

1. Introduction

The use of thermoplastic resin systems instead of thermosets can improve the recyclability of composites, shorten the production cycle time, and reduce manufacturing costs. Although the concept has long been proposed, it is still challenging to fabricate thick, large-scale thermoplastic-based fiber-reinforced composites (FRCs) [1]. Vacuum-assisted resin transfer molding (VARTM) is most commonly used to fabricate large FRCs like wind turbine blades [2] and ships [3]. With this method, fibers are placed on a mold and shielded with a vacuum bag and vacuum tape. A low-viscosity thermoset resin and hardener are infused with the aid of a vacuum. The resin is then cured at a high temperature [5]. There are two approaches to using thermoplastic resin: melt infusion and reactive processing. Because the viscosities of polymer melts are too high at a reasonable temperature in a vacuum, reactive processing is a practical approach. Promising systems include ring-opening polymerization of nylon [6–10]