COUPLED ELECTROMAGNETIC THERMAL AND KINETIC MODELING FOR MICROWAVE PROCESSING OF POLYMERS

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Polymer processing is an important application of microwave heating in industry. Microwave assisted curing of thermosets can lead to superior materials for a variety of applications. Microwave curing has the advantage of heating the polymer precursor materials volumetrically and hence can lead to superior cure with efficiency not available with conventional convection heating. However, due to the complex interactions between the electromagnetic fields and the material, achieving the promise of microwave assisted curing is challenging. This is due to the fact that electrical properties (e.g. the complex permittivity) of the material change during the curing process. Hence, the field distribution within the cavity applicator changes as a function of the cure and local temperature of the materials being processed. It is vital in modeling the curing process that the microwave power deposition, heating, and extent of cure be coupled together. In this work, we develop a self-consistent three-dimensional process model, which includes electromagnetic field distribution, heat transfer, microwave absorption, and chemical reactions/kinetics. This numerical model is implemented with finite element method [1]. Kinetics (e.g. extent of cure) based on experimental data [2] will be included in the model. The numerical results can be used to determine the time-dependent temperature profiles across the polymer sample, as well as the electromagnetic field distribution within the cavity applicator. The results will also be used in the design and diagnosis of a novel multi-feed cavity applicator where the spatial distribution of the electric field can be specified *a priori* to accomplish a desired processing task.

REFERENCES

[1] J. L. Volakis, A. Chatterjee, and L. C. Kempel, *Finite Element Method for Electromagnetics: Antennas, Microwave Circuits, and Scattering Applications.* New York: IEEE Press, 1998.

[2] Liming Zong, Shuangjie Zhou, Rensheng Sun, Leo Kempel, and Martin Hawley, "Dielectric Analysis of a Crosslinking Epoxy Resin at a High Microwave Frequency," *Journal of Polymer Science Part B: Polymer Physics*, in press.