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Visualization of Microwave Energy Distribution in a Multimode Microwave Cavity Using $CoCl_2$ on Gypsum Plates

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ABSTRACT

This study provides a facile method to map the microwave field distribution in a multimode microwave cavity. Anhydrous calcium sulfate powder was used to make the gypsum plates that were used as the carrying medium. Cobalt chloride hexahydrate, whose color changes when losing part or all of its crystal waters, was selected as an indicator of the energy absorption. The cobalt chloride aqueous solution at a concentration of 1.6% was absorbed by the dried gypsum plates. After introducing the plates into a microwave field, those areas that receive more microwave energy were preferably heated, resulting in the release of the moisture and consequently the loss of crystal water from the cobalt chloride hexahydrate. The color change on the plate formed a color map indicating the microwave field distribution. This method was used to investigate the energy distribution of a microwave oven by placing single or multiple plates in horizontal or vertical positions at different locations in the cavity.

KEYWORDS: Microwave distribution, gypsum, calcium sulfate, cobalt chloride, visualization, mapping, power distribution, multimode cavity

INTRODUCTION

Despite the popularity and the intense attention microwave energy has been receiving with many applications in various sectors, the non-uniformity of the energy distribution still remains a problem. When dealing with food, the uneven energy distribution is believed to be responsible for the rubbery and soggy texture in the end product, unacceptable flavor development, insufficient microbiological destruction, and even safety hazard due to the overheating of the center of infant formula bottles (Zhou et al., 1995; Ma et al., 1995). The localized overheating in the drying processes often leads to the burning of the commodity.
Therefore it is wise to know how microwave energy is distributed within the microwave oven and the commodity before the process is carried out. Different methods could be used to visualize the energy distribution within an applicator. Thermal imaging is one of the most versatile tools to visualize the heating profile of a surface or a newly cut surface from a solid sample (Thompson et al., 1978; De Leo et al., 1991; van Remmen et al., 1996; Ryynane, 2002). But considering the price of the equipment, many other methods are encouraged such as prediction techniques (Vegh and Turner, 2006). Iskander (1993) reported the use of a liquid crystal sheet in a multimode cavity to map the field distribution patterns. The price is still an important issue in using the liquid crystal sheet. Thermal paper was also suggested by some researchers to be used to map