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Microwave Drying at Various Conditions Modeled using the Reaction Engineering Approach (REA)

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Abstract

One of the most significant process intensification schemes in drying is microwave drying. Modeling the process of microwave drying is very useful. The lumped reaction engineering approach (REA) is now coupled with appropriate equations for modeling microwave heating. Here, a slight modification of the equilibrium activation energy is needed since the product temperature is higher than the ambient temperature. Unlike the diffusion-based approach, the REA drying parameters were generated from minimum number of drying runs. It has been found that the modifications lead to excellent agreements between the predicted and experimental data. The results of modeling match well with the experimental data. The overall model is accurate to describe the moisture content and temperature profiles. Comparisons with the diffusion-based approach indicate that the REA can achieve comparable or even better agreement towards the experimental data. This exercise has demonstrated that a simple combination of the L-REA and the microwave energy absorption is versatile in predicting the microwave

drying process accurately, thus this worked example will be illustrative for future needed studies.

KEYWORDS: food drying, heat and mass transfer, mathematical modeling, microwave drying, reaction engineering approach (REA), relative activation energy

1. INTRODUCTION

Drying is a water removal process involving simultaneous heat and mass transfer. It is an energy-intensive process since large amount of heat needs to be supplied for water evaporation. Several drying schemes, controlled drying operations and process intensification of drying have been implemented to minimize the energy consumption and maintain the product quality. [1-4] Innovative process design of dryer and exploration of operating conditions of dryer have also conducted for these purposes. [5-7]

The process intensification schemes that have been implemented cover intermittent drying, infrared-heating drying, microwave drying and ultrasonic-assisted drying. [8-14] One of the most important schemes is microwave-assisted drying. It has been used widely in food, textile, paper and ceramics industries. [15-18] The electromagnetic energy excites the polar molecules and ions and forces them to align themselves according to the change of electric field direction. During this process, heat is generated and used for water evaporation. [19-20] Unlike the conventional hot air drying, the dry layer is easily penetrated by the electromagnetic waves which were absorbed by water at the waterfront for evaporation [21] This results in 'rapid pumping effect' of moisture from the core to the