A Research on the Process Simulation of the Supercritical Fluid Extraction of the Vegetable Oils

Jian-Zhong Yin[*1], Yi Liu[1], Qin-Qin Xu[1], Wei Wei[1], and Ai-Qin Wang[2]

1 School of Chemical Engineering, Dalian University of Technology, Dalian 116012, P.R.China
2 Dalian Institute of Chemical Physics, Chinese Academy of Sciences, Dalian 116023, P.R.China

Corresponding Author: Jian-Zhong Yin, aqjzyin@yahoo.com

Abstract: In this work, the process simulation of supercritical fluid extraction of solid material and its development are expounded. The representational kinetic models and the advantages and disadvantage for each one are particularly introduced. Because of the models are immature, the most popular one is discussed, and the improvements of its disadvantages are given. Based on the broken-intact cells model, a new differential mass balance equation is presented. The initial and boundary conditions are obtained by the analysis the process and the acceptable hypotheses, and the numerical solution of the model is given.
Keywords: Supercritical Fluid Extraction; Vegetable Oils; Kinetic Model; Simulation

INTRODUCTION

It is well know that the ionic liquid, supercritical fluid and CO_2-expanded liquid (CXL) are the environmental benign solvents. These green solvents are playing a very important role in the "Green Chemistry". Many SCFE processes were developed especially for the natural products and pharmaceutical processing. The modeling and simulation research for SCFE process is the first step in order to apply SCFE technology into practice. So, in this article, nine kinds of natural materials were selected as objects to study the SCFE modeling and simulation.

I - MATERIALS AND METHODS

The simulation model was based on the differential mass balance equation for a supercritical fluid extraction fixed bed. The process was considered into two stages, for instance, the linear extraction procedure and slow diffusion stage. The materials were taken into two parts: one is with broken cell wall and another is with perfect cell wall. The density of $SCCO_2$ was calculated by use of P-R EOS and the oil solubility in $SCCO_2$ was predicted with del Valle empirical formula. We defined a parameter, φ_f, means the ratio of cell amount of with broken cell wall to cell amount of with perfect cell wall. It was taken into an adjustable variable. k_i was defined as a internal mass transfer coefficient. Some parameters were listed in table1 obtained by the present model.

Table 1 Prediction parameters for some materials

Materials	T(K)	P(MPa)	ki(m/s)	Co(g/g)	φ_f=f(dp)
Grape	313	28	2.4×10^{-8}	0.007	φ_f=1.2725-1.25dp
Almond	333	30	5×10^{-8}	0.011	φ_f=0.663-0.1548dp
Tomato	313	24	5×10^{-7}	0.008	φ_f=1.1017-0.986dp
Peanut	298	55	3×10^{-7}	0.018	φ_f=1.1038-0.2034dp

CONCLUSION

The SCFE process of nine materials are simulated, the internal mass transfer coefficient of each one is obtained by taking the average relative deviation as the objective function, and the relationship between the grinding efficiency and the mean particle size for some substances are also given. The extraction curve and the average relative deviation for each substance are discussed. The results of this work are contrasted with the conclusions in the references, and they agree well.

By simulating different materials, the conclusion of a linear relationship between the grinding efficiency and the mean particle size is first given. And by this conclusion, the two segments of the SCFE process can be exactly distinguished, and the extraction curve at different conditions can be easily predicted. In this article, the effects of grinding efficiency and internal mass transfer coefficient on the extraction curve are discussed.

For egg yolk, because of the microstructure is different from vegetable matrix, the result of the simulation does not quite fit the fact. So this model is not fit for simulating non-vegetable systems.

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