Simulation of a Mathematical Model of SFE Process Through COMSOL Multiphysics®

B. Suryawansi[1], B. Mohanty[1]

[1] Indian Institute of Technology Roorkee, Uttarakhand, India

Abstract

Abstract:
Supercritical fluid extraction (SFE) has been named as 'Green' technology due to its compatibility with the environment during the effective and efficient extraction of various plant products (i.e. Seeds, Leaves, Stems, Flowers, Fruits and Herbs). Besides this, conventional solvent extraction processes (i.e. Mechanical extraction, soxhlet extraction etc.) are energy intensive. Various solvents (n-Hexane, Ethanol, Methanol, Petroleum ether, Acetone etc.) have been used but carbon dioxide in its super critical state (above its critical temperature '31.10 deg C' and pressure '72.9 bar') has shown various excellent qualities such as non-toxic, non-flammable, non-reactive, non-corrosive, residue free, least expensive after water and its better solvent power.

In this work, COMSOL Multiphysics® software was used to solve a mass transfer based mathematical model (Stastova et al., 1996) which is a modified model of Sovova (Sovova et al., 1994) in which the term 'Grinding efficiency' has been added. The model's mechanism is based on DDD (Desorption-Dissolution-Diffusion) phenomenon which is explained by three analytic equations employed for above three different regimes of whole extraction curves. An analytic function available in the COMSOL Multiphysics® software was used to solve each mathematical equation and then the results were added to find over all mass transfer.

The results obtained from the above model was validated with the model results reported by Duba and Fiori, 2015, for the extraction of Grape seeds oil at temperatures (35, 40 and 50 deg C), pressures (200, 300, 400 and 500 bar), flow rates-CO2 (4.71, 7.45, 8.43 and 10.22 g/min), particle sizes (0.41, 0.45, 0.59 and 0.75 mm), bed porosities (0.41, 0.32, 0.23 and 0.10) and D/L (extractor diameter to length) ratios (0.53, 0.26 and 0.11). Results obtained from the model, when solved using COMSOL Multiphysics® software, where compared with the results of Duba and Fiori, 2015 when the same model was solved using MATLAB®. Results compare well within an error band of ± 10.501 %. COMSOL Multiphysics® software took much lesser, computation time (10 s) and memory consumption than MATLAB®.

Reference

1. Duba K.S., Fiori L., Supercritical CO2 extraction of grape seed oil: Effect of process parameters on the extraction kinetics, Journal of Supercritical Fluids, 98, 33-43 (2015).
2. Stastova et al., Rate of the vegetable oil extraction with supercritical CO2-iii. extraction from sea buckthorn, Chemical Engineering Science, 51, 4347-4352 (1996).

Figures used in the abstract

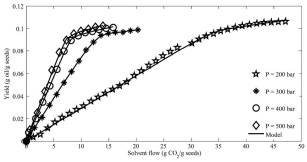

Figure 1: Extraction curves (modeled through MATLAB®) at different pressures: oil yield versus solvent consumption (Duba and Fiori, 2015).

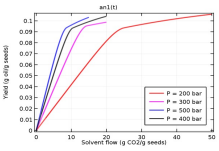

Figure 2: Extraction curves modeled with COMSOL Multiphysics® software at different pressures: oil yield versus solvent consumption.

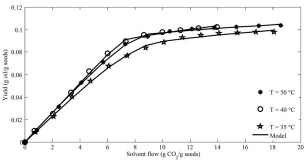

Figure 3: Extraction curves at different temperatures: oil yield versus solvent consumption (Duba and Fiori, 2015).

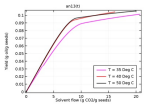

Figure 4: Extraction curves (modeled with COMSOL Multiphysics® software) at different temperatures: oil yield versus solvent consumption.