Validation of Supercritical Fluid Extraction Model Through COMSOL Multiphysics®

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Abstract

Supercritical Fluid Extraction (SFE) has emerged as a green technology for the separation process in the modern research works. Many chemical solvents (Hexane, Ethanol, Ether etc.) are being used as supercritical fluids in SFE process which are not good for health. However, supercritical CO2 solvent makes this process as 'Green Process' because of its properties such as odorless, colorless, nontoxic, nonflammable, non-explosive noncorrosive and easy to separate. Various mass transfer based mathematical models have been reported in the literature for the description of SFE process. Out of which, Sovova (1994) model is being used most widely by many researchers for the extraction of different seeds, leaves, fruits, peels, barks and other parts of plant. He developed a model for the SFE process for the three extraction zones. These zones are fast extraction zone, transition zone and slow extraction zone. He proposed three analytic equations describing these three extraction zones. Sovova et al. (1994) validated this model with experimental data of extraction of Grape seed oil at 280 bar pressure & 40 degC temperature considering different variables i.e. solvent flow rate and grade of grinding.

In this work, mass transfer based Sovova (1994) model was solved using COMSOL Multiphysics® software. All three analytical equations of Sovova (1994) model were solved by 'analytic function' in 'definition' toolbar of the 'component1' in COMSOL software for the variables solvent flow rate and grade of grinding. Results of this model were successfully validated for all three zones with the results obtained by COMSOL Multiphysics® software. The average absolute relative deviation (AARD) was determined, which was found within ± 9.26% error band. Many researchers used this model for their research due to its reliable result. Mira et al. (1996) and Mira et al. (1999) used this model for extraction of orange peel and showed the effect of solvent flow rate on the mass extracted at 323 K temperature and 15 bar pressure for the particle size of 3 mm considering different optimized parameters. This work successfully validates the Sovova (1994) model solved through COMSOL Multiphysics® software within ± 4.44% error band for orange peel in both research works with all above conditions of orange peel.
I am attaching four graphs with this abstract. fig 1 & 3 are showing the effect of grade of grinding and flow rates on extraction yield, validated in COMSOL Multiphysics® software and fig. 2 & 4 are the reference images

Reference

[1] Mira et al, “Supercritical CO2 Extraction of Essential Oils from Orange Peel”, The Journal of Supercritical Fluids, vol 9, 238-243 (1996).
[2] Mira et al, “Supercritical CO2 extraction of essential oil from orange peel. Effect of operation conditions on the extract composition”, Journal of Supercritical Fluids, vol 14, 95–104 (1999).
[3] H. Sovova, “Rate of the vegetable oil extraction with supercritical CO2-I modeling of extraction curves”, Chemical Engineering Science, vol 49, 409-414 (1994).
[4] Sovova et al, “Rate of the vegetable oil extraction with supercritical CO2–II extraction of grape oil”, Chemical Engineering Science, vol 49 415-420 (1994).

Figures used in the abstract

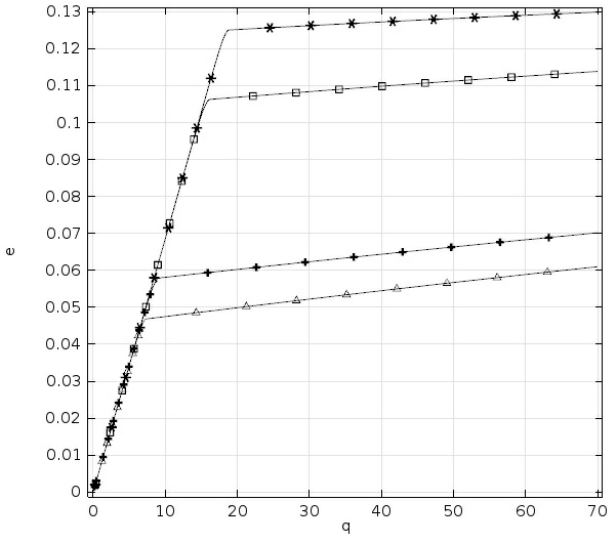

Figure 1: Graph plotted by using COMSOL Multiphysics® software for Grape seed for different grade of grinding.

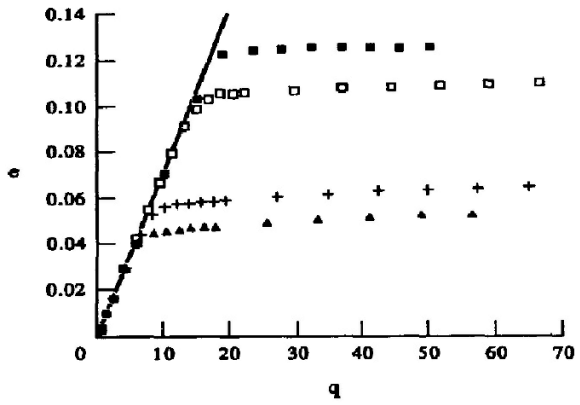

Figure 2: Graph plotted in research paper for Grape seed for different grade of grinding.

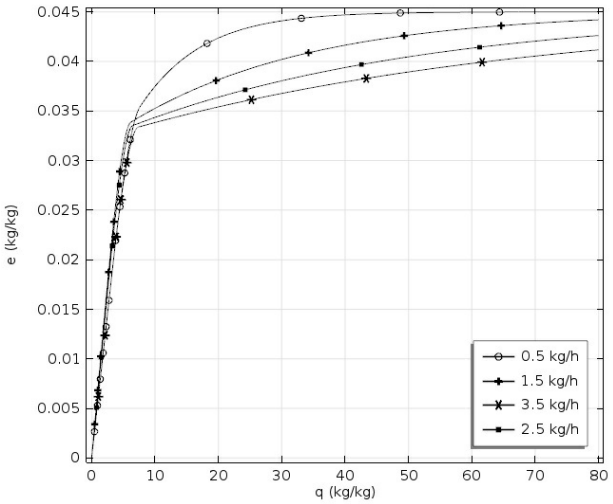

Figure 3: Graph plotted by using COMSOL Multiphysics® software for orange peel for different flow rates.

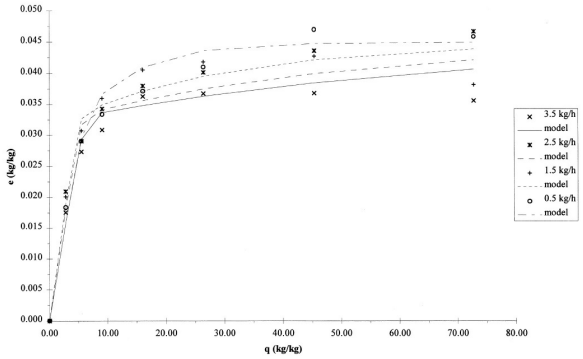

Figure 4: Graph plotted in research paper for orange peel for different flow rates.