Mathematical Model for Pressurized Solvent Extraction from Leuzea carthamoides

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Pressurized solvent extraction (PSE) has become an effective alternative to conventional extraction (Soxhlet extraction, maceration) from plant material. Due to the elevated temperature and pressure, which facilitate better penetration of solvent into the matrix pores, the PSE offers advantages with regard to extraction time, yields and consumption of solvent. In spite of the high temperature above the normal boiling point of solvent, thermo-labile substances are mostly preserved because of the short extraction time (5–20 min). The elevated pressure is mainly used to keep the solvent liquid. The PSE is usually semi-continuous or batch-wise process. In the first case, the pressurized solvent flows through the fixed bed of disintegrated plant material and dissolves the solute. In the case of batch-wise extraction, the extraction column is pressurized with the solvent to desired pressure. After a short period of time (5–20 min), the extraction column is depressurized and solvent is pushed out from the system and trapped into the vial. This process is usually repeated two or three times.

The mathematical modelling of experimental data is important for the prediction of the feasibility of the process. The modelling of the extraction from fixed bed is generally based on differential mass balance equations, which include mass balance of the solute for the fluid phase and mass balance of solute for the solid phase. In the most cases, the distribution coefficient is used as a fitting parameter for experimental data.[1]

Leuzea carthamoides is an adaptogenic plant rich in phytoecdysteroids. The most abundant ecdysteroid in this plant is 20-hydroxyecdysone (20-HE) which is well known for its anabolic and tonic effects on mammals and is used as dietary supplement for muscle growth.[2]

This work concerns PSE from roots of *Leuzea carthamoides* and mathematical characterisation of this process. The PSE experiments were carried out at temperature 80°C, pressure 10 MPa and using methanol or ethanol as solvents. The extraction was semi-continuous with various solvent flow rate (0.5, 1, and 2 ml/min). Soxhlet extraction with methanol was used for comparison of methods. The concentration of 20-HE in extracts was determined by HPLC coupled with mass spectrometry. The basic mathematical model was applied to fit experimental data.

The concentration of 20-HE in extract and total yield of extract were significantly influenced by the type of solvent. Higher extraction yields were obtained using methanol as a solvent. On the contrary, the velocity of solvent flow had a minor effect on the yield of the 20-HE. The model assumed the short extractor, where the concentration difference inside the extractor is negligible and thus the lumped parameter model was used. This model is mathematically identical to the model of ideal mixer.

References

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