

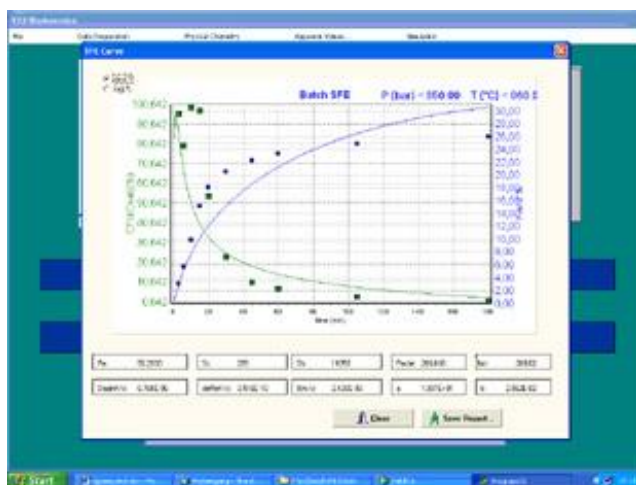
Supercritical Fluid Extraction (SFE): A Sustainable Thermal Separation Process

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Supercritical Fluids, namely compressed carbon dioxide, are alternative solvents with comparable solvent power as conventional organic substances. On the one hand they allow moderate extraction temperatures, on the other hand, their solvent power can be adapted to the solute by simple modification of the process pressure. Batch SFE applications result consequently in the production of solvent free extracts and thus added value for any kind of biomass which is rich in triglycerides(fats) and polyphenols. Continuous SFE applications are applied in the purification of liquids in petrorefinery, as well as in the raffination of bulk oils.

Useful tools for the experimental studies design and the upscale of SFE application are

- the check and modeling of the extraction yield curves (in the case of Batch SFE (figure 1),
- measuring high pressure phase equilibria and applying short cut methods like Mc Cabe Thiele and Ponchon Savarit for continuous SFE, respectively.(figure 2)



$$\frac{\partial c_F}{\partial t} = D_{ax} \cdot \frac{\partial^2 c_F(z)}{\partial z^2} - \frac{u_z}{\varepsilon} \cdot \frac{\partial z_F(z)}{\partial z} - \frac{1-\varepsilon}{\varepsilon} \cdot \frac{\partial \bar{c}_s(z)}{\partial t}$$

$$\frac{\partial \bar{c}_s(z)}{\partial t} = a \cdot k_{oG} \left(c_F(z) - \bar{c}_s(z) \cdot \frac{K(\bar{c}_s)}{\rho_s} \right)$$

$$K(\bar{c}_s) = \frac{c_F^*}{\bar{c}_s} \quad K(\bar{c}_s) = k_1 \cdot \bar{c}_s^{-k_2}$$

$$\frac{\beta_F}{k_{oG}} = 1 + Bi \quad \beta = f(Sh, Re, Sc)$$

Figure 1 : Batch Extraction yield curve (TUHH programming tool "Batch SFE") and modeling approach of mass transfer in a fixed bed (Brunner, 1994)

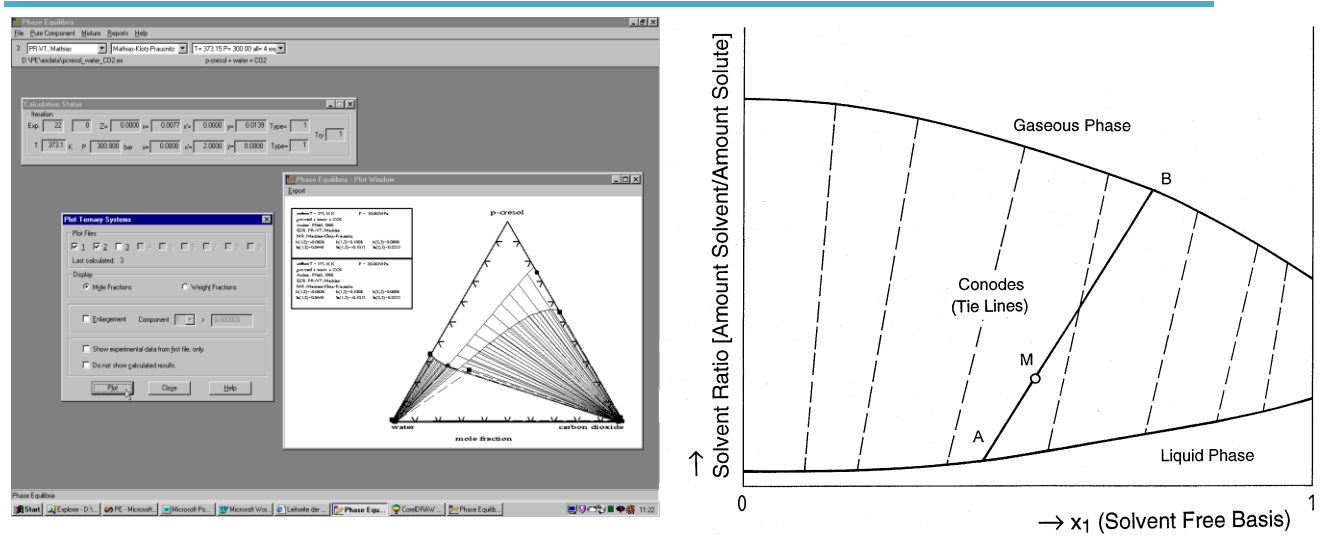


Figure 2 : Ternary High Pressure Phase Equilibrium Plant (TUHH programming tool "PE"), and Ponchon Savarit Approach for column design (Brunner, 1994)

TUHH Laboratory of Thermal Separation Processes disposes on modeling expertises and experimental plants for Batch SFE (size 40 mL to 40 L , 100- 1000 bar, Figure 3) and Countercurrent SFE (height 1,5 m to 7m / reflux, figure 4), as well as High pressure phase equilibrium cells (up to 4000 bar).

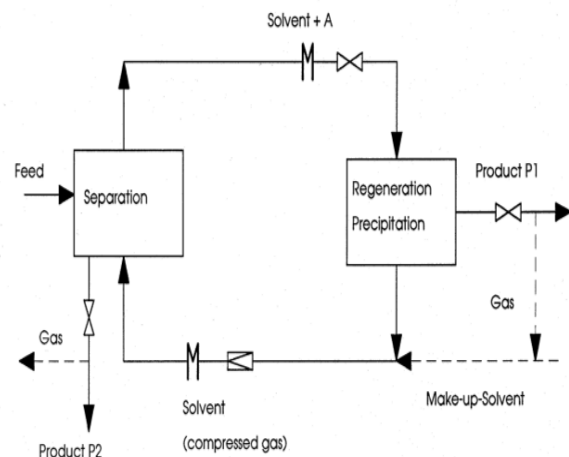


Figure 3: Batch SFE Plant (1L, 1000 bar Capacity , Sitec) and the basic process extraction process (Brunner, 1994)

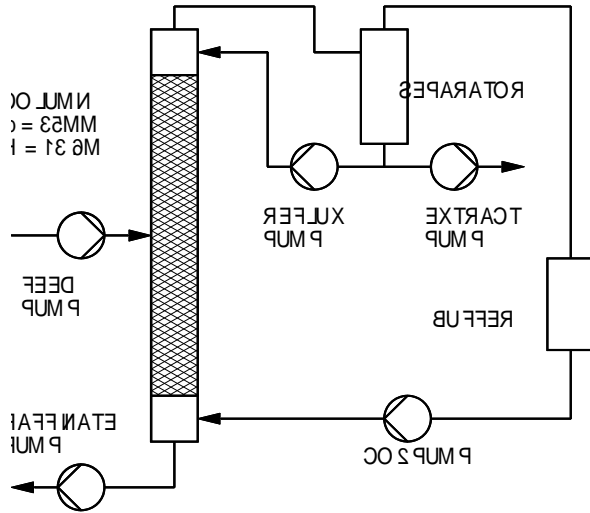


Figure 4 : Countercurrent SFE plant, and basic process design (Brunner, 1994)

Upscale and cost estimations are feasible via flooding point considerations and thermodynamic process cycle diagrams.

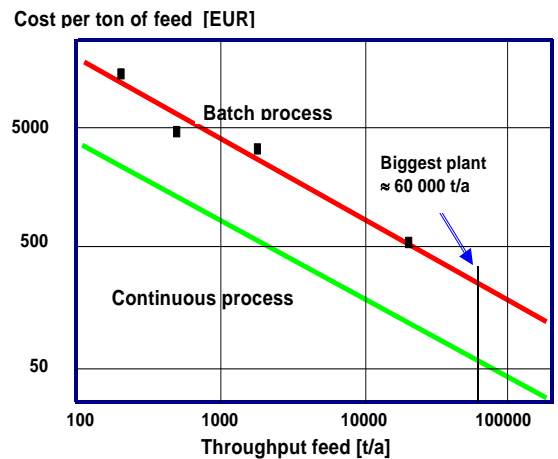
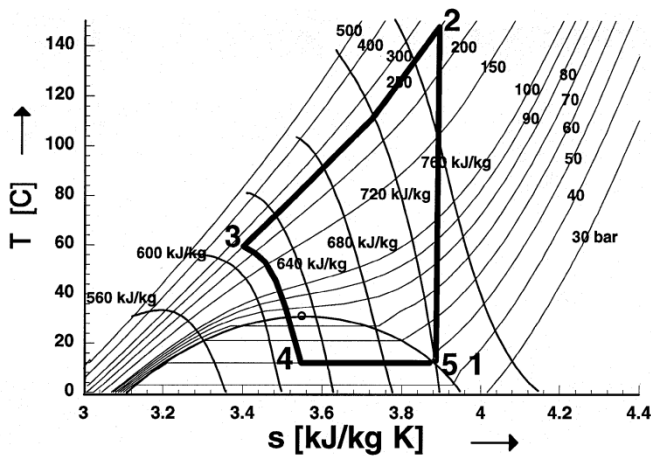


Figure 4 : Pump and Compressor Cycle in the T,s Diagram, Economy of Scale in SFE processes (Brunner, 2009)

The Biorefinery Group at TUHH, Institute of Thermal Separation Processes performs fundamental research (Lignin desodorization, bulk oils, polyphenols) and applied/contract research in the field of supercritical fluid extractions.