SUPERCRITICAL CO_2 EXTRACTION OF BIOLOGICAL SUBSTRATES: FROM THE LABORATORY TO THE INDUSTRIAL APPLICATION

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The extraction of valuable compounds from biological substrates using supercritical (sc) CO_2 as a replacement of conventional organic solvent has been an industrial reality for more than three decades. Current commercial actors in the technology include industrial plant manufactures and companies producing high-value compounds for specialty applications. Despite this, there is reluctance in adopting this high-pressure technology because of the wrong perception that $scCO_2$ extraction is not fully competitive.

This work reviews economics of $scCO_2$ extraction of vegetable oil from prepressed oilseeds (20% residual oil content) that can be viewed as a network of interconnected, open pores filled with freely available oil expelled from parenchymatous cells during pressing. Mass transfer in this substrate can be described using a shrinking core model with an effective diffusivity that can be related to a particle-size and $scCO_2$-condition-independent microstructural factor. This case study was selected because a fully predictive model of the extraction process applies for process simulation purposes. Indeed, there are dimensionless correlations proposed in literature for transport phenomena (film mass transfer, and axial dispersion) in a packed bed operating with supercritical fluids, and for the solubility of vegetable oils in $scCO_2$.

Extraction cost estimates are anchored in a simulation program describing the relationship between oil yield and extraction time in an industrial plant having $\geq$3 extraction vessels, which cannot be properly accounted for in laboratory and pilot plan runs using a single extraction vessel. A typical cost of about 8 USD/kg oil was estimated. The optimal $scCO_2$ mass flow rate depends on particle diameter (which is not necessary to reduce below 2 mm) and extraction cost depends little on the length-to-diameter ratio of the vessels. For a same total volume of extraction vessels, the cost diminished as the number of vessels increased. For the same plant productivity, the cost diminished when increasing extraction pressure above 30 MPa. Economies of scales reduce cost when plant size increased.

Keywords: carbon dioxide, prepressed oilseeds, plant simulation, production cost.

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