Bidisperse shrinking core model for supercritical fluid extraction

A.G. Egorov, A.A. Salamatin[1]
Kazan (Volga Region) Federal Univ., Inst. of Mathematics and Mechanics, Dep. of Aerohydromechanics, 420008, Kazan, 35 Kremlyovskaya, Room 503, Russia; tel. +7 (843) 2337230; e-mail[1]: Arthouse131@rambler.ru

This study re-examines conventional interpretation of overall extraction curves (OEC) observed in supercritical fluid extraction (SFE) of ground oilseeds. A representative set of available SFE experiments with pre-sieved particle fractions of different (measured) characteristic size [1-4] has been chosen for analysis. All the obtained OECs can be divided into two parts: (1) the initial stage I at a constant extraction rate and (2) the subsequent diffusion-controlled stage II with extremely low extraction rates. For each fixed particle size the OECs are usually described as monodisperse packed beds of spherical particles on the basis of the broken-and-intact-cell (BIC) model [5]. This assumes that the cells with broken membranes and free oil are depleted first during the stage I, and oil from intact cells is extracted at the later stage II. BIC model generally agrees with the OEC data but the predicted (deduced) amounts of broken cells have not been so far verified in experiments.

As an alternative possibility, we assume that, instead of broken cells, the packed beds of ground oilseeds always contain a significant fraction of very small particles ("dust") which extraction dominates during the initial period. The bidisperse representation of particle ensembles in the selected series of experiments with a wide variety of apricot [1], pumpkin [2], grape [3] and sunflower [4] seeds allowed us to match the observed OECs with the use of the modified shrinking-core model (SCM) [6, 7]. In case of bidisperse granulometric distribution of the substrate, a simple asymptotic solution was found for typical SFE conditions. The SCM approach has also been expanded to describe SFE in polydisperse beds.

Obviously, the dust fraction in SCM is a substitution for broken cells in the BIC model. Special light microscopy studies were performed to reveal and examine the dust fraction in ground seed substrates. It has been found that the dust particles can adsorb on the surface of bigger particles and/or group together to form a single stable compound. These observations do not exclude the simultaneous existence of broken cells but of lesser volume fraction. Future experimental work is needed to further clarify this question.

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