THERMODYNAMICS AND CHEMICAL ENGINEERING DATA
Chinese Journal of Chemical Engineering, **17**(6) 1014—1020 (2009)

Solubility of Piperine in Supercritical and Near Critical Carbon Dioxide*

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Abstract Piperine is a member of the lipids family commonly found in peppercorn, ginger and other natural sources and is grouped as an alkaloid. The solubility of piperine has been determined in carbon dioxide at near critical and supercritical conditions in a dynamic extraction apparatus. The conditions studied were at pressures ranging from 10 to 20 MPa and temperatures at 293, 300, 313, 323 and 333 K. The results showed that piperine solubility increased with increasing pressure at all temperatures studied. The solubility of piperine in near critical conditions was slightly higher than that at supercritical conditions only at the low-pressure range. Two semi-empirical density dependent correlations, namely the Chrastil model and the Dilute Solution model, were also used to estimate the solubility data. Although both models showed good correlation with the solubility data, the Dilute Solution model performed better prediction than the Chrastil model.
Keywords solubility, piperine, supercritical, near critical, carbon dioxide

1 INTRODUCTION

A large variety of complex alkaloids are abundantly found in natural products. Piperine is an alkaloid commonly found in peppercorn and ginger. It is a solid substance essentially insoluble in water. It is a weak base that is tasteless at first, but leaves a burning after taste. Piperine is the *trans-trans* stereoisomer of 1-piperoylpiperidine. It is also known as (*E*, *E*)-1-piperoylpiperidine and (*E*, *E*)-1-[5-(1, 3-benzodioxol-5-yl)-1-oxo-2, 4-pentdienyl] piperidine. The molecular formula of piperine is $C_{17}H_{19}NO_3$ and its chemical structure is shown in Fig. 1 [1]. Piperine is found naturally in plants belonging to the *Piperaceae* family, such as *Piper nigrum* L, commonly known as black pepper, and *Piper longum* L, commonly known as long pepper. Piperine is the major pungent substance present in these plants and is isolated from the fruit of the black pepper and long pepper plants.

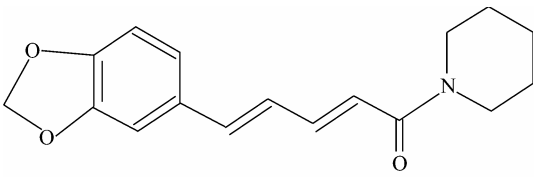

Figure 1 Molecular structure of piperine

The interest in this alkaloid compound is a result of recent medical studies, which have shown piperine to be very helpful in increasing the absorption of certain beneficial vitamins such as vitamin B and β-carotene, and trace element such as selenium. Piperine apparently has the ability to increase the natural thermogenic activities of the body. Thermogenesis is the process of generating energy in the cell. Piperine increases thermogenesis and in turn creates a demand for nutrients necessary for metabolism. This has so far been particularly helpful for patients who are sick or aged with defective intestinal lining [1]. Piperine does not only add a pinch of flavour to food but also to alcohol, for example, brandy, which is known for having a small amount of it. While piperine may sound like a pleasant spice, it can also be a strong repellent. It can be found in most insecticides, particularly those that kill the common housefly [2].

The work presented in this paper is a small part of a broader project to study the use of supercritical carbon dioxide to selectively extract piperine free pepper oil from black pepper corn. Previous researchers have reported that pepper oil is a mixture consisting of 90% hydrocarbons and 10% oxygenated terpenes and aromatic compound [3]. The hydrocarbon fraction is composed of monoterpenes (70%−80%) and sesquiterpenes (20%−30%), which appear to possess the desirable attributes of pepper flavour. Though oxygenated terpenes are relatively minor constituents, they contribute to the characteristic odour of pepper oil [4].

The separation and isolation of piperine from its natural sources is very complex. Thus, it is not synthesised at a large scale in any chemical plant and is not commercially available [1]. Murga and co-workers reported the extraction of phenols from grape seeds using supercritical carbon dioxide and concluded that by adjusting variables such as temperature, pressure and co-solvent amount, a variety of phenolic compounds

Received 2009-02-10, accepted 2009-07-10.
* Supported by the IRPA Project of the Ministry of Science, Technology and Innovation, Malaysia (09-02-03-0101-EA0001) and Fundamental Research Grant 2009 Directorate General of Higher Education, Ministry of National Education, the Republic of Indonesia.
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