A Laboratory Study on the Extraction of Oil from Canola Seeds by Using Supercritical Carbon Dioxide

Soroush Zarinabadi*[1], Riyaz Kharrat[2], Ali Vaziri Yazdi[3]

***Abstract* — in the present study a laboratory Pilot Plant for supercritical fluid extraction was used to make oil out of Canola seeds. This Pilot Plant was designed to function in the operational pressure up to 5000 Psi, and the operational temperature up to 100 degrees centigrade. More than 50 laboratory points concerning the extraction of oil essence out of Canola seeds have been studied and evaluated by the use of supercritical CO_2 in different operational conditions. The required data was obtained by carrying out a series of related experiments. The analysis of data showed that the increase of pressure up to 2250 Psi and the temperature up to 55 degrees centigrade brings about the increase in the viscosity of the extracted oil in supercritical phase, and thereafter, the increase in pressure and temperature was not perceptible in the exit phase.**

***Keywords:* Supercritical fluid, Extraction, Canola Seeds, Essential Oil.**

I. Introduction

In supercritical conditions, fluids show properties which in some situations, can be considered gases and in other cases as liquids. The physical properties of supercritical fluids such as density are similar to liquids, and the transitional properties, such as diffusivity, viscosity, indulgence of traction, behave like gases. Because of their high permittivity, in supercritical condition, these fluids can solve many materials in a specific pressure and temperature, and because of the high vaporization ability of these fluids, they extract easily from fluid. Moreover, the solubility power of these fluids can be changed extremely by an appropriate change in temperature and pressure.

Therefore, these characteristics have created appropriate potentials for implementing these fluids in the processes of extraction. However, this method can be used for extraction of particular, scarce, or expensive materials which can not be extracted via current methods.

* Corresponding author. PhD Student of Chemical Engineering. (Corresponding author to provide phone: 00989166523309; fax: 00986113329193; E-mail: zarinabadi@ yahoo.com).

1- Islamic Azad University- Science & Research Branch – Tehran, Iran. (E-mail: zarinabadi@ yahoo.com).

2-Petroleum University of Technology-Tehran, Iran (E-mail: kharrat@put.ac.ir).

3- Islamic Azad University- Science & Research Branch – Tehran, Iran (E-mail: avy123@behta.com).

II. Review of Literature

In the early 1975, the price of energy increased unpredictably as a result of the world events, which was a great problem for the industrial countries. Consequently, most universities and research centers turned toward the lower consumption of energy. Using the supercritical fluid for separation of mixtures was one of these movements. In this process glorify recovery with the use of a sudden tension was used, for example extraction operations like liquid-liquid do not require distillation operations.

Therefore, this causes reduction in consumption of energy. Among the number of benefits of supercritical technology, are alimentary industries, medicinal industries, and bio-ecology industries.

Cleaning methods of soil is divided into two groups of: cleaning land in general, and cleaning the earth via drilling. Generally, cleaning the soil in its place is cheaper than cleaning the soil via drilling. Cleaning soil in its place is divided into three groups of physical-chemical cleaning and thermal cleaning processes. Since 1982, using supercritical technology for cleaning the soil and the extraction of contaminators from it and other solids, like ashes, river sediments and active carbon dioxide, became the focus of interests.

Dr. Acharman carried out a lot of studies on bio-etiology, which are published in scientific articles, presented in national and international conferences, research seminars and reports, and are appreciated by scientific associations. Some of these studies are as following:

In 1999, Tavalarides, Antitescu and Antitescu studied the solubility power of PCB in supercritical condition. The limits of the pressure in this study were 100 to 300 bar which in the temperature 313 to 323 and 333 degree of Kelvin was examined. The best result of all kinds of PCB was obtained in the temperature of 333 degrees of Kelvin, and pressure of 300 Bar at the presence of normal Butan.

Hartonen and his colleagues in 2002 extracted PAH s, PCBs, and TPH out of soil by using supercritical CO_2. A comparison was made between extraction via supercritical and extraction via solvents. The result revealed the good efficacy and recovering power of extraction via supercritical technology.

In 2004, Libran and his colleagues in Italy used supercritical CO_2 to extract PAHs from sea sediments. This sample contained different kinds of organic contaminators existed in the environments with low density. The extraction operation was carried out in 50 and 80 degrees of centigrade and the limits of pressure were 230 to 600 bar, using three auxiliary instances of organic solvents (Methanol, Toluene

ISBN: 978-988-18210-0-3
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

and Normal Hexane) which were added as 5% of the volume.

III. Supercritical Fluid Extractor (SCFE) laboratory Pilot Plant

For taking the extract oil out of Canola seeds by supercritical fluid, a thermodynamic machine is required to extract the high pressure. The designed method of SCFE has been presented by different researchers such as Van Leer, Paulaititis, Kurnik, Hollow, Red Krukonis, Eckert and Johnson, and Praunits [6] – [8]. This pilot can be used for separation and extraction of oil out of Colza seeds by SCFE laboratory pilot used in this research. As it can be seen in the following picture, this machine can function in static and dynamic states. In this system two specially designed Transfer Vessel are used to provide system pressure by Nitrogen gas.

The possibility of establishing flow of CO_2 gas in the machine in two separate and different directions by fixing (tuning) the existing valve in the machine, is the characteristic of the system. The extraction vessels are made of stainless steel like other parts of the system. It also resists against 10000 Psi pressure. The container has a side glass made of silicon material, and can withstand high pressure. Therefore, seeing the contents of internal compartment and the process of formation of fluids by machine is made possible.

The ability of the designed pump for rotating the supercritical fluid within the system is another unique feature of this machine comparing to other devices the mechanical part of this pump are designed and made manually and have the ability of two-phase fluid in thermal range up to 100 degrees Celsius and with Flow Rate between 2 liters up to 8 liters, which can be tuned by operator regardless of creation of Cavitations in the system. This device uses air bath system to provide the required temperature. The designed air bath is able to provide temperature of 100 degrees Celsius uniformly.

In this study several experiments were carried out in different conditions of pressures and temperatures. So that, in each pressure different temperatures and quantities of extracted oil were investigated and evaluated. The operational conditions and temperatures from 35 degrees Celsius with intervals of 250 Psi to 2750 Psi in the form of pressure changes from 1500Psi to 60 degrees centigrade with 5 degrees interval during the experiment is intended in each test performed, and the amount of oil extracted from other conditions including colors and types of compounds in the extracted essence were investigated.

First, some tests were performed to determine the optimum particle size and. According to the following graphs the best flow rate of supercritical fluid for the extraction of 5.5 liter min, were determined to be best particle size for extraction of 120 micro meters.

III. Experiments

In all tested temperatures the density output increased with the increase of pressure from 1500 Psi to 2750 Psi. In low temperature (35 and 40^{0C}) with the increase of pressure from 1500 Psi to 2750 Psi, about 30 to 40 percents. On the other hand, in higher temperatures (45 to 60 º C) with increasing pressure from 1500 Psi to 2750 Psi, the density of extracted oil from colza in supercritical co_2 phase increased over 100 percents. This increase of density was due to the increase of carbon dioxide pressure in the desired thermal range. In fact, the increase of pressure causes the increase of power and solubility of carbon dioxide and increase in viscosity of solvents with soluble component. Interestingly, with the increase of pressure, the distance between molecular is reduced and the contacts between molecular of CO_2 solvents and essence of colza seeds is increased and consequently the extraction efficiency is increased.

According to observations and the obtained laboratory data, the effect of temperature on the extraction of oil from the extract of Canola is a little complicated. In pressures higher than 2000 Psi, the solubility increased with temperature. This is because of the effect of steam pressure of solved materials in supercritical phase.

This phenomenon is seen when the temperature increased from 35 º C to 50 º C, but in pressures higher than 50 º C this phenomenon is not so sensible, and remained almost without change. In lower pressures, i.e. 1500 Psi and 1750 Psi, with increasing temperature solubility decreased due to the effect of reducing pressure and decreasing density.

IV. Conclusion

In this study, more than 50 laboratory data in relation of extracting the essence of canola seeds with the help of supercritical CO_2 in different operational conditions: temperatures of Supercritical CO_2 35 to 60, pressures from 1500 Psi to 2750 Psi, and supercritical carbon dioxide Flow Rate of 2 Lit / Min to 7.5 lit/Min were examined and the following results were obtained:

According to the obtained tables, the best operational conditions for extraction of oil from Canola seeds and the maximum efficiency with this method was seen to be the pressure of 2250 Psi and temperature of 55 degrees centigrade in Flow Rate with 5.3 Lit / Min and 120 Micrometer of Particle Size of Canola seeds.

In the Fig (5), it can be seen that in the pressures lower than 140 bars the increase of temperature reduces the density. This is because of the reduction in number of neighborhood as a result of is rising temperatures, but in pressures higher than 140 bar very rising temperatures has a little impact on density that this is because of increase in the number of neighborhoods as the result of increase in the pressure.

Appendix

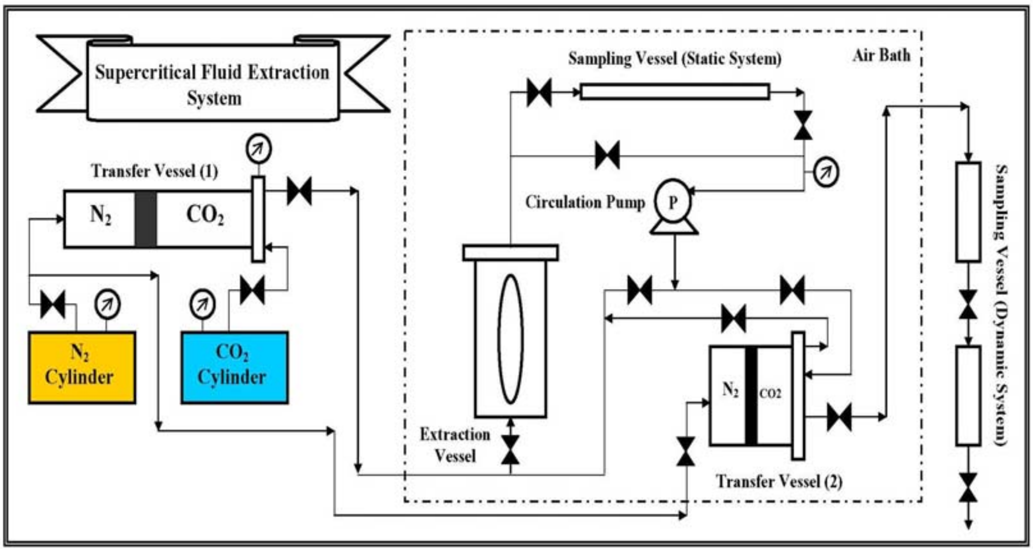

Fig (1). Schematic diagram of the Supercritical Fluid Extraction System (SCFE) for Extraction of oil from canola seed with supercritical carbon dioxide

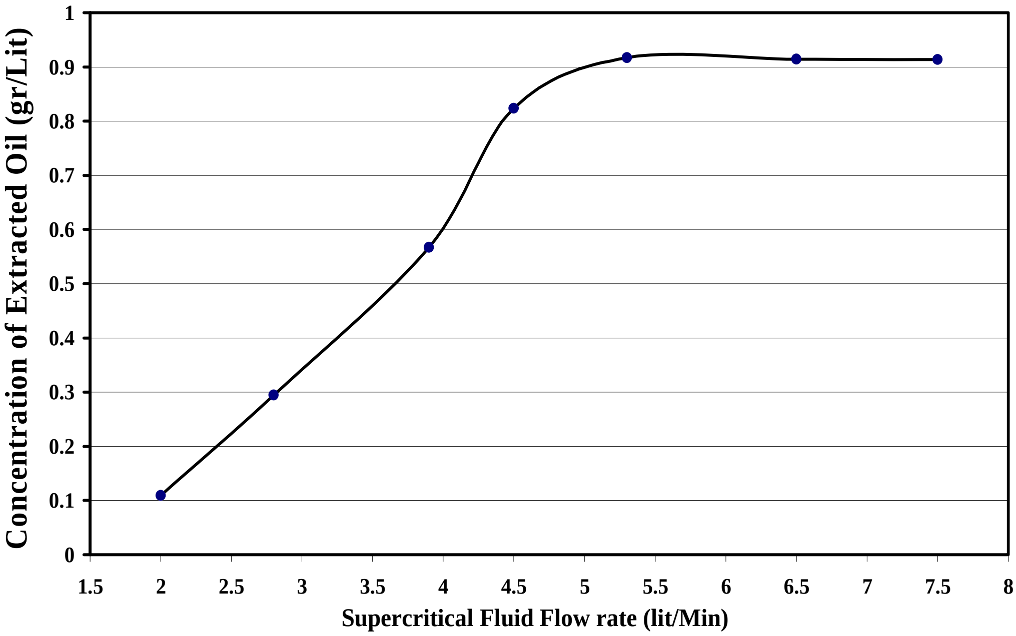

Fig (2). Concentration of Extracted Oil as a function of S.C.F Flow Rate

ISBN: 978-988-18210-0-3
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

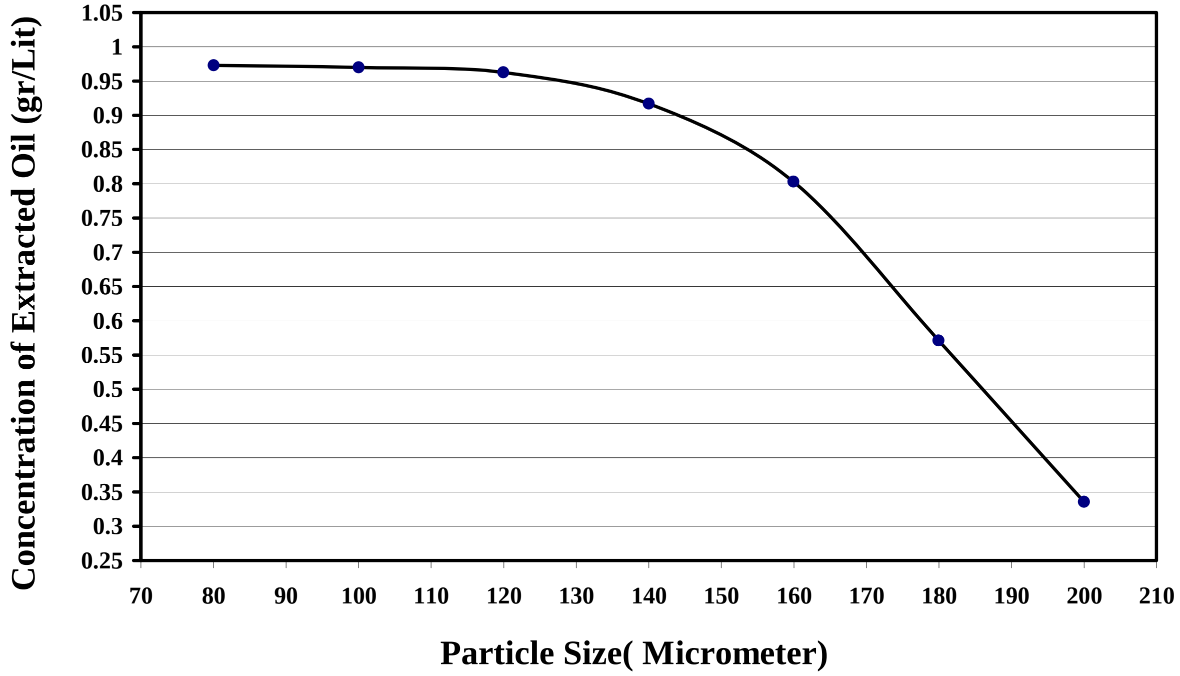

Fig (3). Concentration of Extracted Oil as a function of Particle Size

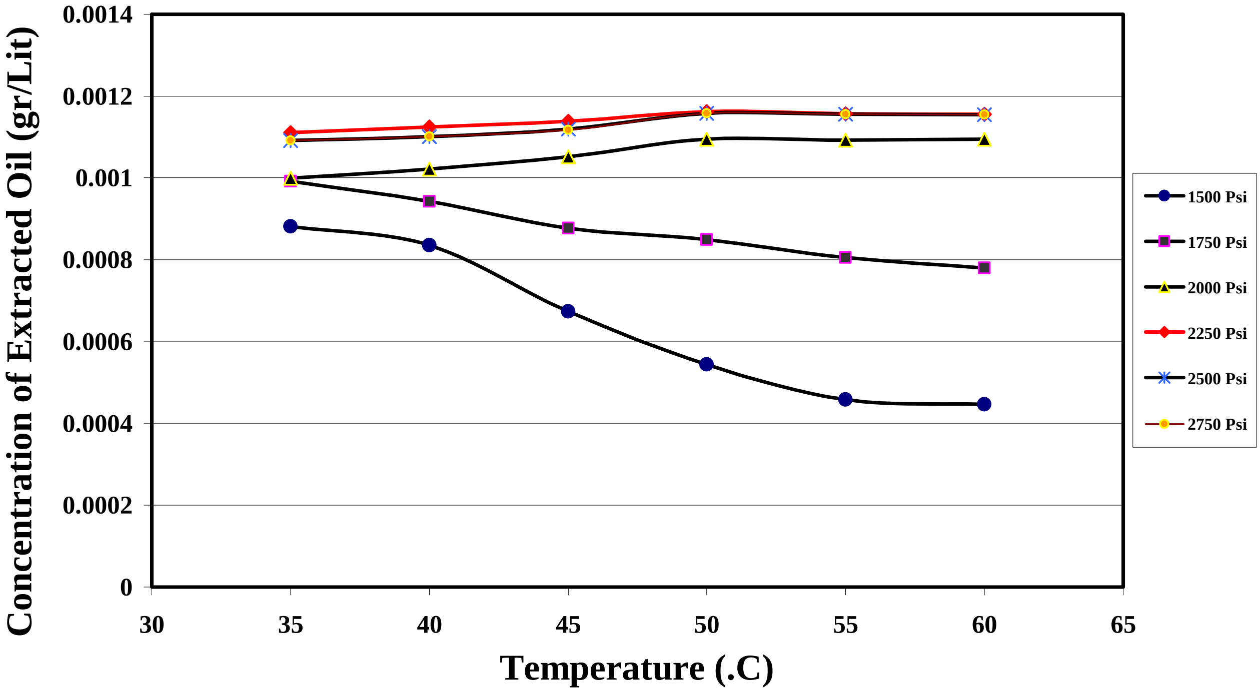

Fig (4). Concentration of Extracted Oil as a function of Temperature

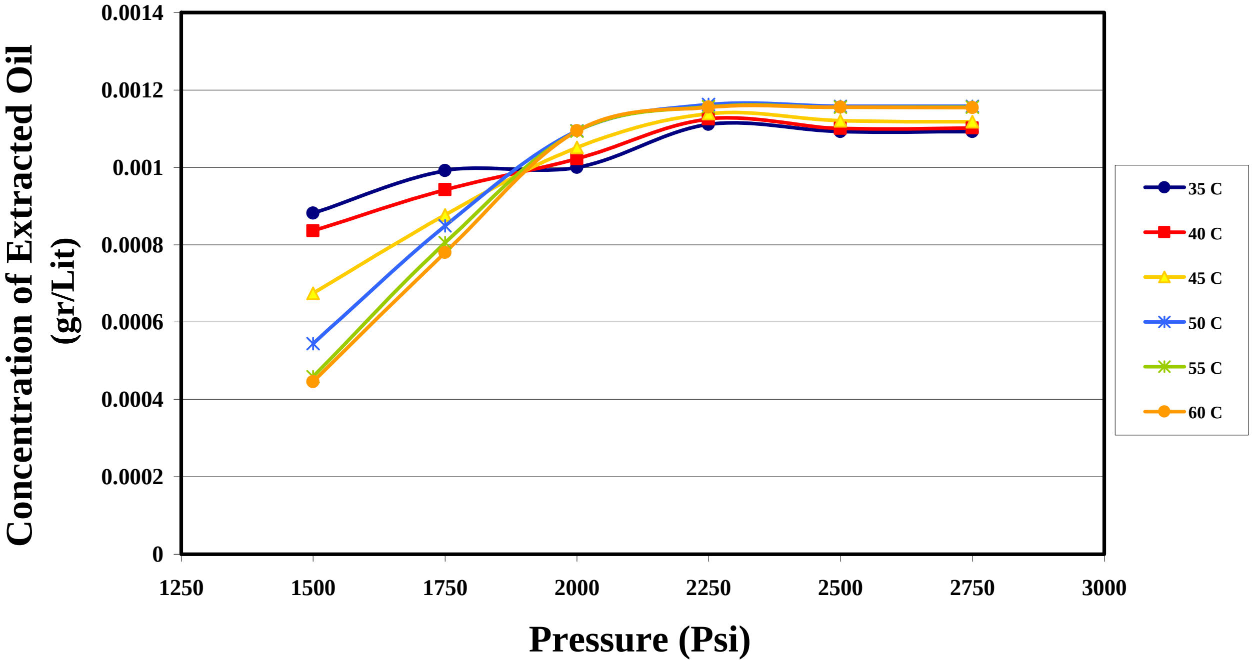

Fig (5). Concentration of Extracted Oil as a function of Pressure

REFERENCES

[1] Ahmadpanah, S. S., Lotfallahi. M. N., Haghighi. A., "Iranian Chemical Engineering Journal" 5-22, 2006, pp. 53-68.
[2] Becnel. J. M., Dooley. K. M., Ind. Eng. Chem. Res 37, 1998, pp. 584-594.
[3] Antitescu, G., Tavalarides. L. L, .,"J. Of supercritical fluids 38 ", 2006, pp. 167-180.
[4] Antitescu, Tavalarides. L.L," J. Superscript. Fluids 14", 1999, pp.197–211.
[5] Hartonen, K, Bøwadt. S., Hans Peter Dybdahl, Kerstin Nylund, "J.Chromatography A 958", 2002, pp. 239–248.
[6] Mgyesy. E. F.," Pressure Pessel Handbook", 6th Edn. Tusla: IN Publishing, 1993.
[7] Nayyar. M. L, "Piping Handbook". 6th Edn. New York. McGraw Hill, 1992.
[8] Nolting. B. E., "Instrumentation Reference Book", London: Butterworth, 1988.
[9] Esmaeilzadeh, F. & Goodarznia, I.. "Separation of phenanthr from anthracite oil using supercritical carbon dioxide". Chem. Eng. Technology, 2005, pp.106-109

ISBN: 978-988-18210-0-3
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)