Extraction of Ginger Oleoresin from Ginger-Root Using Supercritical CO_2

Background

Fairly recent developments in extraction technology have led to the increased use of spice oleoresins as opposed to the spices themselves. An oleoresin consists of the total soluble components that are extracted from a particular spice by a solvent. Ginger oleoresin has widespread uses as a flavoring agent in foods, beverages, and medicines. The increased prominence of oleoresins over natural spices is due to the advantages that oleoresins hold over the spices themselves. These advantages include increased economy in use, more uniform flavor and concentration, and lack of microbial contamination. In particular, oleoresins extracted with supercritical fluids have a higher price, offer higher quality, and have less variations in the final product than those extracted with organic solvents. Replacement of organic solvents such as hexane, ethyl acetate, and chlorinated hydrocarbons with a benign solvent such as supercritical CO_2 is also considered desirable from an environmental standpoint.

Environmental Significance

environmentally friendly extraction process

safe substitute for organic solvents

volatile organic compound (VOC) emissions eliminated

Process Description

The PFD is attached. In the process, Jamaican ginger root is first charged to T-101, the extraction vessel. Supercritical CO_2 is then fed from the holding tank, TK-101, to the extractor. The supercritical CO_2 is then passed through the extraction vessel for a total of six hours. At this point, 95% of the 6-gingerol, which is assumed to make up 30% of the ginger oleoresin, has been removed from the ginger root. The CO_2 and extracted ginger oleoresin leave the extractor and enter E-101, the pre-heater, where the mixture is heated using low-pressure steam. The pressure of the mixture is then throttled to 65 bar, causing the supercritical CO_2 to become a gas. The two-phase mixture then enters the flash vessel, V-101, where essentially all of the liquid oleoresin exits from the bottom of the flash vessel. Essentially all of the CO_2 exits the top of the flash vessel and then enters C-101 and E-102, where it is compressed and cooled back to supercritical pressure and temperature. The recycled CO_2 is then sent back to TK-101.

After the extraction, the CO_2 and extracted ginger oleoresin enter a pre-heater and then a throttling valve. It is necessary to heat the mixture before entering the valve to keep the oleoresin above its freezing point of 31°C upon the reduction in pressure.

The process is operated such that the entire amount of CO_2 in the holding tank is circulated through the process only once over the six-hour extraction period. Once a given amount of CO_2 has passed through all the pieces of equipment, it is sent back to the storage tank where it is accumulated for extraction of the next batch of ginger root. The process is then shut down for two hours while the spent ginger is removed from the extractor and a new batch of ginger root is charged to the extractor.

Necessary Information and Simulation Hints

A process simulator is not used for this design. All calculations are easily done on a spreadsheet.

CO_2 becomes a supercritical fluid (SCF) when heated above its critical temperature and compressed or pumped above its critical pressure, which are approximately 31°C and

74 bar, respectively. Most SCF extractions require temperatures and pressures well above the critical temperature and pressure to obtain reasonable recoveries of the extract.

The six-hour extraction time was determined from available experimental data[1]. The extraction proceeds through three stages. The first stage is a washing stage in which the root is washed prior to extraction. Next is the fast extraction stage, which occurs at low concentrations of the oleoresin in the supercritical fluid and results in relatively low extraction times. Finally, there is the slow extraction stage which requires longer extraction times due to decreased rate of mass transfer, which is hindered by high concentrations of the oleoresin in the extracting fluid. It is assumed that the extraction is complete at the end of the fast extraction stage, which requires six- hours[1].

Also, there is a CO_2 make-up stream shown on the PFD. This make-up stream takes into account the fact that, in reality, a process such as this would lose some of the recycled CO_2 over a period of time. This CO_2 should be replaced to maintain the desired flowrate and, thereby, the desired mass transfer of the oleoresin into the supercritical CO_2.

References

1. Spiro, M. and M. Kandiah. “Extraction of ginger rhizome: kinetic studies with supercritical carbon dioxide.” *International Journal of Food Science and Technology.* Vol. 25, pp. 328-338, 1990.

Equipment Descriptions

T-101	Ginger Oleoresin Extraction Vessel
E-101	Flash Vessel Pre-heater
V-101	Flash Vessel
C-101	CO_2 Recycle Compressor

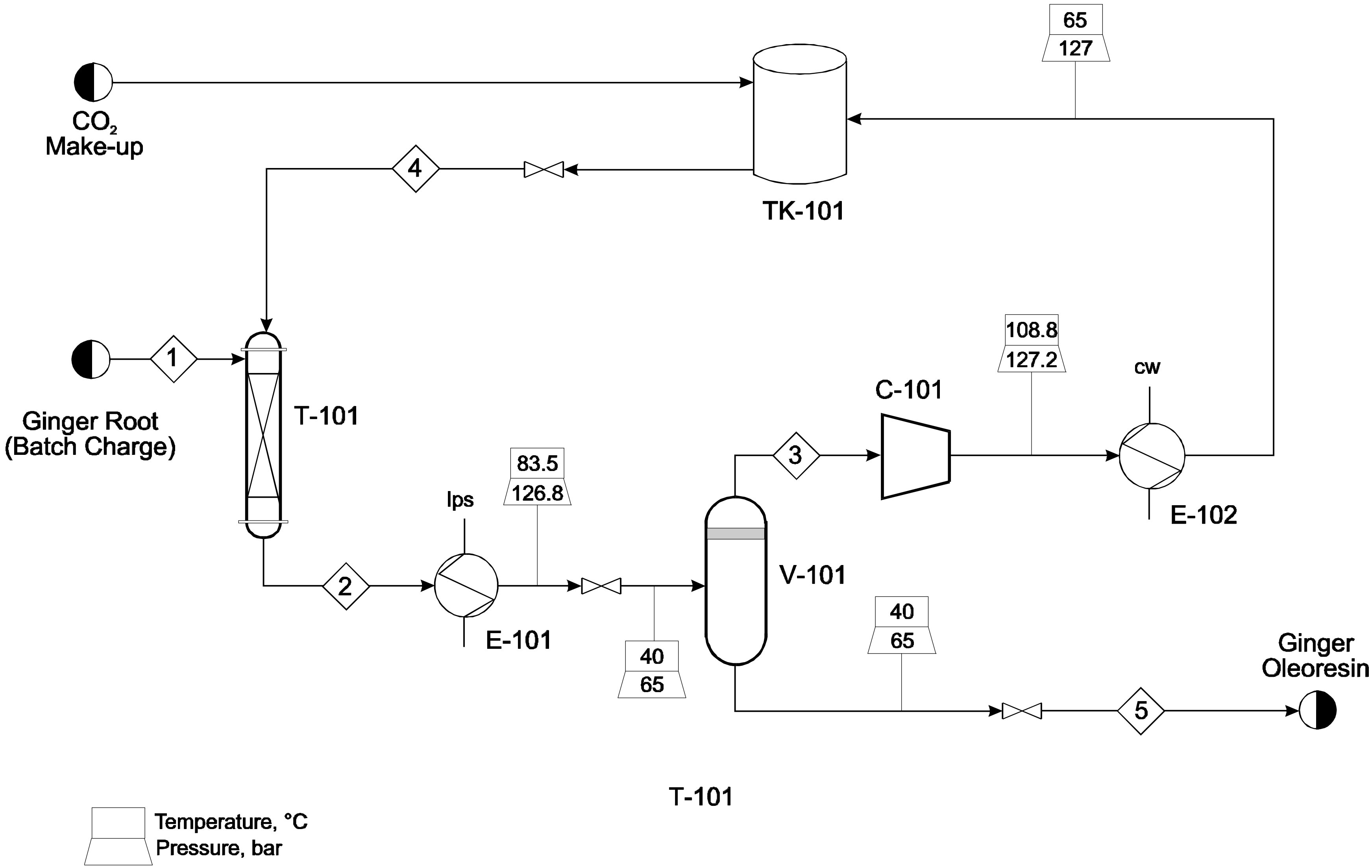
E-102 Recycle Cooler

TK-101 CO_2 Storage Tank

Ginger Oleoresin Extraction Stream Table

Stream No.	1	2	3	4	5
Temperature (°C)	--	65	40	65	40
Pressure (bar)	--	127	65	127	1.0
Phase	solid	supercritical	vapor	supercritical	liquid
Total Flow (kg/h)	468.2*	3708	3706	3706	2.27
Component Flowrates (kg/h)					
Carbon Dioxide	--	3706	3706	3706	--
Jamaican Ginger Root	468.2*	--	--	--	--
Ginger Oleoresin	--	2.27	--	--	2.27

* Note: The flow of Jamaican ginger-root is actually a batch charge at the beginning of each extraction under ambient conditions.



PFD for Extraction of Ginger Oleoresin from Ginger Root