CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)

Samantha M. Guhan

Project Number

31622

Project Title

A Unique Liquid CO(2) Based Green Extraction Process to Obtain Essential Oils from Spices

Abstract

Objectives/Goals

There is a great need to develop teaching labs that expose students to green chemical processing. The goal of this project is to develop a unique, convenient, visually dramatic process that employs the green solvent liquid CO2 to extract essential oils from spices. Students learn to draw on a wide variety of concepts such as phase diagrams, steam distillation, analytical techniques such as gas chromatography and mass spectroscopy, and chemistry of natural products.

Methods/Materials

The success of this design hinges on developing a system that safely builds and maintains pressure to maximize liquid phase CO2 and its contact with the spice. Therefore key parameters such as nature and size of extraction vessel, sample characteristics (size, texture and container), liquid CO2 availability, and bath temperature were optimized. Spices such as cloves, cumin, cinnamon, nutmeg and cardamom were extracted.The yield of essential oil was measured and composition determined using GC-MS. For cloves, the liquid CO2 method was compared with steam distillation in terms of yield, overall product distribution and quantitative assessment of the main component eugenol.

Results

The lab provides a real time visually dramatic evidence of phase change and extraction. The ideal extraction vessel that meets pressure requirements and safety criteria is a 15ml plastic centrifuge tube. Other optimal conditions include 1g sample of moderately ground spice in a sealed tea bag, dry ice (7g) filled to maximum capacity and a 38C water bath. The designed process successfully extracts essential oils from all spices tested. Yields are consistent with literature values and the key component of every essential oil is reproducible. In cloves, while steam distillation gave a higher yield, product distribution was superior in liquid CO2 extraction; twice the ratio of secondary products, caryophyllene and acetyl eugenol, to eugenol was obtained. A significant advantage of this process is the speed of extraction - about 15-20 minutes compared to 4 hours for steam distillation.

Conclusions/Discussion

The designed liquid CO2 extraction process works and is a great addition to a teaching lab curriculum based on green processing. Future experiments will focus on further optimizing the experimental set up, testing it in undergraduate labs to ensure reliability, and finding a way to measure the exact temperature and pressure in the extraction tube.

Summary Statement

A unique, visually dramatic, teaching lab on green processing that employs liquid CO2 to extract essential oils from spices was successfully designed and evaluated for its merits.

Help Received

Dr. Hampton was my advisor for this project - all experiments were done in his lab. Parents gave rides and edited report.