

Incorporation of the GEMs item: **Liquid CO<sub>2</sub> extraction of D-limonene from orange peel** submitted by James E. Hutchison into the Organic Chemistry curriculum.

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**Summary:** This experiment is an environmentally friendly extraction of a natural essential oil (limonene) from a citrus peel using liquid CO<sub>2</sub>, which is generated by liquefying crushed dry ice in a 15 mL polypropylene centrifuge tube. There is a definite 'wow' factor to this student favorite as the triple point of CO<sub>2</sub> is visualized. This experiment has broad utility in a variety of settings, including the organic lab. It is rapid and easy, leaving time during a traditional laboratory period for thorough characterization of the natural product by techniques such as <sup>1</sup>H NMR, GC (or GC-MS) and IR.

Essential oils are organic compounds that are extracted from natural sources and used in many products such as flavorings, fragrances, and cleaning products. Traditionally essential oils have been extracted through the use of steam distillation or organic solvent extraction. It is a productive exercise to contrast these techniques with the use of liquid CO<sub>2</sub>. The purity of the product can be compared to that of products isolated by traditional steam distillation or solvent extraction methods. The chemical concepts demonstrated in this experiment include extraction, utilization of natural products, physical properties, and phase change.

Another venue of discussion is the utility of CO<sub>2</sub> as a green alternative solvent. It provides environmental and safety advantages over traditional organic solvents. Since CO<sub>2</sub> is nonflammable, essentially nontoxic, readily available, and environmentally benign. Processing with CO<sub>2</sub> also poses minimal hazard in the event of unintentional release or residual solvent in the product. Although CO<sub>2</sub> can act as a greenhouse gas, it is captured from the atmosphere to be used as a solvent. Since it is not created anew, there is no net CO<sub>2</sub> increase.