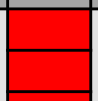
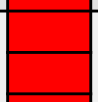
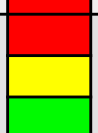
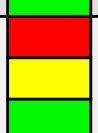
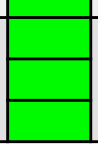
Distillation: Simple and Fractional

Summary:

Simple and fractional distillation are commonly taught as they are essential techniques for the organic chemistry laboratory. Organic solvents such as toluene and cyclohexane are commonly used to demonstrate the separation of solvent mixtures through distillation (Simple and Fractional Distillation of a Cyclohexane-Toluene Mixture, Macroscale and Microscale Organic Experiments, Williamson, K.L., Masters, K.M., 6th Edition, Brooks/Cole Cengage Learning, 2011, pp. 92-95). Ethanol-water mixtures can also be used and the purified ethanol tested for purity through an ignition test (Simple Distillation of an Ethanol-Water Mixture, Macroscale and Microscale Organic Experiments, Williamson, K.L., Masters, K.M., 6th Edition, Brooks/Cole Cengage Learning, 2011, pp. 93-95).

Laboratory experiments involving the purification of waste acetone are also being performed as means for teaching students about solvent recycling and for a simple way to recycle acetone that is used extensively in the organic chemistry laboratory to clean glassware and for other purposes (Simple Distillation: Purification and Reuse of Acetone, Lecher, C.S., Marian College, Greener Educational Materials for Chemists, 2007 [http://greenchem.uoregon.edu/PDFs/GEMsID91.pdf, Accessed February 2017], Recycling of Waste Acetone by Fractional Distillation, McDougal, O.M., et. al., J. Chem. Educ., 2011, 88 (12), pp 1724–1726

Solvent table: Refer to the solvent selection resources in the introduction of this resource for further information regarding solvent substitution. The table below listed commonly used distillation solvents and their relative EH&S information.

Chemical Name Aldrich Catalog #	Amount per 100 students (g or mL)	EH&S	Purchasing cost per liter
Cyclohexane	(varies)		$65.25
Toluene 244511	(varies)		$41.90
Acetone 650501	(varies)		n/a (if waste acetone is used)
Ethanol 459836	(varies)		$77.50
Water n/a	(varies)		n/a

Chromatography: TLC and Column

Summary:

Chromatography techniques are essential in the organic chemistry laboratory for identifying whether or not the reaction has occurred (and if starting materials are present) and for testing the purity of a product and purifying the product. The choice of chromatography solvent can be limited due to the required solvent properties for the eluting solvent. There are many available resources for guiding chemists towards greener solvent choices, many of which have been outlined in the introduction Solvent Selection Resources section. Simple choices can make a large impact, including shifting away from chlorinated solvents (see: A convenient guide to help select replacement solvents for dichloromethane in chromatography, Taygerly, J. P., Miller, L. M., Yee, A., Peterson, E. A., Green Chem., 2012, 14, 3020), and switching from hexanes to heptane (see: Green chemistry tools to influence a medicinal chemistry and research chemistry based organisation, Dunn, P. J., et. al., Green Chemistry, 2008, 10, 31-36).

Greener chromatography experiments often involve the separation of pigments from plants and include the use of recycled solvents in the extraction process (see: A Green Approach To Separate Spinach Pigments by Column Chromatography, McDougal, O.M., et. al., J. Chem. Educ., 2013, 90 (6), pp 796–798), and the use of alternative media for use within column chromatography (see: "Supermarket Column Chromatography of Leaf Pigments" Revisited: Simple and Ecofriendly Separation of Plant Carotenoids, Chlorophylls, and Flavonoids from Green and Red Leaves, J. Chem. Educ. 2015, 92(1), 189-192).

Solvent table: Refer to the solvent selection resources in the introduction of this resource for further information regarding solvent substitution. The table below listed commonly used solvents in chromatography and their relative EH&S information.

Chemical Name Aldrich Catalog #	Amount per 100 students (g or mL)	EH&S	Purchasing cost per liter
Hexane 296090	(varies)		$77.92
Heptane 246654	(varies)	*	$49.50
Dichloromethane 676853	(varies)		$44.38
Ethyl acetate 270989	(varies)		$40.94

Extraction

Summary:

Extraction techniques are commonly performed as means for purifying a product, or extracting a product (i.e., essential oil or natural product extraction). Solvents that are typically used include methylene chloride, petroleum ether, or hexanes. Greener solvent choices can be explored for solvents that have similar solvent properties. See the Solvent Selection Resources section for further information.

A greener extraction procedure for use within the organic chemistry laboratory involves the extraction of avocado oil using ethyl acetate and isopropanol. The oil is then used in the making of an avocado soap (see: Green Soap: An Extraction and Saponification of Avocado Oil, Sutheimer, S., Caster, J. M., Smith, S. H., J. Chem. Ed., 2015, 92, 1763-1765).

Solvent table: Refer to the solvent selection resources in the introduction of this resource for further information regarding solvent substitution. The table below listed commonly used solvents in extraction and their relative EH&S information.

Chemical Name Aldrich Catalog #	Amount per 100 students (g or mL)	EH&S	Purchasing cost per liter
Dichloromethane 676853	(varies)		$44.38
Petroleum ether 320447	(varies)	*F	$69.10
Hexanes 296090	(varies)		$77.92
Heptane 246654	(varies)	*	$49.50
Ethyl acetate 270989	(varies)		$40.94
Isopropanol 278475	(varies)		$43.90