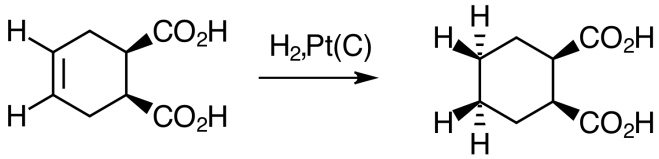
Hydrogenation

Summary:

This reaction demonstrates the selective reduction of an alkene by catalytic hydrogenation in a classically performed reaction involving sodium borohydride as the hydrogen source. Platinum is used as the catalyst.



Reference: Hydrogenation of 4-cyclohexene-cis-1,2-dicarboxylic acid, Experimental Organic Chemistry, Gilbert and Martin, 5th Edition, 2011, pp. 567-569 (Miniscale procedure)

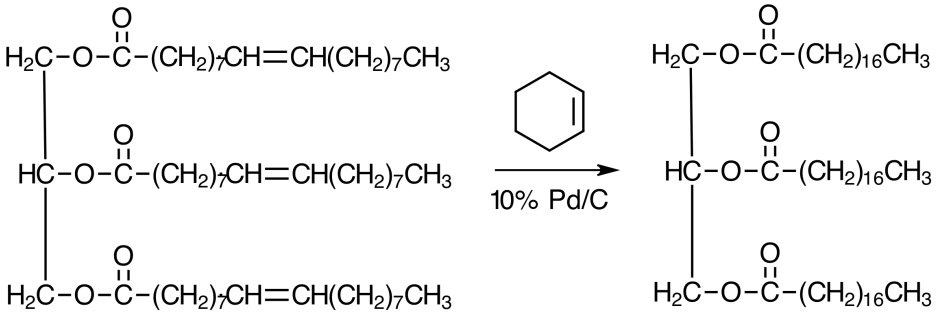
Chemical Name Aldrich Catalog #	Amount per 100 students (g or mL)	EH&S	Purchasing cost per 100 students ($)
Sodium borohydride, 1M aq. Soln 71320	250 mL		$9.20
Water n/a	500 mL		n/a
Chloroplatinic acid, 5% soln 262587	25 mL		$149.74
Activated charcoal C2889	10 g		$0.72
4-cyclohexene-cis-1,2-dicarboxylic acid n/a	25 g		*
Hydrochloric acid, conc. 320331	100 mL	*C * *	$3.90
Diethyl ether 346136	1750 mL	*F	$160.48
Sodium chloride 746398	250 g		$15.92
Sodium sulfate 239313	250 g		$17.50

* This chemical is prepared in another procedure within the textbook: Hydrolysis of Anhydrides: 4-cyclohexene-cis-1,2-dicarboxylic acid, Experimental Organic Chemistry, Gilbert and Martin, 5th Edition, 2011, pp. 430-431.

Hydrogenation – A Greener Approach

Summary:

In this procedure the technique of transfer hydrogenation is utilized to transfer hydrogens from cyclohexene to the double bonds of the olive oil. A palladium catalyst is used in this approach to catalyze the hydrogenation.



Reference: Transfer hydrogenation of olive oil, Macroscale and Microscale Organic Experiments, 6e; Brooks/Cole, 2011; pp. 385

Chemical Name Aldrich Catalog #	Amount per 100 students (g or mL)	EH&S	Purchasing cost per 100 students ($)
Olive oil n/a	40 mL		$0.40
Cyclohexene 8.02824	100 mL		$6.50
Palladium on carbon, 10% 205699	5 g		$65.75

Comparison: Hydrogenation

Comparison of greener and traditional lab:

- Greener method avoids the use of sodium borohydride
- Greener method uses a simplified procedure and introduces concepts such as hydrogenated fats and oils
- Greener method avoids the use of diethyl ether in the work-up procedure

	Purchasing costs	Waste (per 100 students)	"Greener" benefits
Greener method	$72.65	145 mL liquid waste	
Traditional method	$357.46	2.9L waste (1L aqueous waste) 250 g solid waste	

Other greener lab options to explore:

- The Solvent-less Hydrogenation of Unsaturated Esters using 0.5% Pd/Al(O)OH as a Catalyst, Fry, D., O'Connor, K., Chem. Educator, 2013, 18, 144-146.
- Catalytic Transfer Hydrogenation of Castor Oil, Alwaseem, H., Donahue, C.J., Marincean, S., J.Chem. Ed., 2014, 91, 575-578.