Wilkinson’s Catalyst Pre-labs

Week 1

Catalytic Hydrogenation of Olefins in the presence of Wilkinson’s Catalyst

The first homogeneous catalytic hydrogenation of unsaturated organic compounds was achieved using \((\text{P(C}_6\text{H}_5)_3\text{RhCl})\) (Wilkinson’s catalyst) in 1965.\(^\text{1}\) Detailed studies have resulted in the proposed mechanism shown below in figure 1. Molecular hydrogen is activated through oxidative addition to the unsaturated rhodium complex shown in step 2. The resulting hydrido complex allows for addition of an olefin or other unsaturated species with a concomitant loss of phosphine. The rate limiting insertion reaction in step 5 is followed by a reductive elimination step which completes the catalytic cycle.

![Proposed mechanism for hydrogenation of alkenes by Wilkinson’s catalyst.](image)

**Figure 1.** Proposed mechanism for hydrogenation of alkenes by Wilkinson’s catalyst.\(^\text{ii}\)
• Define a catalyst.
• How does a catalyst speed up a reaction?
• What is Wilkinson’s catalyst?
• How might one prepare this catalyst (via reduction with PPh$_3$)? (A useful website to refer to is http://www.chem.uh.edu/Courses/Thummel/Chem6352/Ch05/)

Look up the MSDS safety info on the following chemicals:

• Rhodium (III) chloride hydrate
• Triphenylphosphine
• Ether
• Hydrogen
• Chloroform
• Cyclohexene

**Week 2**

1. What is the oxidation state of rhodium in each of the steps in figure 2 above?
2. In the proposed catalytic cycle above, the first step involves oxidative addition of hydrogen to a square planar rhodium complex. Propose an alternative mechanism in which the olefin reacts with the square planar complex prior to hydrogen addition. Draw the key intermediates and indicate the oxidation state of the metal in each step.
3. How might one experimentally determine that a phosphine ligand is lost during the catalytic cycle?
4. What is gas chromatography and how does it work? (try a google search or look in an analytical chemistry text)

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\[\text{References:}\]
