FRIEDEL-CRAFTS ALKYLATION OF DIMETHOXYBENZENE

CHM 222

The following experiment has been adapted from experiments in Fieser and Williamson's **Organic Experiments**, seventh edition.

EXPERIMENTAL OBJECTIVES

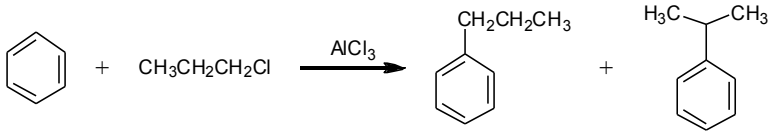
To synthesize, purify, and characterize 1,4-di-tert-butyl-2,5-dimethoxybenzene as an example of a Friedel-Crafts alkylation reaction.

LEARNING OBJECTIVES

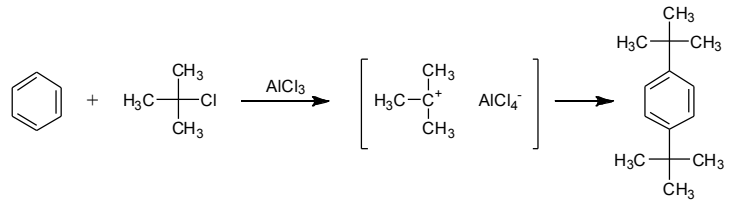
- To see the utility of an EAS reaction in the laboratory
- To characterize a purified product in preparation for the synthesis project

BACKGROUND

Friedel-Crafts alkylation of aromatic rings most often employs an alkyl halide and a strong Lewis acid catalyst. Some of the catalysts that can be used, in order of decreasing activity, are the halides of Al, Sb, Fe, Ti, Sn, Bi, and Zn. As in today's experiment, the reaction can also be accomplished by using a strong acid with an alcohol. Although useful, Friedel-Crafts alkylation reactions have several limitations. The aromatic ring must be unsubstituted or bear activating groups, and, because the monoalkylated aromatic molecule is more reactive than the starting material, multiple substitutions usually occurs. Finally, primary alkyl groups will sometimes rearrange under the reaction conditions:



In the reaction shown below, a tertiary alkyl chloride and the most powerful Friedel-Crafts catalyst, $AlCl_3$, are allowed to react with benzene. The initially formed *t*-butylbenzene is a liquid while the product, 1,4-di-*t*-butylbenzene, which has a symmetrical structure, is a beautifully crystalline solid. The alkylation reaction probably proceeds through the carbocation under the conditions of the present experiment:

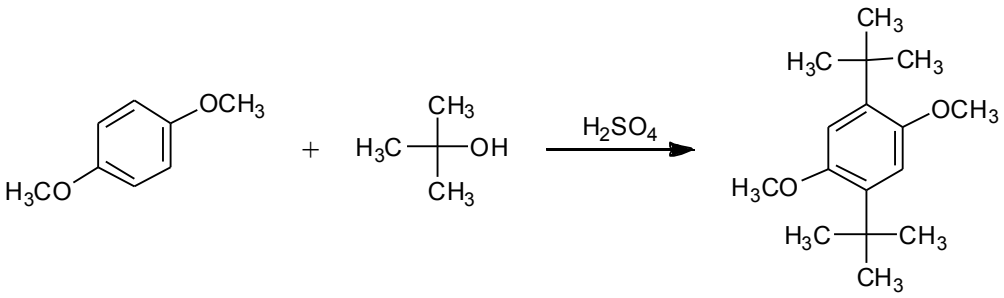


Today's reaction is similar, although we are not using the air and moisture sensitive aluminum trichloride catalyst. We will use t-butyl alcohol and sulfuric acid as discussed below.

EXPERIMENT

This experiment illustrates the Friedel-Crafts alkylation of an activated benzene molecule with a tertiary alcohol in the presence of sulfuric acid as the Lewis acid catalyst. As in the reaction of benzene and *t*-butyl chloride, the substitution involves attack by the electrophilic trimethylcarbocation.

1,4-DI-*T*-BUTYL-2,5-DIMETHOXYBENZENE



1,4-Dimethoxybenzene
MW 138.16 mp ~57°C

t-Butyl alcohol
MW 74.12
d 0.79
bp 82.8°C
mp 25.5°C

1,4-Di-t-butyl-2,5-dimethoxybenzene
MW 250.37 mp 104-105°C

Place 2 g of 1,4-dimethoxybenzene (hydroquinone dimethyl ether) in a 50-mL Erlenmeyer flask, add 3.5 mL of *t*-butyl alcohol and 10 mL of acetic acid, and put the flask in an ice-water bath to cool. Measure 10 mL of concentrated sulfuric acid (note the danger of getting concentrated sulfuric acid on your skin) into a 50-mL Erlenmeyer flask, and put the flask, properly supported, in the ice bath to cool to 0-3°C (solid, if present, will dissolve later). While swirling the dimethoxybenzene/*t*-butyl alcohol mixture in the ice bath, add the chilled sulfuric acid in small portions using a disposable pipette.

By this time considerable solid reaction product should have separated, and insertion of a thermometer should show that the temperature is near room temperature . Swirl the mixture while maintaining the temperature at about 20-25°C for 5 min more. Pour your reaction mixture into a 125 mL Erlenmeyer flask and cool on ice. Slowly add ice water to the mixture to dilute the sulfuric acid to a volume of about 120 mL. Cool and collect the product on a Buchner funnel with suction. It is good practice to clamp the filter flask so it does not tip over. Apply only very gentle suction at first to avoid breaking the filter paper, which is weakened by the strong sulfuric acid solution. Wash liberally with water and then turn on the suction to full force. Press down gently on the filter cake with a spatula and let drain well. Meanwhile, cool 15-mL of methanol on ice for washing to remove a little oil and a yellow impurity. Release the suction, cover the filter cake with 5 mL of the chilled methanol, and then apply suction. Repeat the washing procedure two more times.

Transfer your solid to an Erlenmeyer flask, and add about 20 mL of methanol (bp 65°C) to the solution and heat to boiling. If you still see solid in your flask, carefully add small portions of methanol until everything is dissolved. Cool on ice and collect the product by vacuum filtration, and dry. Characterize your product as instructed by your professor.

CLEANING UP

Dispose of your solvents in the appropriate containers in the disposal hood.