

Resin Oxidation of 9-Hydroxyfluorene

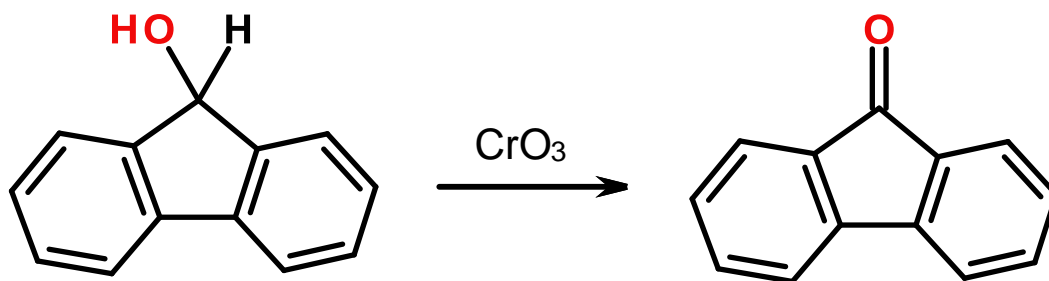
Microscale procedure developed and written by Anthony Winston

1. Introduction

Oxidation is a common practice in organic chemistry. By this means alcohols may be converted to aldehydes, ketones, or acids, depending on the structure of the alcohol. Similarly, aldehydes may be converted to acids. Oxygen is the one of the most common oxidizing agents. Strong oxidizing agents for the organic laboratory include potassium permanganate (KMnO_4), potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$), and chromic acid (CrO_3).

In this experiment, 9-hydroxyfluorene is oxidized by chromic acid to yellow 9-fluorenone and the experiment is written up for this case. However, other hydroxy compounds may also be used. An alternative is benzoin, which is readily oxidized under identical conditions to give the yellow benzil.

The chromic acid oxidizing agent has been incorporated into an ion exchange resin. The compound to be oxidized is dissolved in toluene and then heated under reflux with the chromate impregnated resin. The hydroxy compound diffuses into the resin where the oxidation takes place and the product ketone diffuses out. The advantage of using a solid phase oxidizing agent is the easy by which the product can be separated from the oxidizing agent. The separation is accomplished simply by drawing off the solution from the resin using the micropipette. The oxidation of 9-hydroxyfluorene is shown below:



A major objective in this experiment is to learn how to follow the extent of the reaction while it is in progress. For every reaction, a decision must always be made as to the length of time to allow the reaction to proceed in order to ensure that the reaction is complete. Often this is done by guesswork based on experience. However, if a method can be devised to measure the extent of reaction at various times during the course of the reaction, the question can be answered explicitly as the information will tell us when the reaction is 100% complete.

This information will prevent us from terminating the reaction prematurely before it is complete, and it will save time because the reaction will not be allowed to proceed longer than is necessary to complete the reaction. In other words, it tells us when to stop. If, in our measurements, we find that the reaction does not go to completion, this might indicate that there was not enough

reagent present to drive the reaction to 100% completion. The solution to this would be to add more reagent and continue the reaction to completion.

One of the best and simplest methods for following a reaction while it is proceeding is Thin Layer Chromatography, (TLC). It turns out that the starting material, 9-hydroxyfluorene, is easily separated from the product, 9-fluorenone, by TLC. Similarly the product benzil is easily separated from benzoin by TLC. The R_f values are quite different because the starting alcohol is fairly polar, as are most alcohols, whereas the product ketone is of very low polarity. Thus, by running TLC at various stages of the reaction, the degree of conversion of reactant to product at various times into the reaction can be roughly ascertained. This is done by observing the relative sizes of the two spots on thin layer chromatogram, one spot for the starting material and one spot for the product. The procedure is to take a very small sample of the reaction mixture every 5 or 10 minutes and immediately run a TLC on the sample. A sample taken before the reaction has started should show only one spot for the starting material. As the reaction proceeds under refluxing toluene, another TLC is run on a new sample. In the new TLC, the spot for the product ketone should appear together with a spot for the reactant. As the reaction continues, and more TLC's are run, the spot for the product should get larger and larger, while the spot for the starting material should get smaller. When the TLC shows only one spot for the product, with the spot for the starting material having completely disappeared, the reaction is complete and may be terminated at that point.

Note: It is important, and also obvious, that in order for the TLC's to provide the information needed to indicate the point at which the reaction is to be terminated, it is necessary to run the TLC on each sample immediately after the sample is taken from the reaction flask. To keep the samples to run later on is not acceptable and *misses* the whole point of the experiment.

2. Procedure

a. Thin Layer Chromatography

Prepare several capillary pipettes for spotting the plates by heating melting point tubes in a flame and drawing out to a fine capillary. Break in the middle to give two capillary pipettes per melting point tube.

A large beaker with the top closed by a watch glass or aluminum foil is a convenient developing chamber. Add a solution of 10% acetone in hexane to the beaker so that the level of the solution is only about one half centimeter in depth. It is important that the depth be not too great, because if solvent in the developing chamber comes above the level of the spot on the TLC plate, the spot will be dissolved away and the TLC will fail. Place a piece of filter paper along the wall of the developing chamber and saturate the paper with solvent to help maintain a saturated atmosphere in the developing chamber.

For the separation of 9-hydroxyfluorene and 9-fluorenone, or the separation of benzoin and benzil, 2 x 6 cm silica gel plates with fluorescent indicator will be used. Draw a light pencil line on several of the plates about 1 cm from one end, making sure that the pencil does not break through the surface of the plate. The plates will be spotted along this line. To sample the reaction

mixture at various stages of the reaction, a thin section of glass tubing that will fit through the bore of the water condenser will be needed. A section about 25 cm and 4 mm OD will be about right. To remove a sample of the reaction mixture, reach down through the condenser with the tube until it is immersed in the reaction mixture. Some of the solution will be drawn into the tube by capillary action. Touch the capillary pipet (the one made from the melting point tube) to the solution caught in the end of the tube and a small sample of the solution will be drawn into the capillary. Using this capillary pipet, spot the TLC plate at the pencil line to form a very small spot about 1 mm in diameter, but the smaller the better. Then, about a cm away, using a fresh capillary pipet, spot the TLC plate with a methylene chloride solution of the starting material. Place the plate in the developing solution in the beaker and replace the watch glass. Make sure that the level of the developer in the beaker is not above the pencil line on the plate. Develop the plate for a time sufficient for the developing agent to rise up 3 or 4 cm into the plate. At this time remove the plate and immediately mark the solvent front with a pencil. This must be done quickly because the solvent front will rapidly disappear as the plate dries. Allow the plate to dry and examine it under the UV lamp (short wave length tube). Mark the spots with a pencil by drawing small circles around them.

b. Oxidation of 9-Hydroxyfluorene

To use as a standard for TLC analysis, place a few milligrams of starting material in a test tube and dissolve it with a few drops of methylene chloride. The reaction is carried out in a 10 mL round bottom flask with a water cooled reflux condenser as shown in Figure 1.

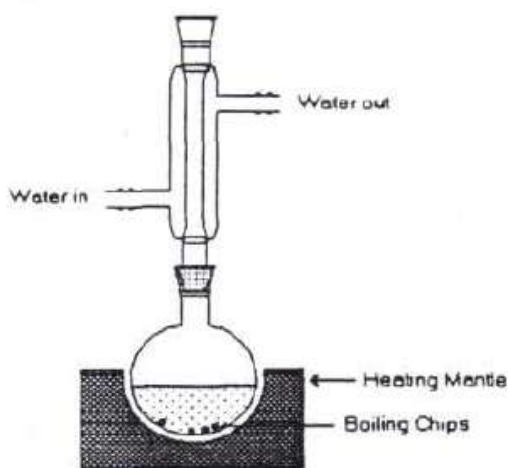


Figure 1. Equipment for a reaction under reflux.

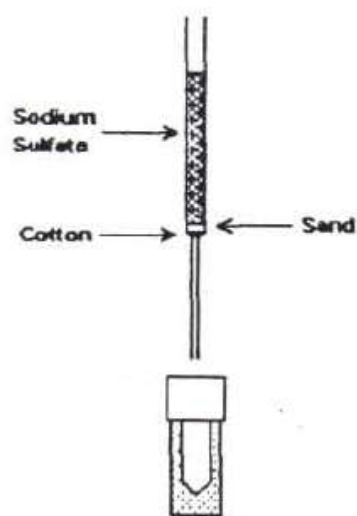


Figure 2. CaSO₄ Drying Tube

Place 100 mg of 9-hydroxyfluorene (or 60 mg of benzoin) and 3.5 mL of toluene in a 10-mL round bottom flask. Take a small sample of the solution using the capillary micropipette, spot a TLC plate, and immediately run the TLC. While the TLC is running, add 1 g of the chromated resin to the flask. Attach a water cooled reflux condenser, and heat to reflux. Five minutes after refluxing commences, take a sample of the reaction mixture for TLC analysis. On one side of the TLC plate, place a spot of the sample from the reaction and then about 1/2 cm away, place

another spot of the pure reactant that has been dissolved in methylene chloride. Run this TLC. Continue to heat under reflux and after 10 minutes, sample the reaction mixture again and run the TLC and the standard as before. Note the time that each sample is taken, using pencil at the top of the TLC plate. Continue in this fashion and sample the reaction mixture every 10 minutes. It does not have to be always exactly 10 minutes, but just mark the time that you actually take the sample. When the spot for the starting material no longer appears on the TLC plate, or is very faint, the conversion of reactant to product is complete and the reaction may be terminated. The reaction will probably take between 20 minutes to an hour.

c. Isolation of the Product

Prepare a drying tube as shown In Figure 2.

When the reaction is judged to be complete, allow the reaction to cool and then using a micropipette, remove the liquid from the resin. An easy way to do this is to place the tip of the pipet on the bottom of the flask, withdraw the liquid carefully so as not to draw up any of the resin, and place it in a 5 mL vial. If done properly, the particles of resin will not be drawn up with the liquid. Wash the resin several times with 1/2 mL portions of methylene chloride, draw off the methylene chloride with the pipet in the same manner, and add the washing to the reaction mixture in the vial. Evaporate the solvent using mild heat from the hot plate under a slight stream of nitrogen. When the volume is very small, it is best to remove the vial from the hot plate and stir with a spatula, while maintaining a stream of nitrogen. When the solid appears dry and powdery, remove it and obtain a crude weight and percent yield. Recrystallize 50-60 mg from about 1 mL of hexane using the Craig tube and determine a melting point on this sample. Measure the R_f values of reactant and product from two or three of the TLC plates. The values should agree closely. Record the nmr and the infrared spectrum.

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D. Report: Resin Oxidation of 9-Hydroxyfluorene

Name _____ Date _____

Chemical Reaction:

Reagents:

Compound Mol Wt. wt., mg Vol. μ L mmole

Products:

Compound Mol Wt. We, mg mmol

Theoretical Theoretical

Attach IR spectrum, Gas Chromatograms, c IR bands and assignments

Yield mg mmol

Yield %

mp range, Lit.

Evidence for the confirmation of structure.

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