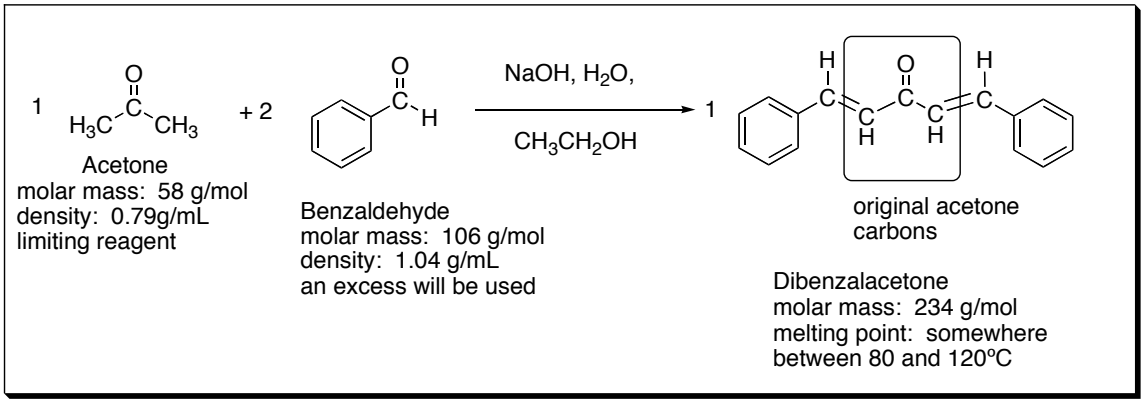
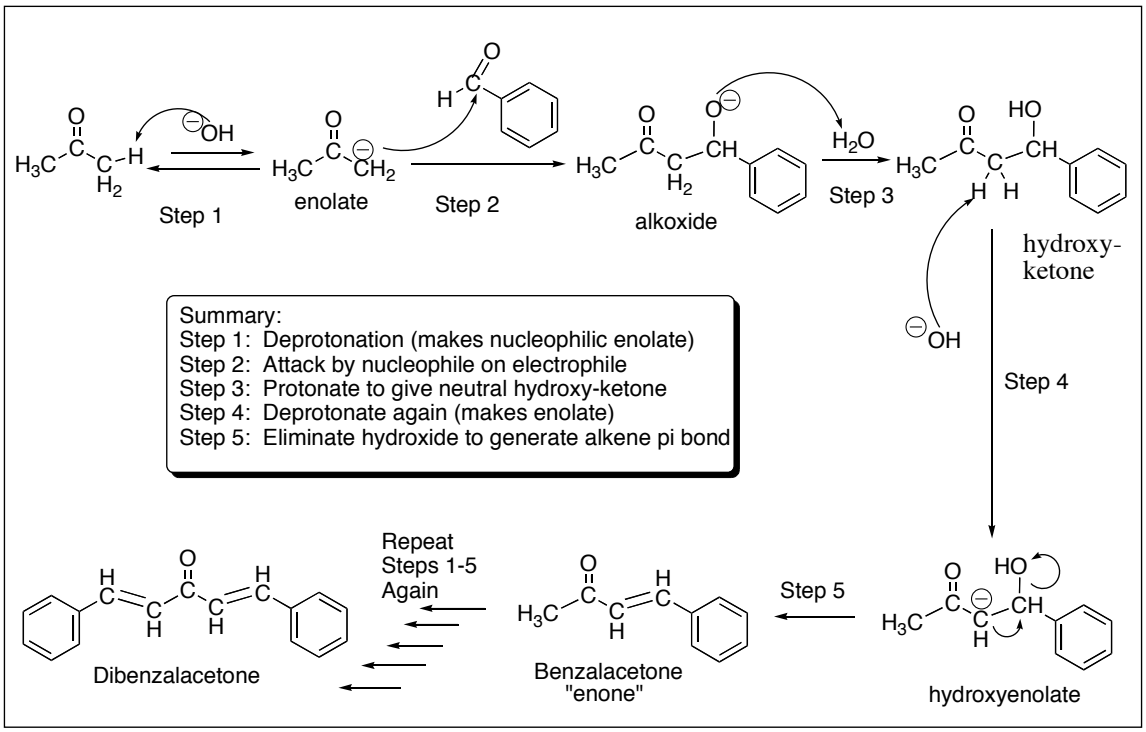
ALDOL SYNTHESIS of DIBENZALACETONE, AN ORGANIC (SCREEN



Overview: The reaction of an aldehyde with a ketone employing sodium hydroxide as the base is an example of a mixed aldol condensation reaction. You will do a double mixed-aldol condensation reaction between acetone and benzaldehyde. Acetone has α-hydrogens (on both sides) and thus can be deprotonated to give a nucleophilic enolate anion. The aldehyde carbonyl is much more electrophilic than that of a ketone, and therefore reacts rapidly with the enolate. The alkoxide produced is protonated by solvent, giving a β-hydroxyketone, which undergoes base-catalyzed dehydration. The elimination process is particularly fast in this case because the alkene is stabilized by conjugation to not only the carbonyl but also the benzene. In today's experiment you will use excess benzaldehyde, such that the aldol condensation can occur on both sides of the ketone.

Mechanism for Aldol Condensation



Procedure:

Calculations

1. Calculate the volume required to produce 0.0125 mol of acetone.
2. Calculate the volume of 2.2 "equivalents" of benzaldehyde. (In other words, 2.2 times as many moles of benzaldehyde as of acetone.) Note: the equation involves a simple 2:1 stoichiometry.

- By using an actual 2.2:1 ratio, it ensures that the benzaldehyde is surplus and that the acetone is limiting. This is helpful for several reasons:
  a. **Aldehyde oxidation**. Aldehydes are often impure, because oxidation to carboxylic acid is fairly facile. By using 2.2 equivalents of benzaldehyde, then even if 10% of the benzaldehyde is corrupt we ensure that we still have enough to fully react with the acetone.
  b. **Reaction Time**. By having an excess of benzaldehyde, it makes it easier for the reaction to go to completion. Otherwise late in the reaction there isn't much benzaldehyde left to react, so the reaction slows down a lot. By intentionally putting in some extra, it maintains at least a minimal concentration of electrophilic benzaldehyde till the very end, such that getting 100% conversion of isn't so hard and doesn't take so long.
  c. **Ease of Product Purification**: **Disubstitution versus monosubstitution**. Enabling complete conversion greatly simplifies purification. If complete conversion does not occur, either because benzaldehyde runs out or because insufficient time is used, the desired "disubstitution" product "dibenzalacetone", in which two benzaldehydes have been incorporated, is contaminated by "benzalacetone", the "monosubstitution" product in which only one benzaldehyde has been incorporated. Since the mono- and disubstituted products aren't that different, it's not that easy to remove the undesired side-product from the main desired product. But if you just make sure the reaction goes all the way to the desired product, then you don't need to worry about it!

Doing the Reaction:

1. Use a 125-mL Erlenmeyer flask with a magnetic stirring bar.
2. Add 50 mL of the NaOH-Ethanol-Water solution mixture. (This was premixed for you.)
3. Place the solution on the magnetic stirrer and adjust the stirring dial to get a nice, even stirring action.
4. To this add the calculated amount of benzaldehyde by syringe
5. Add the calculated amount of acetone by syringe, last. (The acetone should go in last, after the benzaldehyde electrophile is already available. If the acetone goes in first, it could do aldol condensation on itself, in which enolate anions just attack neutral acetone carbonyls. Ketone carbonyls aren't competitive with aldehyde carbonyls as electrophiles, but if there are no aldehydes available, ketones are better than nothing!)
6. Watch the solution carefully, with a watch, at the beginning of the reaction, so that you can keep good observational records.
   - How long does it take for the solution to turn yellow? Given that all the reactants are colorless, what does the yellow color mean?
   - How long does it take for the solution to become cloudy, and for solid to then accumulate?
7. Let the solution stir for 30 minutes. (Calculate, write report, do theoretical yield, etc.)
8. Add 20 mL of water, and then filter the mixture
9. Pour the filtrate into the waste container.
10. Wash the crystals three times with 50-mL of water each time.
    - The product is so organic that it has essentially no solubility in water. Water washes are no threat to your yield.

- The initial product is contaminated by sodium hydroxide. The extensive water washes removes all traces of sodium hydroxide.

11. If the crystals are still pretty wet, press them drier by pressing a filter paper on top to absorb water.
12. Weigh the crude product, and remove a small crystal for a crude melting point that you can run later. Note: your yield may be >>100%, due to residual water. That's OK, you're going to recrystallize again anyway.
13. Prepare a hot water bath (400-mL beaker, hot-plate ~5). Having somebody in your hood (or adjacent) heat some ethanol, in case one of you needs it, is advisable, too.
14. Purify the bulk of your crystals by recrystallizing from ethanol, using a 125-mL Erlenmeyer inside your hot-water bath. A reasonable starting guess is to add ~4mL ethanol/gram product, and heat it up. Improvise if needed once hot, depending on what you see. (You can add more hot ethanol to increase solubility, or hot water to reduce solubility.) Note: The product has a low melting point, so it's easy to think you've dissolved it when actually you've only melted it. Note: the water bath provides even heating and avoids overheating on the hot-plate surface.
15. After cooling, rinse the crystals with an appropriate rinse solvent. (What might that be?)
16. Dry thoroughly.
17. Take yield and mp, and calculate the % yield.

Lab Report:

Standard synthesis lab report. Yield, % yield, and mp's of crude and recrystallized products.

Questions:

1. How would you modify the experiment in order to make benzalacetone, $PhCH{=}CHCOCH_3$ instead of dibenzalacetone PhCH=CHCOCH=CHPh?

2. What ingredients would you use if you wanted to make benzalacetophenone, PhCH=CHCOPh?

Miscellaneous Notes

- Does the benzaldehyde smell familiar? It's found in almond, almond paste, and is familiar from cherries and vanilla. Lots of cookies and bars have this smell.
- Acetone has many uses, including as a paint and varnish remover; as a fingernail polish remover, and as a solvent in many varnishes, rubber cements, lacquers, etc. It is also a natural metabolic byproduct found in the body in limited quantity. Elevated quantities are symptomatic of metabolic disorders, such as uncontrolled diabetes.

- Q: The formation of the yellow color shows that a new chemical is forming, very quickly. The formation of the cloudiness and the insoluble solid also indicates that something is forming that wasn't present at first. Actually, the yellow color and the solid are one and the same. But how come the solid doesn't appear instantly, as fast as the yellow color?
- A: This is the result of solubility chemistry. The solvent has the ability to dissolve a limited quantity of the product. Product is forming continuously, right from the start; but it takes a minute or so until there is enough product formed to hit the solubility-saturation threshold. Any further product exceeds the solvent's ability to hold it, and thus comes out as insoluble solid. At first this insoluble stuff looks to the eye as if it is just milky cloudiness. But soon enough it look like solid crystalline material.