Multi-Step Synthesis of Betaine-30

Background information & Introduction

The synthesis I chose for this multi-step project is synthesis of Betaine-30, is also know as 2,6-diphenyl-4-(2,4,6-triphenylpyridinio)-phenolate, and Reichardt's dye (Fig.1). It was often used as indicator to determinate solvent polarity by solvatochromism. Solvatochromism is used to describe a pronounced change in the position of a UV-vis absorption band with a change in solvent polarity. As a solvatochromic dye, betaine-30 changes color in response to polarity, and moreover, it has one of the largest effects ever observed. For example, this compound is red in methanol, violet in ethanol, blue in isoamyl alcohol, green in acetone and yellow in anisole, which covering the whole visible range (Osterby, Mckelvey)

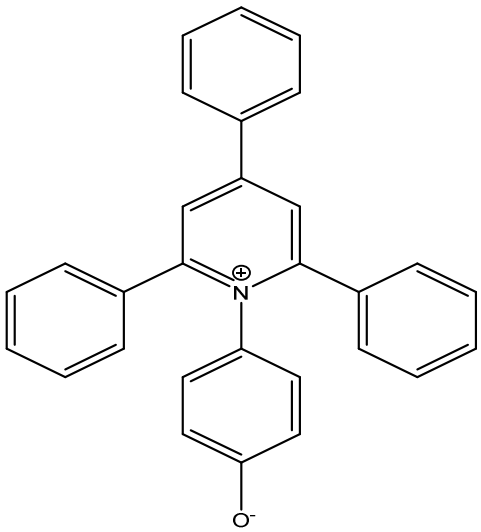

Figure 1

Convergent Synthesis of Betaine-30

The entire synthesis can be divided into three steps, and for each of the step, melting point analysis were used to confirm the identity of the

product. The identity of the final product is determined by both melting point analysis and demonstrations by mix it in different solvent.

The first steps is to synthesis 2,4,6-Triphenylpyrylium Hydrogen by reacting Chalcone and Acetophenone by mix them together and heated by water bath (Fig.2)

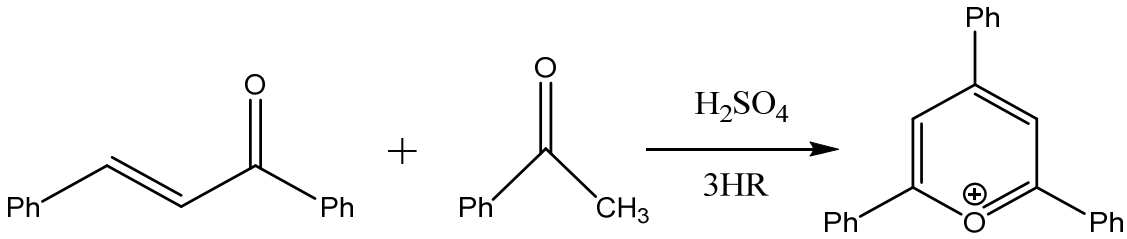

Figure 2

The seconed step is to add NO2 groups on Aldrich by using HNO3, and lead it to form 4-Nitri-2,6-Diphenylphenol. And then use Na2S2O4 to kick of the NO2 group and add NH2 group, which gives us 4-Amino-2,6-diphenylphenol as product (Fig.3)

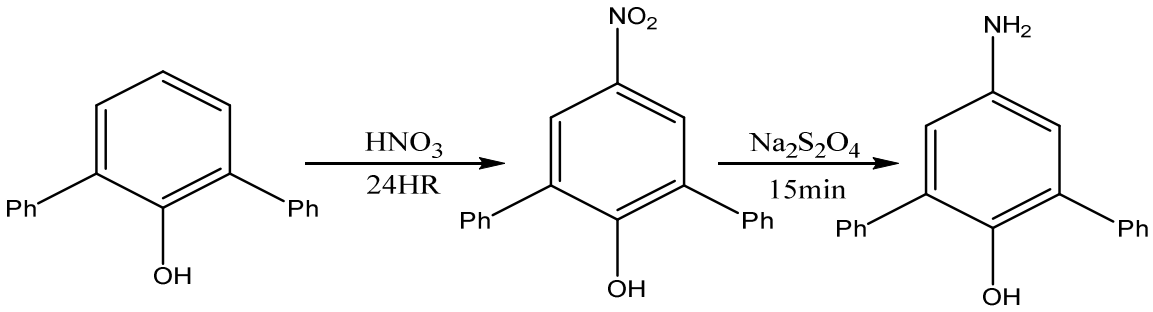

Figure 3

The final step is to mix the product form the pervious two steps, 2,4,6-Triphenylpyrylium Hydrogen and 4-Amino-2, 6-diphenylphenol to complete the synthesis of Betaine-30 (fig.4)

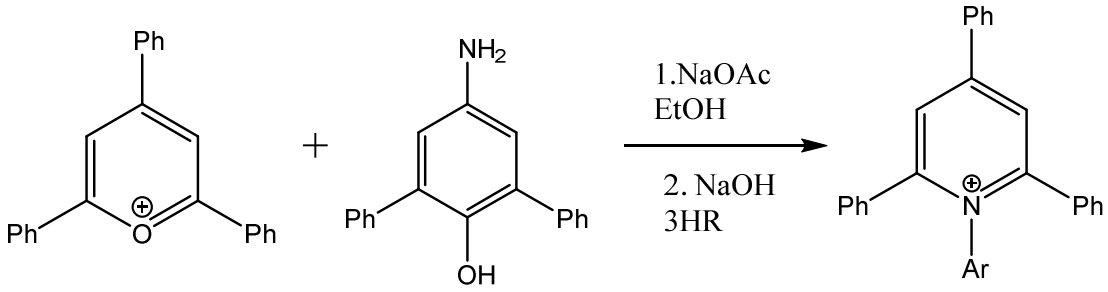

Figure 4

Data and Observations of Each Step

Step one

4.28 g (0.0206 mol) of Chalcone and 1.24 g (0.0103 mol) of Acetophenone was mixed with 3.2 g of H2SO4 and heated on the water bath for 3 hours. During the process of heating, the solution was turning into a dark red brownish color. After 3 hours of heating, 20 ml of water was added. A yellow precipitate formed and dissolved on further heating, and a black oil was separated out. The oil was removed by vacuum filtration, and the filtrate was set aside to allowed the precipitate to form. A yellow crystal was formed after a few minutes, and the crystal was collected by vacuum filtration. The theoretical yield of 2,4,6-Triphenylpyrylium Hydrogen Sulfate is about 4.1896g and the actual yield is 1.635g. I am expecting to get about 58% of percent yield, and the percent yield was 39% Melting point is determined to be about 230 °C which is a little bit off compare to literature value , which is around 271-273.5°C. The more specific mechanism for the formation of 2, 4, 6-Triphenylpyrylium Hydrogen Sulfate is showed in figure 5 below.

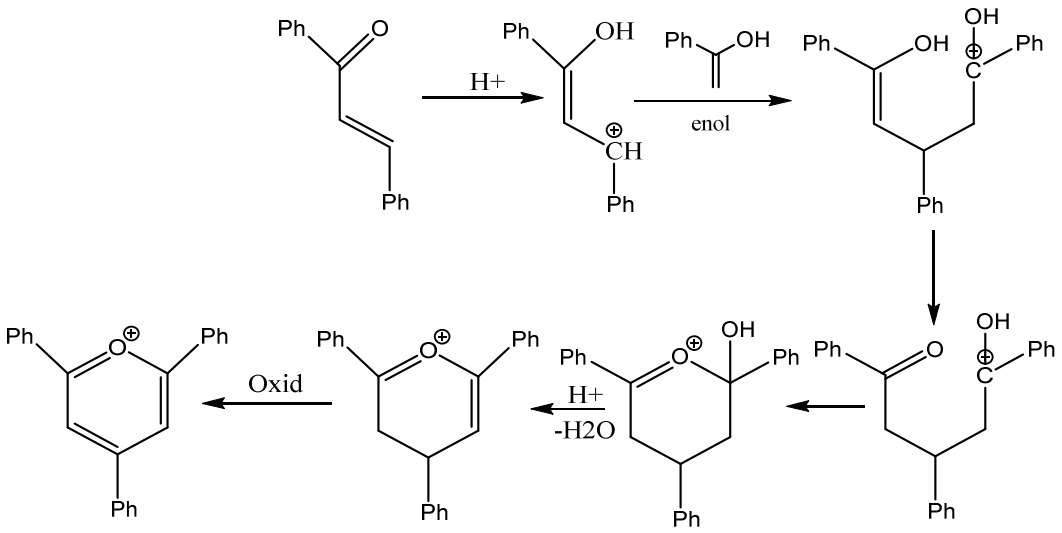

Figure 5: Mechanism for the formation of 2, 4, 6-Triphenylpyrylium Hydrogen Sulfate

Step two

The step two was divided into two small separate parts. The part a is to synthesis 4-nitro-2,6-diphenylphenol, and the part b is to synthesis 4-Amino-2,6-diphenylphenol from 4-nitro-2,6-diphenylphenol.

In part a, 65% Nitric Acid (HNO_3) and 2.00 g (8.12 mol) of 2, 6-diphenylphenol was mixed together and stir over night. The color was first appears to be light pink, then turned in to light yellow after few minutes, after a while it slowly turned into light orange and eventually turned into orange. The cruse product was collected by vacuum filtration. The yield is 2.717g and the melting point is 117-120°C. Then the crude produce was dissolved in hot ethanol and treated with activated Carbon. After vacuum filtration the solution was concentrated by rotary evaporization. The purified product yield 1.427g, the theoretical yield is 2.369g and the percent yield is determined to by 60%. The melting point is 127-128 °C (lit: 135 °C).

In part b, 1.427 g of 4-Nitro-2, 6–Diphenylphenol was added to 50 ml of hot NaOH, string and heated for 15 minutes. The solution was expected to

turned into deep-red solutions, and would turned yellow when small amount of solid sodium dithionite was added. However, the solution turned in to yellow directly, and the stir bar turned black. And there were black flakes keep precipitated out. So I have to vacuum filtrated the black stuff out, and continued with my process. After the mixture was heated for 15 minutes, the glacial acetic acid was add to adjusted the solution to pH 5, and the product precipitated after cooling. The theoretical yield was 1.048g, and the actual yield is 0.777g. So the percent yield is 74%. The melting point is 133-134 °C (lit: 147-148 °C).

Step three

To a small reflux set-up, 2, 4, 6-Triphenylpyrylium Hydrogen Sulfate, 4-Amino-2,6–Diphenylphenol, 0.245 g of anhydrous sodium acetate, and 3.1 ml of ethanol was mix together and reflux for 3 hours. After reflux, 1.5 ml of NaOH was added to the mixture, and the dark blue crystal was expected to form, and it would turned green after dry. However, only a very little amount of product was form, and it was not appears to be dark blur crystal. The theoretical yield was 0.363 g and the actual yield was 0.012g, which makes the percent Yield lower than 3%. And I was not able to take the melting point. However betaine-30 can also by determined by dissolving it in variety of solvent, so I tried to conform the identity of product through demonstration.

The more detailed mechanism for the convergent step in the synthesis of Betaine-30 was showed in figure 6 below.

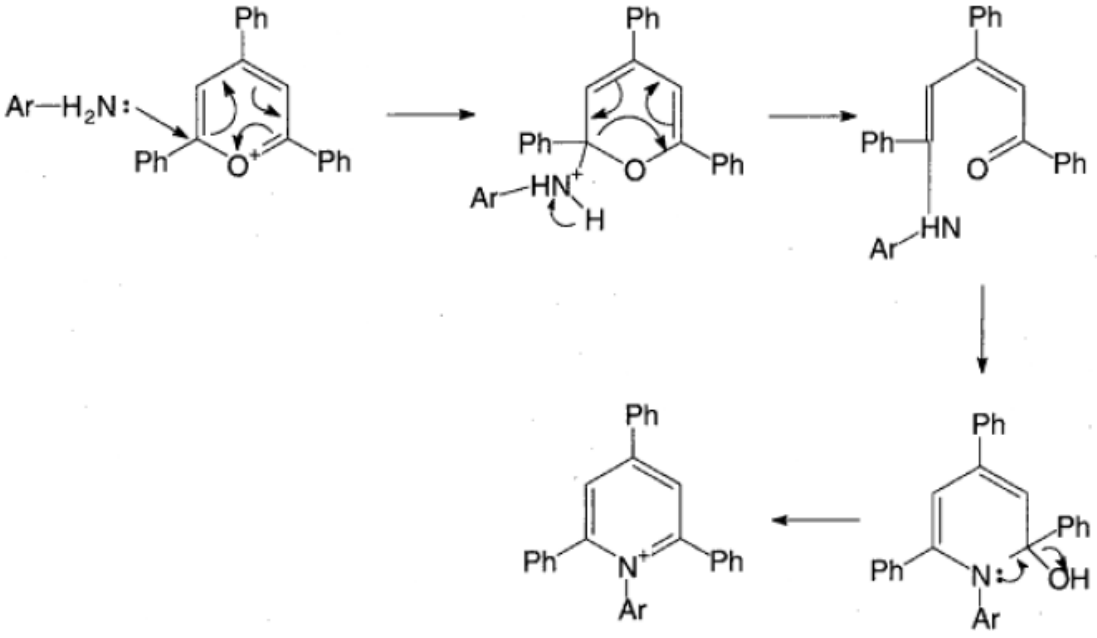

Figure 6: Mechanism for the convergent step in the synthesis of Betaine-30

Conclusion

The solvatochromic effect of beatine-30 can be demonstrated by dissolving it in different solvent. It supposed to be red in methanol, purple in ethanol, blue in isoamyl alcohol, green in acetone and yellow in anisole, however, the product I got only successfully turned green in Acetone but remains yellow green or green blue in other solutions. Thus, the overall synthesis of Betaine-30 was sadly, unsuccessful. The major error was most like occurred during the second step, caused by stir bar that was not properly cleaned and might contained other dyes from pervious experiments. Other than that, each step goes smoothly and fun.

Reference:

Convergent Synthesis of Betaine-30, a Solvatochromic Dye: An Advanced Undergraduate Project and Demonstratio, Bruce R. Osterby and Ronald D. McKelvey, *Journal of Chemical Education* **1996** *73* (3), 260