Alkylation of Mesitylene

PreLab Note:

PreLab Question:
How much formic acid is consumed in this reaction? Show enough mechanistic reaction details to prove this.

Introduction:
The Friedel-Crafts reaction of an alkyl halide with an aromatic molecule in the presence of aluminum chloride proceeds through the formation of an intermediate carbocation:

\[
\begin{align*}
\text{CH}_3\text{C}_2\text{H}_5\text{Cl} + \text{AlCl}_3 & \rightleftharpoons \text{CH}_3\text{C}_2\text{H}_5 + \text{AlCl}_4^- \\
\text{CH}_3\text{C}_2\text{H}_5 + \text{C}_6\text{H}_5\text{Cl} & \rightleftharpoons \text{CH}_3\text{C}_2\text{H}_5 + \text{HCl} + \text{AlCl}_3
\end{align*}
\]

Friedel and Crafts (who later became the president of MIT) discovered this reaction in 1879, but 7 years before, Baeyer and his colleagues carried out very similar reactions using aldehydes as the alkylating agent and strong acids as catalysts. These reactions, like the Friedel-Crafts reaction, proceed through carbocation intermediates. Consider the synthesis of DDT [1,1,1-trichloro-2,2-di(p-chlorophenylethane), 1:}
Trichloroacetaldehyde (chloral) forms a carbocation on reaction with concentrated sulfuric acid. This reacts primarily at the para position of chlorobenzene, and the intermediate alcohol, being benzylic, in the presence of acid readily forms a new carbocation, which in turn attacks another molecule of chlorobenzene. Even though synthesized in 1872, the remarkable insecticidal properties of DDT were not recognized until about 1940. It took another 25 years to realize that this compound, which is resistant to normal biochemical degradation, was building up in rivers, lakes, and streams and causing long-term environmental damage to wildlife as brought to the public’s attention by Rachel Carson in her book *Silent Spring*. In particular, it was found that birds that fed on insects containing traces of DDT laid eggs with very thin and delicate shells which would break before the baby birds could fully develop and hatch. Its use is now outlawed in this country.

In the present experiment, discovered by Baeyer in 1872, formaldehyde is allowed to react with mesitylene in the presence of formic acid. The sequence of reactions is very similar to those that form DDT:
When aluminum chloride, a much more powerful catalyst, is used in this reaction, the methyl groups on the mesitylene rearrange and disproportionate to form a number of products, including polymeric material. The strongly activated ring of phenol reacts with formaldehyde at the ortho and para positions to form a polymer, Bakelite.

Formaldehyde itself is a gas. A convenient form of formaldehyde to use in a reaction of this type is paraldehyde, a polymeric solid that readily decomposes to formaldehyde:

**Overall reaction scheme:**

**Synthesis of Dimesitylmethane:**

Add 30 mg of paraldehyde (paraformaldehyde) to a 20-mL screwcap vial that is equipped with a small stir bar. Add 0.2 mL (243 mg) of 95% formic acid and cap the vial with a 14/20 rubber
septum and insert a syringe needle through the septum to allow for release of pressure. Stir the mixture and heat gently if necessary to dissolve the paraldehyde in the formic acid.

Add 0.40 mL (346 mg) of mesitylene to the mixture and heat for 2 hours using a sandbath, with the Varistat set at 30 to 35 to achieve a gentle reflux.

**Isolation and Purification**

Cool the mixture to room temperature. Cool the mixture in ice whereupon crystals should form. Remove the excess formic acid using a Pasteur pipette, then wash the crystals with water, aqueous sodium carbonate solution, and again with water. Scrape them out onto a piece of filter paper and squeeze the crystals between sheets of filter paper to dry.

Determine the weight of the crude product and save a few crystals for a melting-point determination. Recrystallize the product by dissolving it in the minimum quantity of boiling hexanes. Allow the solution to cool to room temperature, add a seed crystal if necessary, and then cool the mixture for at least 15 min in ice before removing the solvent using a Pasteur pipette. Another solvent for crystallization is a mixture of 0.75 mL of toluene and 0.1 mL of methanol, which is adequate for 0.5 g of crude product. Obtain the melting points of the crude and recrystallized product.

**Analysis**

You may be instructed to analyze your final product by GC/GC-MS or NMR. Analyze your sample according to your Assignment sheet and the instructions on Sample Preparation in Lab Guide (inside back cover).

**Cleaning Up:**

At the end of this reaction there should be no formaldehyde remaining in the reaction mixture. If necessary to destroy formaldehyde, it should be diluted with water and 7 mL of household bleach added to oxidize 100 mg of paraformaldehyde. After 20 min it can be flushed down the drain. The formic acid solvent from the reaction and aqueous washings should be combined, neutralized with sodium carbonate, and flushed down the drain. Mother liquor from recrystallization is placed in the organic solvents container.

**Postlab Questions:**

1. The intermediate benzylic carbocation is stabilized by resonance. Draw the contributing resonance structures.

2. Arrange the following carbocations by their relative stabilities (least stable to most stable)

   ![Carbocation Structures]