FRIEDEL-CRAFTS ALKYATION

Introduction

The aim was to utilise Friedel-Crafts alkylation to synthesise 1,4-di-t-butyl-2,5-dimethoxybenzene from 1,4-dimethoxybenzene and t-butyl alcohol.

Experimental

1,4-dimethoxybenzene (2.02 g, 14.62 mmol), t-butyl alcohol (2.75 g, 37.10 mmol) and glacial acetic acid (6.5 mL) were combined and cooled in an ice bath. Concentrated sulfuric acid (2.5 M, 10 mL) was cooled and, once both solutions had reached below 3 °C, slowly added dropwise into the acetic acid mixture with gentle swirling in the ice bath. After all the sulfuric acid was added the solution was swirled outside the ice bath for 10 minutes and then placed back into the ice bath with ice water added to the solution. The solid product was collected by vacuum filtration on sintered glass, washed thoroughly with water and allowed to dry. The product was then recrystallised by dissolving in a minimum amount of boiling methanol and being allowed to crystallise. The crystals were then collected by vacuum filtration on sintered glass and dried. Yield: 2.07 g, 56.55 % M.P.: 102.7 °C – 103.3 °C

Results and Discussion

The melting point of 102.7 °C – 103.3 °C is close to the reported value of 103 °C – 105 °C\(^1\) and the small melting range indicates dryness and purity of the sample. TLC was performed on both the product and starting material. TLC mobile phase: 15 % ethyl acetate/petroleum spirit.

\(^{1}\) Referenced in the text as a previously reported value.
A more polar solvent would have moved both spots toward the top of the plate increasing R_f while a less polar solvent would have decreased R_f due to less interaction between the stationary phase and the mobile phase. NMR assignments:

\(^1\)H NMR assignment is simple due to all peaks being singlets, integration gives a ratio of 1:3:9 equivalent to the 2:6:18 protons in the various functional groups. The largest peak is due to the tert-butyl protons, the second largest is due to the oxymethyl protons and the smallest peak is due to the phenyl protons.

<table>
<thead>
<tr>
<th>Chemical Shift (ppm)</th>
<th>No. of Hydrogens</th>
<th>Multiplicity</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3771</td>
<td>18</td>
<td>1</td>
<td>t-butyl</td>
</tr>
<tr>
<td>3.8194</td>
<td>6</td>
<td>1</td>
<td>methoxy</td>
</tr>
<tr>
<td>6.8424</td>
<td>2</td>
<td>1</td>
<td>phenyl</td>
</tr>
</tbody>
</table>

\(^13\)C NMR assignment are mostly characterised by chemical shifts. We ignore the peak at δ 77 from CDCl₃. The highest field peak is likely due to a primary carbon like those on the t-butyl groups and the next peak matches the range for the quaternary carbon. Methoxy carbons typically have a range of δ 50 – 60 so the peak at δ 55 is likely due to the methoxy groups. The benzene ring has 3 pairs of equivalent carbons exhibiting the peaks from δ 111 – 151. Those bonded to oxygen would be the most deshielded and have the lowest field peak. The aromatic carbons bonded to protons would have more shielding than those bonded to the t-butyl groups and would account for the peak at δ 111 rather than δ 136.

<table>
<thead>
<tr>
<th>Chemical Shift (ppm)</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>29.7867</td>
<td>Primary, t-butyl</td>
</tr>
<tr>
<td>34.5789</td>
<td>Quaternary, t-butyl</td>
</tr>
<tr>
<td>55.9187</td>
<td>Primary, methoxy</td>
</tr>
<tr>
<td>111.6917</td>
<td>Aromatic</td>
</tr>
<tr>
<td>136.3261</td>
<td>Aromatic, bonded to t-butyl</td>
</tr>
<tr>
<td>151.9757</td>
<td>Aromatic, bonded to OMe</td>
</tr>
</tbody>
</table>
Polysubstitution frequently occurs with Fiedel-Crafts alkylation because alkyl groups are activating so the first alkyl group activates the ring to more alkylation. This does not occur with acylation because the carbonyl group is electron-withdrawing and therefore deactivates the ring towards substitution.

If benzene is reacted with t-butyl chloride the chief disubstituted product is para- rather than ortho- due to less steric crowding associated with para t-butyl groups rather than adjacent t-butyl groups (t-butyl groups are bulky).

**Conclusion**

Friedel-Crafts alkylation is a useful reaction for building aromatic compounds under conditions where we can control the site of substitution.
References