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| **CHEM202 LABORATORY REPORT** | | **Name:** | | Harry Stanley |
| **Experiment 5** | **Lab Day:** | **Thursday** | **Date:** | **17/04/25** |

***Synthesis of a substituted quinoline***

**Abstract**

A Grignard reagent was prepared by refluxing benzyl chloride(I) with magnesium turning in dry ethyl ether under anhydrous conditions. After initiation with iodine, benzylmagnesium chloride (II) was formed and reacted pentan-3-one (III) to give a tertiary alcohol 3 benzylpentan-3-ol (IV). The crude alcohol was purified by vacuum distillation (b.p. 110 oC, 40 mbdr) to yield 4.683 g of (IV) (39.7 % yield). IR spectroscopy showed complete disappearance of the carbonyl band (1712 cm-1) and the appearance of a broad O-H stretch showed at 3425 cm-1. Full 1H and 13C NMR characterisation (including COSY, HECTOR, DEPT) allowed unambiguous assignment of all resonance, confirming the structure of (IV)

Dehydration of (IV) was completed by reacting our tertiary alcohol with orthophosphoric acid in a microwave reactor for 15 minutes to furnish a mixture of three alkenes in a combined yield of 50 % (0.7 g). Analysis of the 1H NMR spectrum (integrals of olefinic vs benzylic signals) have a product ration of 1:1.10:1.03. NOESY experiment revealed key through-space cross-peaks that enabled assignment of E/Z geometry of the olefinic protons in each isomer. The observed chemical shift agreed with predicted values.

**Experimental**

The experiment was performed as detailed in the CHEM202 laboratory manual (p33), without modification. The accurate masses used of the reagents are detailed below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Substance** | **Formula** | **Mr** | **mass (g)** | **amount (mmol)** |
| Magnesium turnings | Mg | 24.305 | 2.521 | 103.72 |
| Benzyl chloride | PhCH2Cl | 126.58 | 12.65 | 99.94 |
| Pentan-3-one | C5H10O | 86.1 | 5.70 | 66.20 |
| Orthophosphoric acid | H3PO4 | 97.994 | 3.79 | 43.17 |
| 3-benzylpentan-ol | C12H18O | 174.14 | 1.512` | 8.68 |

All reactions were carried out in a fume-hood to contain ether and acid vapours. After the Grignard reaction the mixture was quenched by slow addition of ice-cold saturated NH4Cl, the aqueous layer was separated and washed down the fume-hood sink with excess water. The organic layer was dried over anhydrous MgSO4, the drying agent was filtered off and washed into the sink with water; diethyl ether was removed on the rotary evaporator. The final extracts were dried, filtered and stripped of solvent by rotavap. Contaminated waste when in the contaminated waste bin.

**Results and calculations**

Reaction 1 percentage yield calculation:

The limiting reagent in this reaction was (Pentan-3-one)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ∴ n (product) expected | = | 0.0662 | mol | | |
| M (product) | = | 178.14 | g mol-1 | | |
| Theoretical yield | = | N | x | M |  |
|  | = | 0.0662 | mol x | 178.14 | g mol-1 |
|  | = | 11.792 | g | | |
| Actual yield | = | 4.683 | g | | |
| ∴ Percentage yield | = |  | | | |
|  | = | 39.7 | % | | |

Reaction 2 percentage yield calculation:

The limiting reagent in this reaction was (3-benzylpentan-ol)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ∴ n (product) expected | = | 0.00868 | mol | | |
| M (product) | = | 160.13 | g mol-1 | | |
| Theoretical yield | = | N | x | M |  |
|  | = | 0.00868 | mol x | 160.13 | g mol-1 |
|  | = | 1.39 | g | | |
| Actual yield | = |  | g | | |
| ∴ Percentage yield | = |  | | | |
|  | = | 50.3 | % | | |

*IR spectrum of ketone(*C5H10O*)*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ν / cm-1** | **intensity** | **appearance** | **assignment** | **inference** |
| 2997 | m | sh | C-H stretch | alkyl C-H |
| 2940 | m | sh | C-H stretch | alkyl C-H |
| 1712 | s | sh | C=O stretch | non-conjugated ketone |
| 1376 | m | sh | C-H bend | methyl C-H |
| 1357 | m | sh | C-H bend | methyl C-H |

*IR spectrum of intermediate product(*C12H18O*)*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ν / cm-1** | **intensity** | **appearance** | **assignment** | **inference** |
| 3425 | w | br | O-H stretch | alcohol |
| 3028 | w | sh | C-H stretch | aromatic C-H |
| 2966 | w | sh | C-H stretch | alkyl C-H |
| 2938 | w | slightly br | C-H stretch | alkyl C-H |
| 1602 | w | sh | C=C stretch | aromatic skeletal stretch |
| 1495 | w | sh | C=C stretch | aromatic skeletal stretch |
| 1453 | w | sh | C-H bend | sp3 hybridised carbon |
| 1380 | w | slightly br | C-H bend | methyl C-H |
| 756 | w | sh | C-H deformation | monosubstituted benzene derivative |
| 696 | s | sh | C-H deformation | monosubstituted benzene derivative |

*IR spectrum of final product(*C12H16*)*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ν / cm-1** | **intensity** | **appearance** | **assignment** | **inference** |
| 3061 | w | sh | C-H stretch | alkene or benzene derivative |
| 3026 | w | sh | C-H stretch | alkene or benzene derivative |
| 2963 | w | sh | C-H stretch | alkyl C-H |
| 2931 | w | slightly br | C-H stretch | alkyl C-H |
| 1648 | w | sh | C=C stretch | C=C conjugated with aromatic ring |
| 1601 | w | sh | C=C stretch | Aroma tic skeletal stretch |
| 1493 | w | sh | C=C stretch | aromatic skeletal stretch |
| 1452 | w | sh | C-H bend | sp3 hybridised carbon |
| 839 | w | sh | C-H deformation | trisubstituted alkene |
| 722 | s | sh | C-H deformation | monosubstituted benzene derivative |
| 695 | s | sh | C-H deformation | monosubstituted benzene derivative |





*13C NMR Intermediate product (125 MHz, CDCl3)*

|  |  |  |
| --- | --- | --- |
| **d/ppm** | **HETCOR shows coupling to** | **Assignment** |
| 130.6 |  | C-1, C-5 |
| 128.2 | H1 | C-2, C-4 |
| 126.4 | H3 | C-3 |
| 74.6 | ~ | C-8 |
| 44.8 | H4 | C-7 |
| 30.5 | H6 | C-9, C-11 |
| 8.0 | H7 | C-10, C-12 |

*1H NMR Intermediate product (500 MHz, CDCl3)*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **d/ppm** | **Integration** | **multiplicity** | **J/Hz** | **Assignment** |
| 7.28 | 2 | m | ~ | H2, H3 |
| 7.23 | 3 | m | ~ | H1 |
| 2.75 | 2 | s | ~ | H4 |
| 1.46 | 4 | qd | H7 | H6 |
| 0.93 | 6 | t | H6 | H7 |



*1H NMR Final product (500 MHz, CDCl3)*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **d/ppm** | **Integration** | **multiplicity** | **J/Hz** | **NOESY shows coupling to** | **Assignment** |
| 6.28 | 1.00 | s | ~ | ~ | Ha |
| 5.45 | 1.10 | q | 6.7 | ~ | Hb |
| 5.27 | 1.03 | q | 6.7 | Hd | Hc |
| 3.45 | 2.25 | s | ~ | Hc | Hd |
| 3.34 | 2.15 | s | ~ | ~ | He |

The olefinic region (6.3-5.0 ppm) of the 1H-NMr spectrum contained three well-seperated signals that each integrated for a single proton. The most down-field resonance, a singlet at 6.28 ppm was assigned to Ha, the vinylic proton of the conjugated product, because conjugation with the aromatic ring is expected to deshield the proton by 0.7 ppm relative to a simple internal alkene. Two further quartets, at 5.45 and 5.27 ppm (J = 6.7 Hz) were attributed to the vinylic protons of the two possible internal alkenes. The quartet at 5.45 ppm showed no through-space correlation to any benzylic signal in the NOESY spectrum and was therefore assign to Hc, the E-isomer. The quartet at 5.27 ppm displayed a clear through-space correlation to a benzylic proton at 3.45 ppm, placing the olefinic and benzylic protons on the same side of the double bond and confirming it as Hb of the Z-isomer.

Only the two internal alkene retain the benzylic CH2 group, and two singlets at 3.45 ppm (Hd) and 3.34 ppm (He) together integrated for 4.40 H. the NOESY cross-peak between the 3.45 ppm and 5.27 ppm quartet linked these signal to the Z-alkene, leaving the singlet at 3.45 ppm as the benzylic CH2 of the E-isomer.

**Discussion**

In this experiment we first converted pentant-3-one into a tertiary alcohol with benzylmagnesium chloride, then dehydrated that alcohol to a mixture of three alkenes. The IR spectra recorded at each step showed the expected changes in functional groups. The starting ketone exhibits a strong, sharp C=O stretch at 1712 cm-1 with no O-H absorption. After the Grignard addition and aqueous NH4Cl work-up, this carbonyl band has disappeared and is replaced by a broad O-H stretch around 3400 cm-1, confirming formation of the tertiary alcohol. In the final product the O-H band is gone, while a medium C=C stretch at 1648 cm-1 appears, clearly indicating that dehydration to alkenes has occurred. Throughout the aromatic C=C bands at 1600/1500 cm-1 and the C-H deformations in the fingerprint region remain unchanged, showing that the benzene ring was unaffected

Mechanistically, the first step required the generation benzylmagnesium chloride by insertion of magnesium into the C-Cl bond of benzyl chloride in dry diethyl ether (I). This organomagnesium reagent then attacks the electrophile carbonyl of pentan-3-one (II), forming a magnesium alkoxide intermediate. On addition of saturated NH4Cl this alkoxide is protonated to give the tertiary alcohol (III). No rearrangements occur because the benzyl carbanion is resonance stabilized and adds cleanly to the ketone.

The second step is an acid-catalyzed dehydration of the isolated tertiary alcohol. Protonation of the hydroxyl group (IV) by orthophosphoric acid converts -OH into a good leaving group, and loss of water yields a tertiary benzylic carbocation. From this carbocation, β-elimination (V) of a proton can occur either at the benzylic potion, producing the conjugated double bond, or at one the adjacent methyl groups producing the non-conjugated internal alkene. Since elimination at the methyl can take place from either face of the planer carbocation, both E and Z stereoisomers of the internal alkene are formed. Although formation of the Conjugated alkene is thermodynamically favored, steric accessibility of the methyl protons makes internal elimination competitive, resulting in all three alkene in roughly equal proportions

