Lab Notebooks and Lab Reports

Chemistry 2312 September 7, 2023

Honors Organic Chemistry Laboratory T. R. Hoye

Notebooks: Use a separate page in your laboratory notebooks (non-loose leaf) for each new experiment/reaction you perform. During the course of the experiment at least the following information should be entered (read Mohrig *et al.*, *Techniques*, Chapter 3 Laboratory Notebook):

a) date
b) equation of attempted reaction
c) molecular weight, exact quantity (mass or volume to two significant figures), and number of millimoles (mmol) for each reactant and reagent
d) solvent quantity
f) brief description of the apparatus and experimental procedure
g) tlc data, including elution solvent (hand-draw an actual-size replica of the data you see)
h) method of quench of the reaction mixture
i) work-up procedure and manipulations
j) mass of crude product recovered (free of volatile solvents, this is the "crude mass recovery")
k) description of the purification/separation that was performed
l) mass of pure product (from which you will deduce your yield of isolated, purified product)
m) cross-reference to each of your NMR, IR, and gas chromatography/mass spectrometry data files collected for each purified product [e.g., NMR-TRH-32A would be the first (A) NMR spectrum taken and described on page 32 of my (TRH) notebook--the spectrum (file name) should also bear this label to complete the cross-referencing]
n) physical description of each pure product [mp, bp, appearance (e.g., pale yellow oil or white crystals)]

Reports: The final report (hard copy, please) for each experiment should be succinct. It need only consist of a cover page (containing the course number, experiment number and title, your name, and date), an experimental description of the reactions performed, and answers to any specific questions asked in the handout for that experiment. There should be no introduction, no discussion of results, and no conclusion section. The report should be typed (there's a word from my distant past!) and **double-spaced**. This makes it easier for us to give editing feedback before returning your report to you. The format (abbreviations, spaces, recording of spectroscopic data, etc.) should *carefully parallel* that found in the primary literature. [For an example, see various experimental procedures in the *Journal of Organic Chemistry* **1996**, *61*, 1219-1222, which you can get to via the "List of Issues" tab at this url: <http://pubs.acs.org/journals/joceah/index.html>. (Note: you will need to use VPN to access the UMN library resources such as this from an off-campus site.)

Your report should include:

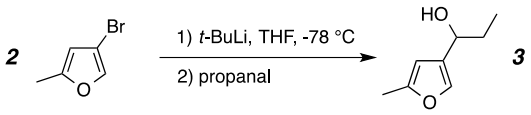
a) masses and molar proportions [usually in milligrams (mg) and millimoles (mmol)] of all reactants and catalysts and the volumes (in mL) of all reaction solvents
b) a *concise* description in words of the apparatus, procedure, and workup (cf. journal examples)
c) a description of the purification protocol
d) the yield of purified product
e) if relevant, the mp or bp (always as a range of degrees) of the compound and literature values for the same (you should reference the primary literature source of this data)
f) the gc conditions used for determination of purity (all reported gc retention times should be longer than three minutes)
g) a linear tabulation of interpreted spectral data (^{1}H NMR, IR, and MS); each data set should start with the largest value and proceed to the smallest.
h) attached copies of gc chromatograms, and ir, nmr, and mass spectra (we will use these to judge spectral quality [SQ] and product purity [PP])

Sample Templates/Formats for Experimental Description for Reports (double-space, please):

Preparation of 2,3-dimethyl-2-butanol (1).

Magnesium turnings (17 g, 740 mg atom) and anhydrous ether (100 mL) were placed in a 1000 mL round-bottomed flask fitted with a mechanical stirrer, reflux condenser, pressure equalizing addition funnel, and drying tube. A solution of 2-bromopropane (86 g, 700 mmol) in dry ether (300 mL) was added dropwise at room temperature to the stirred mixture at such a rate as to maintain a gentle reflux. After addition was complete and most of the magnesium was consumed, a solution of reagent grade acetone (41 g, 710 mmol) in dry ether (200 mL) etc., etc., etc (*i.e.*, the workup procedure). The residue was distilled through a 40 cm Vigreux column to give 2,3-dimethyl 2-butanol (**1**) as a colorless liquid (43 g, 60%). GC: (30 m x 0.25 mm ID, HP-5, 50 °C/1.5 min/20 °C min^{-1}/150 °C) t_R = 3.8 min; bp 114-115 °C @ 1 atm (lit.[1] bp 118 °C); IR (neat (or thin film)): 3400 (OH), etc. cm^{-1}; ^1H NMR ($CDCl_3$, 300 MHz) δ 2.11 [septet, *J* = 6.2 Hz, 1H, C*H*$(CH_3)_2$], 2.01 (br s, 1H, O*H*), 1.10 [s, 6H, $(CH_3)_2CO$], and 0.90 [d, *J* = 6.3 Hz, 6H, $(CH_3)_2CH$]. MS [70 eV, *m/z* (rel int)]: 102 (6, M^+), 87 (24, M^+-Me), and 59 (100, M^+–*i*-Pr).

[1] locate (e.g., using Reaxys or SciFinder) and provide a citation to the source of published boiling point data.



Preparation of 1-(5-methylfuran-3-yl)propan-1-ol (3)

An oven-dried 250 mL round-bottomed flask was charged with dry THF (75 mL). The flask was cooled to -78 °C before dropwise addition of a solution of *t*-BuLi (38 mL, 1.7 M, in hexanes; 65 mmol). 4-Bromo-2-methylfuran (**2**, 4.98 g, 29 mmol) was added dropwise at -78 °C, which produced an orange solution. This mixture was stirred at -78 °C for 10 min before dropwise addition of propionaldehyde (6.0 mL, 84 mmol). The reaction mixture was allowed to warm to room temperature, quenched by the addition of satd. aqueous NH_4Cl solution, and extracted with ethyl acetate The combined organic layers were washed with brine, dried with Na_2SO_4, filtered, concentrated, and purified using flash column chromatography on silica gel (hexanes:ethyl acetate = 5:1) to give 1-(5-methylfuran-3-yl)propan-1-ol (**3**, 3.8 g, 95% yield) as a colorless liquid. GC: 30 m x 0.25 mm ID, HP-5, 50 °C/1.5 min/20 °C min^{-1}/150 °C) t_R = 4.1 min. IR (neat): 3384, 2964, 2933, 2877, 1555, 1452, 1381, 1266, and 1208 cm^{-1}. ^1H NMR (500 MHz, $CDCl_3$) δ 7.22 (br s, 1H, *H2*), 5.98 (br s, 1H, *H4*), 4.49 (br t, *J* = 6.5 Hz, 1H, C*H*(OH)CH_2), 2.27 (s, 3H, ArCH_3), 1.75 (ddq, *J* = 14, 7.4, 7.4 Hz, 1H, C$H_a$$H_b$$CH_3$), 1.71 (ddq, *J* = 14, 7.2, 7.2 Hz, 1H, $CH_aH_bCH_3$), 1.71 (br s, 1H, OH), and 0.93 (t, *J* = 7.5 Hz, 3H, CH_2CH_3). MS [70 eV, *m/z* (rel int)]: 140 (M^+), 111 (M^+-CH_2CH_3), and 83 (M^+-$COCH_2CH_3$).

Some Miscellaneous Notes:

- Enter NMR, MS, and IR spectral data from larger to smaller values (of δ, *m/z*, and cm^{-1}, respectively).
- Include "and" between the next to last and last entries of a series of spectral peaks (see nmr data above).
- Insert a space between a number and its unit (*e.g.*, 31 mg not 31mg; 67 °C not 67°C).
- Get in the habit of using milligrams (mg) and millimoles (mmol) for reporting quantities less than 1 g or 1 mole.
- Do not begin a sentence with an Arabic numeral.
- Use an "en-dash" to separate two numbers that define a range of values (e.g., the pages in the citation below).
- Include literature references to journals with (***precisely***) the following (ACS journal style) format:
  Meinwald, J.; Gassman, P. G. *J. Am. Chem. Soc.* **1960**, *82*, 5445–5450.
  (By the way, this publication describes the ozonolysis reaction that you will perform in Experiment 2.)

Report Grades are based on**:**

A. Product Purity and Yield
   i. 20 pts purity as judged from bp, mp, gas chromatogram, and/or nmr spectral data [PP]
   ii. 20 pts (%yield divided by10 and added to 10, IF you obtained <u>any</u> of the expected prod) [PY]

B. Spectral Data
   i. 20 pts quality of ir, nmr, and mass spectra [SQ]
   ii. 20 pts interpretation (assignment) of spectral data [SI]

C. Laboratory Report
   i. 20 pts format of experimental description (ACS journal style) [LR]
   ii. 10 pts for answers to questions asked in the handout for that experiment [Q]

No reports will be accepted after 5 pm, Wednesday, December 13, 2023

2,2,2-Trifluoroacetophenone (2). Solid magnesium turnings (2.7 g, 110 mg atom) and a magnetic stirring bar were placed in a three-necked 250 mL round bottom flask fitted with an addition funnel (125 mL) and a condenser. Bromobenzene (16 g, 100 mmol) was dissolved in anhydrous ether (90 mL). A small portion of this solution (~2 mL) was added to initiate the reaction (if necessary, a small quantity (~100 μL) of 1,2-dibromoethane can be added to initiate formation of the Grignard reagent). Once the reaction to form PhMgBr had initiated, the remainder of the PhBr solution was added dropwise. After the addition was complete, the reaction mixture was refluxed for 30 minutes. The mixture was allowed to cool to room temperature and trifluoroacetic acid (4.6 g, 40 mmol) in dry ether (10 mL) was added dropwise. The reaction mixture was refluxed for 1 h and quenched by being poured onto a mixture of 10% HCl and ice. This mixture was extracted three times with ether. The combined organic layers were washed with saturated aqueous $NaHCO_3$ and brine, dried ($MgSO_4$), filtered, and concentrated to leave a yellow liquid (17 g). Purification was … etc., etc.

General procedure for preparing lithium diisopropylamide (LDA), using it to generate an enolate anion, and alkylating the enolate anion with methyl iodide.

Adapted from "Not Voodoo", a source of tips and tricks maintained by Professor Alison Frontier (University of Rochester) for "Demystifying Synthetic Organic Chemistry" manipulations (since 2004): http://www.chem.rochester.edu/notvoodoo/pages/how_to.php?page=prepare_lda

BTW, you will make and use LDA in experiment #3.

Using, for example, 1 mmol of the carbonyl (e.g., ketone or ester) starting material"

1. To diisopropylamine (0.17 mL, 1.2 mmol) in 3 mL of THF at -78 °C was added 0.69 mL of a 1.6 M solution of *n*-BuLi in hexanes (1.1 mmol). The mixture was stirred for 1 min (longer times are fine) at -78 °C.

   [notes: mixing *n*-BuLi with diisopropylamine quickly forms LDA even at "dry-ice temperature" because the pKas of butane and diisopropylamine differ by ca. 15 units (i.e., ca. 10^{15}-fold difference in ionizability) and proton transfers have very few consequences from steric hindrance. It is also common to see procedures where researchers have carried all of the manipulations described here at 0 °C (wet-ice bath) rather than in a dry-ice/acetone cold bath. Commercial redistilled diisopropylamine is dry enough for this or you can redistill it yourself. Diisopropylamine of unknown purity should be distilled from CaH_2 (100 mL/g) or KOH pellets.]

2. A solution of the carbonyl starting material (SM) (1 mmol) in 2 mL of THF was added via syringe or cannula needle (using a slight positive pressure of N_2 into the SM flask to push this solution through the needle into the anion solution), and the resulting mixture was stirred for 15 min at -78 °C.

   [notes: Adding SM to the LDA avoids undesired intermolecular reactions of lithiated SM with neutral SM. Rarely do deprotonations with LDA require more than 15 min. You can judge based on recovery of SM whether the anion requires more time to form or whether you need more LDA because adventitious water is present. If these two do not increase the yield, then you may have an example where your sample of the electrophile contains an acidic (protic) impurity that quenches the anion.]

3. Add the electrophile (e.g., MeI; 1.2 mmol) as a solution in 2 mL of THF via syringe to the enolate anion solution. Stir for ca. 15 min at -78 °C and then 1 hour 0 °C.

   [note: This is usually more than enough time for organolithium reactions, but there is little harm to allowing this mixture to stir longer before beginning the following workup.]

4. Quench by addition of 1 M aqueous NH_4Cl and Et_2O. Partition. Wash the organic layer with water and brine, dry ($MgSO_4$) and evaporate to provide the product residue ready for further purification.