

Organic Chemistry for Materials Scientists (MSE-211)

Prof. Holger Frauenrath

Ecole Polytechnique Fédérale de Lausanne (EPFL)

School of Engineering

Associate Dean for Industry & Innovation

Institute of Materials (IMX)

Laboratory of Macromolecular and Organic Materials (LMOM)

Laboratory Director

Table of Contents

1. Organic Chemistry & Soft Matter Research (2 h)

2. The Nature of the Covalent Bond (7 h)

- 2.1. Carbon as the Basis of Organic Chemistry
- 2.2. Atomic Orbitals and Hybridisation
- 2.3. Formation of Single Bonds
- 2.4. Formation of Multiple Bonds
- 2.5. Electron Delocalization & Resonance Structures

3. Molecular Structure and Nomenclature (3 h)

- 3.1. Basic Rules of Nomenclature
- 3.2. Isomerism

4. Mechanisms of Organic Reactions (15 h)

- 4.1. Reaction Thermodynamics & Kinetics
- 4.2. Reaction Types and Intermediates
- 4.3. Nucleophilic Substitutions (S_N1 , S_N2)
- 4.4. Elimination Reactions ($E1$, $E2$, $E1_{CB}$)

4.5. Nucleophilic Reactions on Carbonyl Carbons (S_{AE} , A_N)

4.6. Electrophilic Additions on Double Bonds (A_E)

4.7. Electrophilic Substitutions on Aromatic Systems (S_E)

4.8. Radical Substitutions and Additions (S_R , A_R)

4.9. Orbital-Controlled Reactions

5. Polymer Chemistry (6 h)

- 5.1. Introduction to Polymer Science
- 5.2. Step-Growth Polyreactions
- 5.3. Chain-Growth Polymerizations
- 5.4. Living and Controlled Polymerizations
- 5.5. Molecular Weight Determination

6. Organic and Polymer Materials (3 h)

- 6.1. Industrial Chemistry
- 6.2. Polymer Materials
- 6.3. Surfactants
- 6.4. Organic Dyes and Semiconductors

Learning Objectives

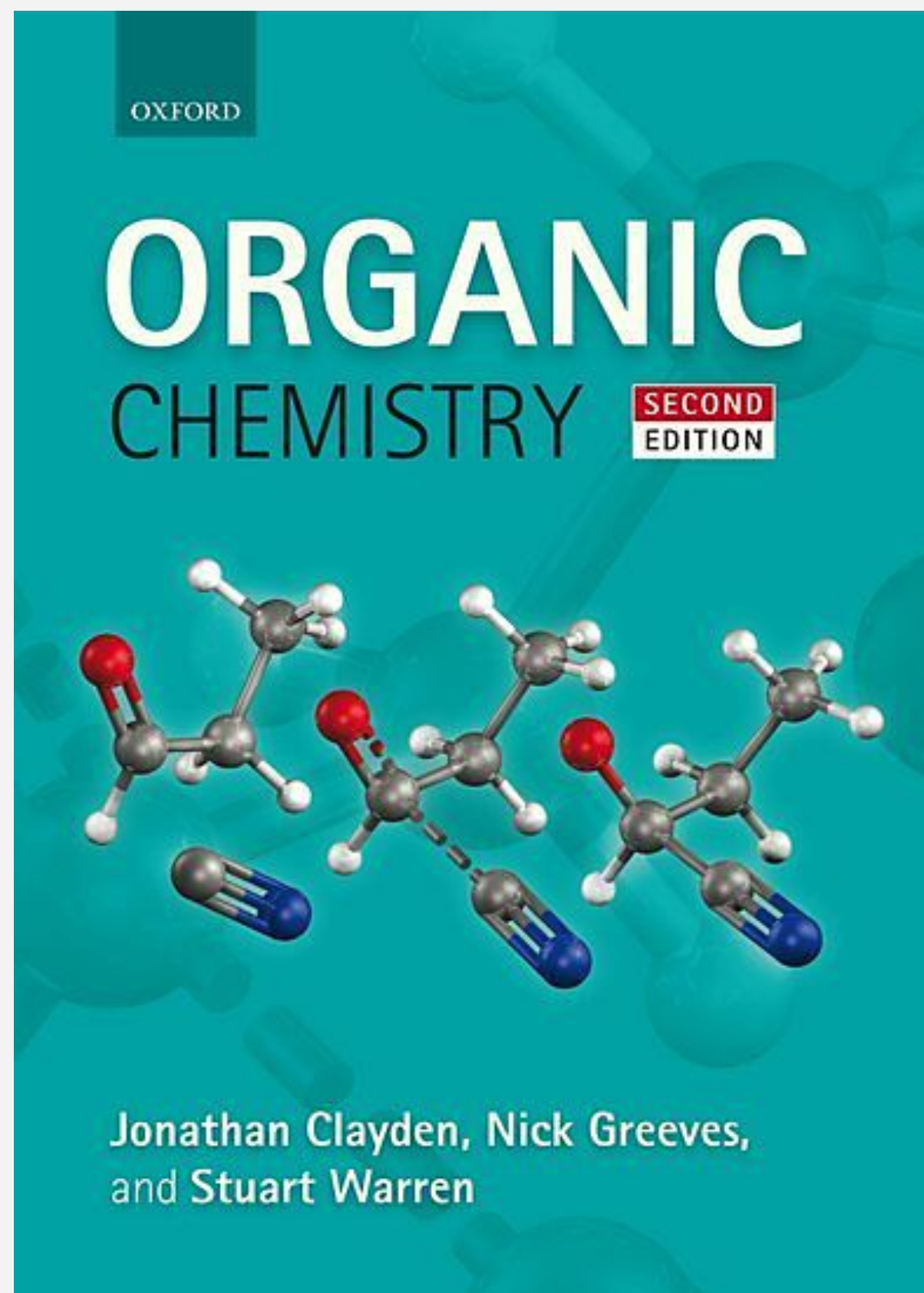
Class & Exercise

- draw and correctly name organic molecules
- comprehend the three-dimensional structure of organic molecules
- understand covalent bond formation and electron delocalization
- know functional groups and understand principles of chemical reactivity
- formulate chemical reactions and understand their outcome
- know classes of organic compounds relevant in materials science

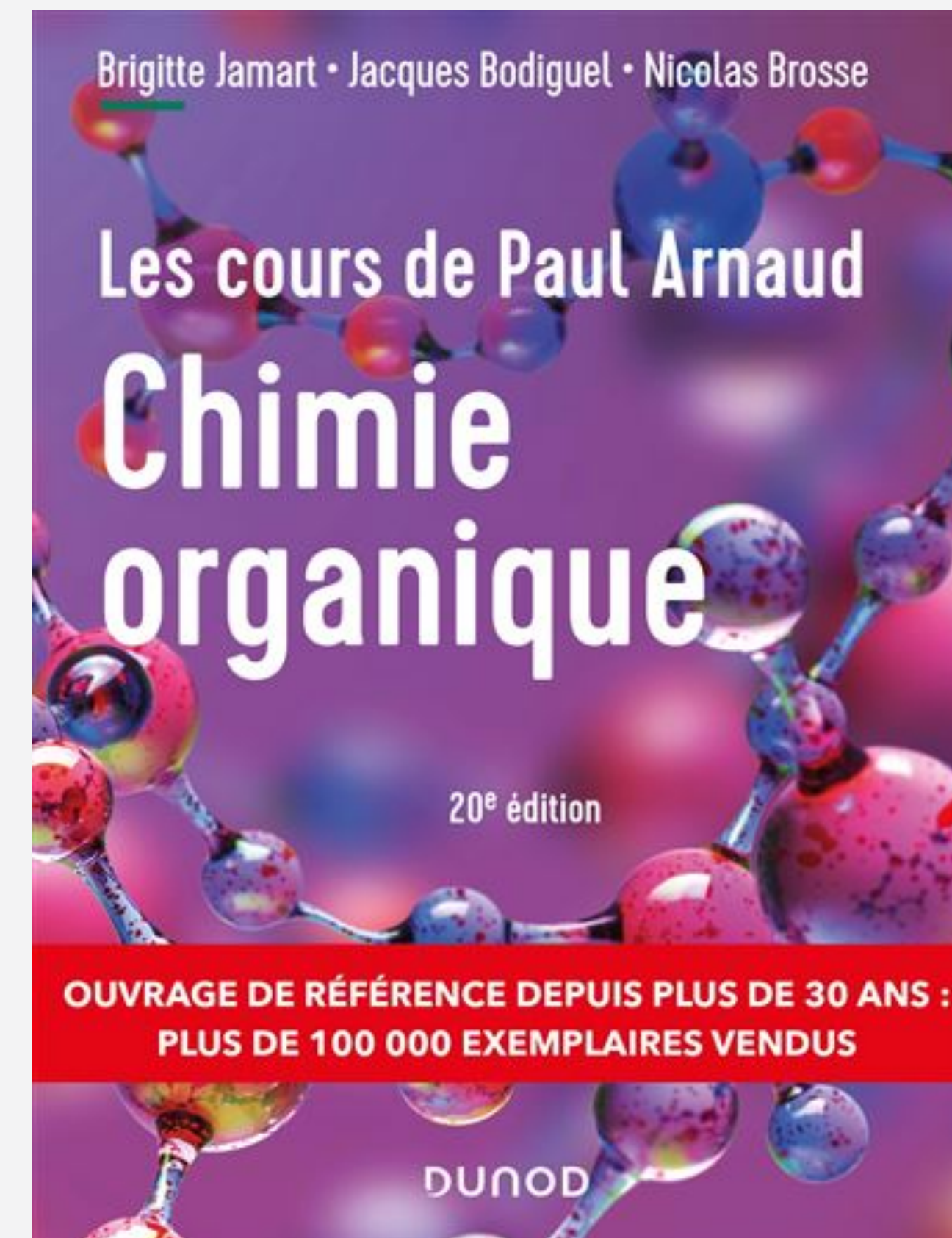
Lab Course

- prepare and run chemical reactions
- stoichiometric calculations
- work-up, product isolation and purification
- basic characterization techniques

Recommended Text Books



Clayden, Greeves, Warren
Organic Chemistry, Oxford
University Press, 2nd ed., **2012**.



Jamart, Bodiguel, Brosse
*Les cours de Paul Arnaud – Chimie
organique*, Dunod, 19th ed., **2015**.

Teaching Assistants

Dr. Daniel Görl
Senior Scientist
daniel.gorl@epfl.ch



Berlind Vosberg
PhD student LP
berlind.vosberg@epfl.ch



Matthias Kellner
PhD student COSMO
matthias.kellner@epfl.ch



Chihui Zheng
PhD student SuNMIL
chihui.zheng@epfl.ch



Matthieu Wendling
PhD student LMOM
matthieu.wendling@epfl.ch



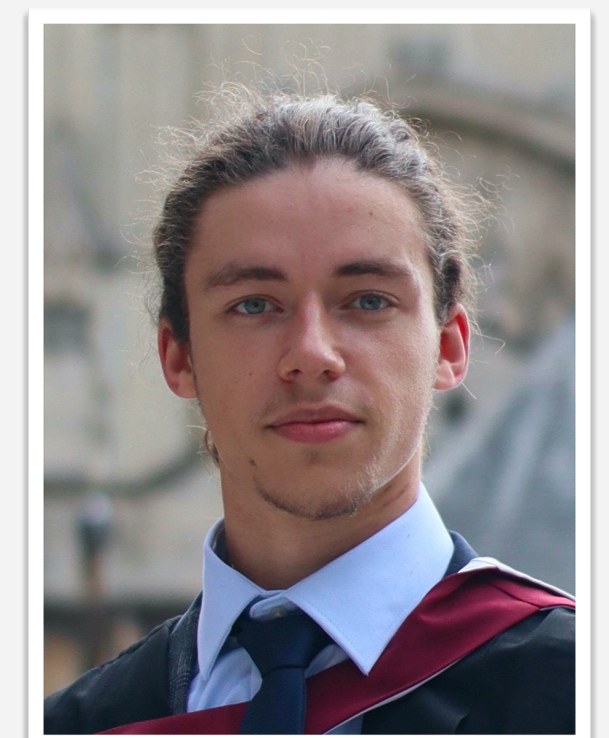
Cecilia Siri
PhD Student SunMIL
cecilia.siri@epfl.ch



Wei Bin How
PhD student COSMO
weibin.how@epfl.ch



Joseph Abbott
PhD student COSMO
joseph.abott@epfl.ch



Exercise Sheets

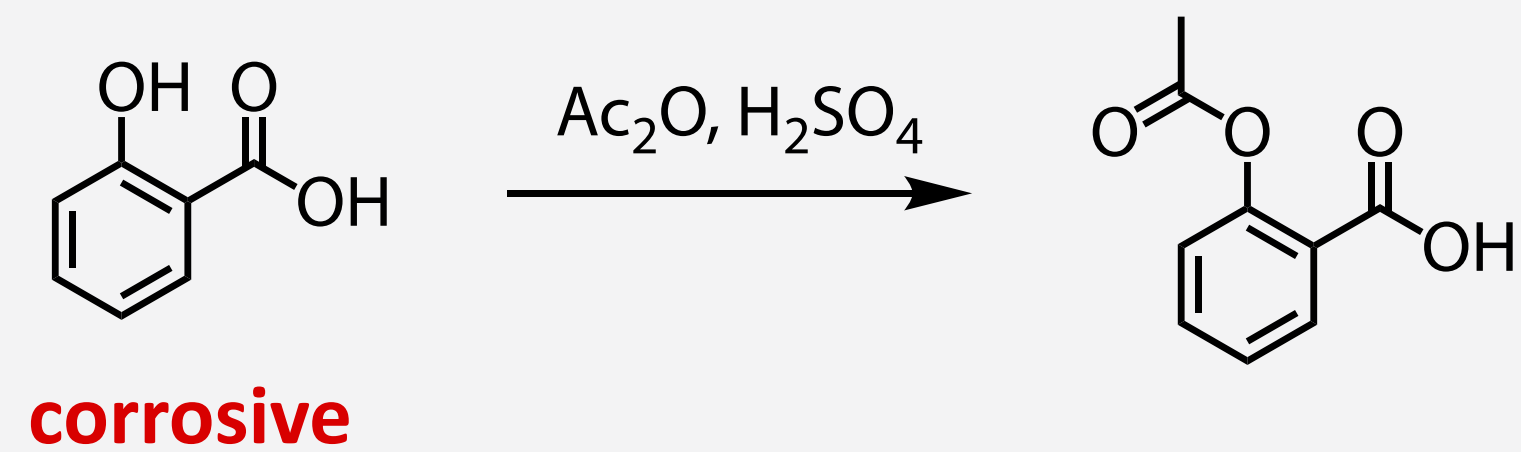
- **goal of the exercises is to encourage you to work on the course continuously**
 - the exercises also serve to prepare you for the exam questions
 - the style of the exam will follow closely the exercise
 - we do not want to control or punish you
- **exercise hours are voluntary, your chance to talk to the teaching assistants**
 - we will distribute exercise sheets (almost) every week of the course (overall 10)
 - you solve them at home or during the exercise hours, even with the help of the assistants
 - you return the exercise sheets at the indicated dates
 - we correct them and give detailed feedback if you want
 - we do not give actual grades for individual exercise sheets!
 - if $\geq 60\%$ of the questions are treated in a reasonable way, a sheet counts as “passed”
 - exercise grade 6.0 for 10 sheets, 5.75 for 9 sheets, 5.5 for 8 sheets, 5.25 for 6 sheets, ...
- **total course grade is 75% exam, 15% exercises, 10% lab course & reports**

Lab Course

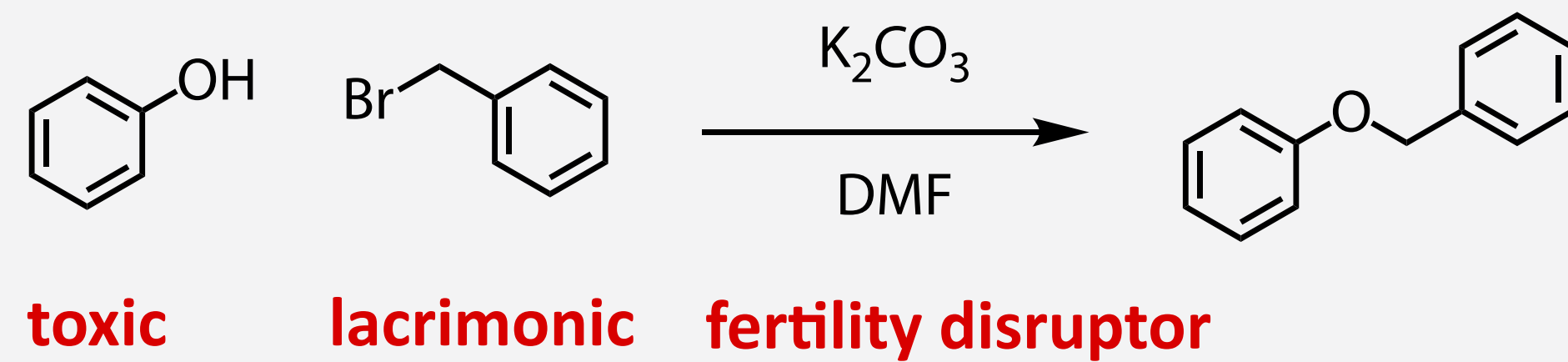
- Each one of you will be performing chemical syntheses in a lab course at the UNIL Chemistry Teaching labs in the UNIL Amphipol building
 - POL-452 (<https://planete.unil.ch/plan/?local=POL-452>)
 - POL-456 (<https://planete.unil.ch/plan/?local=POL-456>).
- The lab course is a full-day course, from 8 am to 5 pm (with a break for lunch and Analysis III). You absolutely need to be at the UNIL Chemistry Teaching labs at **8 am sharp** on lab course days.
- We will split you into two groups A and B (Moodle); the lab course takes place over a total of 6 weeks (three days per group), **starting November 9 (group A) or November 16 (group B)**
- The group that is not doing the lab course will do a regular class with me...
- You will have to follow a short safety course and perform a short safety exam on October 19, in order to be allowed to participate in the lab course.

Lab Course Overview

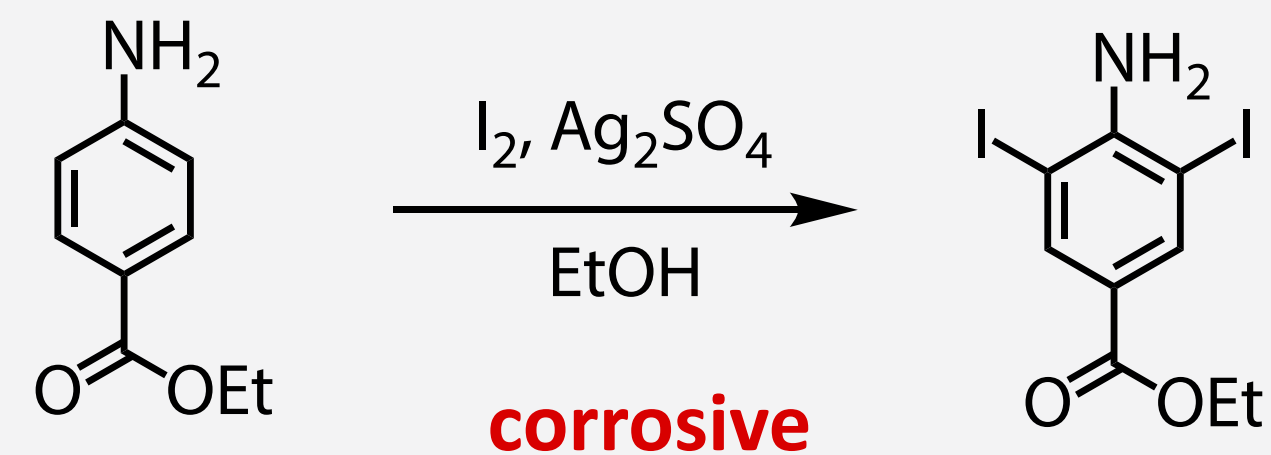
- synthesis of Aspirin



- synthesis of benzyl phenyl ether



- synthesis of ethyl diiodoaminobenzoate



- safe handling of toxic, corrosive, harmful chemicals is part of this lab course!

Lab Coats and Safety Glasses

- **lab coats, safety glasses, and masks must be worn at any time!**



- **lab coats will be sold at the first day of the lab course for 35 CHF**
- please fill out the Google form: <https://forms.gle/3EQEPSskhWjk8ARw8>
- glasses will be sponsored by the Section de Materiaux.
- masks will be provided (4 per person).

Protocol Preparation

- we will make available the documentation for the three reactions
- the first two pages of the protocol must be filled for the lab course day!

Organic Chemistry for Materials Scientists (MSE 211)
- Lab Course -

Prof. Holger Frauenrath
EPFL - STI - IMX - LMOM, Station 12
1015 Lausanne, Switzerland

Phone: + 41 21 693 7396
Fax: + 41 21 693 5270
E-mail: holger.frauenrath@epfl.ch

EPFL

Date:
Assistants:
Name, <u>surname</u> :
Name, surname:
N°:

Signature(s):

Synthesis and Purification of _____

Reaction Equation + Mechanism (including electron arrows)

Name of the Reaction Mechanism:

Organic Chemistry Lab Course for Materials Scientists (MSE 211) 1

Quantities and Safety

Compound Name	Molar Mass (g.mol ⁻¹)	Mass/Volume, (g, mL)	Hazardous Symbol	Phrases H/P (n°)

Phrases H:	Phrases P:

Organic Chemistry Lab Course for Materials Scientists (MSE 211) 2

- a video on protocol writing will be available at the Moodle site by 4.11.21

Course Schedule

Date	12.9	19.9	26.9.	3.10.	10.10.	17.10.	24.10.	31.10.	7.11.	14.11.	21.11.	28.11.	5.12.	12.12.	19.12.
8–9							fall break					Rctn 1	Rctn 2	Rctn 3	
9–10	Ann.	2.2	3.1	3.2	4.2	4.4		4.6	4.7	5.1	5.2	A	A	A	E
10–11	1	2.3	3.1	4.1	4.3	4.5		4.6	4.8	5.1	5.3	A	A	A	E
11–12	1	2.4	3.1	4.1	4.3	4.5		4.7	4.9	5.2	5.3	A	A	A	E
12–13	(Ana III)	(Ana III)	(Ana III)	(Ana III)	(Ana III)	(Ana III)		(Ana III)	(Ana III)	(Ana III)	(Ana III)	(Ana III)	(Ana III)	(Ana III)	(Ana III)
13–14															
14–15	2.1	2.4	E	E	E	E		E	E	Safety	E	Recryst.	MS	NMR	E
15–16	2.1	2.4								Safety		A	A	A	
16–17												A	A	A	
17–18		(ES1)	(ES2)	(ES3)	(ES4)	(ES5)		(ES6)	(ES7)	(ES8)	(ES9)	(ES10)	(ES11)	(ES12)	

In-person class

exercise session

laboratory (UNIL)