

Special Topics in Organic Chemistry
8833A Pulping and Bleaching Chemistry

Course Description: This course focuses on developing an understanding of the fundamental chemistry associated with pulping and bleaching of wood. The subject material encompasses: (1) the detailed analysis of the chemical structure of the major wood components, (2) the nature and scope of the reactions of pulping and bleaching reagents with typical carbohydrate and lignin functional groups, and (3) the underlying factors which explain differences in the degree of lignin vs. carbohydrate degradation during pulping and bleaching stages. The focus is on alkaline/NaSH pulping and ClO₂, H₂O₂, O₂/NaOH, O₃ bleaching chemistry of chemical and mechanical pulps.

Course Objectives:

1. To provide a fundamental understanding of the chemical components present in wood and their relationship to modern pulping, bleaching and biorefinery principles.
2. To develop an advanced understanding of chemical mechanisms involved in the modern pulping, delignification, and chromophore removal reactions.

Course Outline:

Wood component structures

Lignin

- Basic structures in wood
- Structural dependency on wood species

Cellulose/Hemicellulose

- Structure (crystalline and amorphous, polymorphs of cellulose)
- Reactivity under acidic and basic conditions

Extractives

- Structure of Wood Extractives
- Tall Oil Production, Chemistry and Chemical Functionalization

Chemistry of Pulping

Lignin reactions during chemical and mechanical pulping

- Depolymerization reactions
- Condensation reactions

Carbohydrate reactions

- Peeling and stopping reactions
- Formation and hydrolysis of hexenuronic acids
- Formation of lignin-carbohydrate complexes.

Chemistry of Bleaching and Biorefinery

Reactivity of lignin and carbohydrates with

- Chlorine-containing reagents (i.e., Cl₂ and ClO₂)
- Oxygen-based reagents (i.e. H₂O₂, O₂/NaOH, activated peroxide and O₃)

Student Seminars describing the fundamental chemistry, conformation, synthesis/derivatization, reaction mechanisms and application of pulping/bleaching:

- a. Chemistry of AQ-kraft pulping
- b. Laccase biobleaching
- c. Xylanase pretreatments
- d. DMD bleaching chemistry
- e. Oxidation/Functionalization of cellulosic fibers
- f. Chemistry of bleaching recycled fiber: dye oxidation
- g. Kraft lignin recovery and application for fuels/materials
- h. Hemicellulose pre-extraction and use for biofuels

Note: Dr. Ragauskas will provide each student a list of key papers for each presentation/paper and technical focus once each student selects a biopolymer.

Course Format:

The course is taught in a seminar style by the professor and students. Literature articles will be assigned for reading and will be reviewed at class meetings. Students will be assigned course topics for which they will research the literature and present their findings to the class in an oral and written report.

Course Grading:

Midterm Exam:	20%
Term Paper/Presentation:	30%
Presentation/Review:	30%
Final Exam:	20%

Reference Texts:

1. Sjoestrom, Eero. **Wood Chemistry: Fundamentals and Applications, 2nd Edition.**
2. Dence, Carlton W.; Reeve, Douglas W.; Editors. **Pulp Bleaching: Principles and Practice.** (1996),
3. Hon, David N.-S.; Shiraishi, Nobuo; Editors. **Wood and Cellulosic Chemistry, Second Edition.** (2001),

4. Fengel, Dietrich; Wegener, Gerd. **Wood: Chemistry, Ultrastructure, Reactions.** (1988),

Principal Journals:

Carbohydrate Research, Cellulose, Carbohydrate Polymers, Can. J. Chem.,
Holzforschung, J. Wood Chem. Technol., Angew. Chem. Int. Ed. Engl., Ind. Eng. Chem.
Res., Nord. Pulp Pap. Res. J., Acta Chem. Scand., J. Pulp Paper Science, Tetrahedron
Letters, Enzyme Microb. Tech.

LECTURE ATTENDANCE: It is required that you attend all lectures.

STUDENT ID NUMBERS: All work submitted for grading must include your name.

REGRADES: *If you want any work regraded you must make a written request and return the assignment within one week to the instructor. Work will not be regraded after this deadline.*

CLASS NOTES : Class notes and reference papers will be available at the beginning of each class.

MIDTERM (20% OF FINAL GRADES): A closed book mid-term exam will be assigned to each student worth 20% of the final grade. You must take the exam at the assigned time. All exams are closed to textbooks, class-notes and electronic devices (unless otherwise stated prior to the exam). The only valid reason for missing an exam are illness and official GA Tech business. Make-ups can only be given if advance notification is given or upon presentation of a doctor's note.

REVIEW PAPER, PRESENTATION, AND CRITIQUE: Each student will be assigned a biopolymer topic to review and will present to the class a presentation and paper. (Upon selection of each topic Ragauskas will provide a scope for the paper/presentation and recommended papers) The review paper will contribute 50% to the final grade, with the presentation accounting 30% and the paper accounting 20%. Each presentation will be 1.5 hours in duration and will be presented via MS Power-Point presentation format. A week prior to each student's presentation the student will submit a draft copy of the presentation to Ragauskas for an initial review and feedback. No scanned material is permitted in either the report or presentation, plagiarism will not be tolerated. It is anticipated the presentation and paper will reflect a state-of-the-art review in the selected topic area, as such the bulk of the reviewed material will originate from research publications no more than 5 years old.

FINAL EXAM (20% OF FINAL GRADES): A closed book, final-exam will be given to each student during finals week worth 20% of the final grade. You must take the exam at the assigned time. All exams are closed to textbooks, class-notes and electronic devices (unless otherwise stated prior to the exam). The only valid reasons for missing an exam are illness and official GA Tech business.

RETURNED WORK: All graded assignments will be returned as soon as possible. Work not picked up in lecture will be available form outside of the instructor's office door in the IPST Building.

MATERIAL COVERED/STUDENT RESPONSIBILITIES: You are responsible for all material presented in lectures and in assigned readings. You are also responsible for announcements made in class, which will also be posted on the www page or distributed by email. You must check the web site and you *prism.gatech.edu* email account on a regular basis. Note: there are potential problems associated with automatic forwarding of

messages from *prism* to other email addresses; check your *prism* account even if you have it set up to forward email elsewhere.

WORKING IN GROUPS: Most learning takes place *outside* of the classroom. Although lectures should put things in perspective, working through the textbook, and solving the problems is when you will come to terms with the material. We encourage you to work together on these reading and problem assignments. For most students, it is actually unwise to try to work alone. Although you might study in groups, remember that you are ultimately responsible for your learning. Everybody can benefit from team work. You will learn through teaching. Office hours are available for individual instruction. No *new* information will be introduced during office hours. Come prepared to ask *and answer* problems.

COMPETITION AND GRADING: Formal education often puts students in competition with each other for good grades. We do not believe that competition for grades, and the exclusion of everything else, is the most effective way to foster student development. Although grades will be assigned based on a numerical score which judges attainment on exams, We hope that the course is structured such that if you show a desire to learn, put *the effort in, and have some intellectual ability, you can get the grade you want. With this in mind, please take the time to read the Grades, Expectations and Minimum Requirements section, and decide what you want from the course.*

CANCELLATION OF CLASSES: If class is cancelled by Georgia Institute of Technology owing to campus closing, the entire schedule for the course will be delayed by one lecture. This will move all exams and Homework due dates back by one lecture.

TIME COMMITMENTS: We all have extensive demands on our time. For each lecture you should aim to put in *at least* another two hours of your own time. You will need to spend much more time preparing for the mid-term exam and your term paper. Some students will require more, some less.

GRADES, EXPECTATIONS AND MINIMUM REQUIREMENTS

adapted from J. H. Williams in *The Teaching Professor*, (Aug 1993)

"D" -50%- Some demonstration of detailed knowledge of biopolymers chemistry reactions.

"C" -60%- Detailed knowledge of structure, bonding and chemistry of biopolymers including lignin and polysaccharides. Understand the basics if monosaccharide chemistry and conformational analysis.

"B" -70%- Requirements for a "C", plus some demonstrated success of multistep reaction mechanisms involved in the synthesis of oligosaccharides conformational analysis of these structures. Understands current literature in biopolymer chemistry

“A” -85%- Requirements for a “B”, plus: write consistently good complete pathways for multistep bleaching/pulping reactions, excellent knowledge of lignin/polysaccharide chemistry research literature, able to critically analyze literature results and propose good mechanisms reactions involving biomass polymers.

“A” students have virtually perfect performance. Their commitment to the class resembles that of the teacher. They always read the assignment, and their attention to detail is such that they occasionally catch the teacher’s mistakes (we all make them!). An “A” student is CREATIVE, COMMITTED, ORGANIZED, and CURIOUS, has a RETENTIVE MIND (and exercises it), has a WINNING ATTITUDE, and SHOWS INITIATIVE.” “V” audit - same as for “S” , “S”atisfactory (S/U) - Exams 1-5 to a “C” level (no drops), Final not required, or “D” including Final

If every student gets 85+%, everyone gets an “A”

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“WORD – Past Tests/Exams”

If you want word just ask! The *processes* by which you can solve the problems will be *exactly* the same as those in the book. Occasionally, an exam question will be taken directly from the text.

SOME STUDY TIPS

Understand and Rationalize. Read the notes, assigned literature papers, prepare your own summaries. Study in groups. ***Keep up to date! Ask Questions!!***

STUDENT CLASS ACCOMMODATIONS

Students with disabilities who require reasonable accommodations to fully participate in course activities or meet course requirements are encouraged to register with ADAPTS-Disability Services Program at (404)894-2564 or www.adapts.gatech.edu and contact me to discuss access issues.

GEORGIA TECH ACADEMIC HONOR CODE: Please visit www.honor.gatech.edu

When copying any written material use "Quote and attribute any words that are not your own." Do not cut and paste more than 1 % of a paper; any percentage more than this will be considered plagiarism. This includes the use of "word." (With "word" being any material a student may have acquired from a previous semester of this class.) With "word" being any material a student may have acquired from a previous semester of your class. Use of any previous semester course materials is allowed for this course; however, I remind you that while they may serve as examples for you, they are not guidelines for

any tests, quizzes, homework, projects, or any other course work that may be assigned during the semester.

For Tests: Cheating off of another person's test or quiz is unethical and unacceptable. Cheating off of anyone else's work is a direct violation of the GT Academic Honor Code, and will be dealt with accordingly. For any questions involving these or any other Academic Honor Code issues, please see me or consult www.honor.gatech.edu.

