University of Maryland
Dept of Materials Science and Eng.
ENMA 445/645
Liquid Crystals and Structured Soft Matter Materials
January 28, 2020

Course Description: Elective course on the properties and behavior of liquid crystals and related soft materials, and their relationship to biomaterials and to applications.

Pre-requisite: None. However, knowledge of physics and mathematics assumed

Textbook:
1. Required: Peter J. Collings and John W. Goodby, Introduction to Liquid Crystals, Chemistry and Physics, 2nd Edition, Taylor and Francis, 2020.
2. Recommended: Peter J. Collings, Liquid Crystals: Nature's Delicate Phase of Matter, Princeton, 2nd edition, 2002. Available in the STEM library.
3. Articles provided in class plus faculty notes provided in the powerpoint presentations

Course Objectives: At the end of this course, the student should be able to answer the following questions:
1. What are liquid crystals?
2. How do the properties of anisotropy, self-ordering, and nanometric size relate to the liquid crystal?
3. How are liquid crystals ideal for applications?
4. How do liquid crystals relate to biological materials?
5. How can the knowledge of liquid crystals and their properties be extended to other materials?

MSEMS: The MSEMS are related to the course objectives and are:
1. How are liquid crystals ideal for applications?
2. How do liquid crystals relate to biomaterials?

I. Introduction (chap 1)
- A. Liquid crystals –
  - 1. What are they?
  - 2. Brief history of liquid crystals (chap 1 - end, chap 2)
- B. Types of liquid crystals
  - 1. Phases:
    - a. Nematic
    - b. Smectic
  - 2. Types by phase change:
    - a. thermotropic
    - b. lyotropic (amphiphiles)
  - 3. Other types of liquid crystal by size or shape: calamitic, polymeric, discotic
- c. How to characterize them:
  - a. What is the order paramenter?
  - b. How to measure it

II. Liquid Crystal: 1. What are they (in more detail) – Chap. 2, secs 2.1 – 2.3, 2.5

III. More detailed look at the behavior of anisotropic fluids (Some details from chap 1, chap 3)
- A. How LC's deform and react to an electric field
  - 1. Order parameter - revisited
  - 2. Mathematical expression: tensors
- B. Microscopic structure
  - 1. Review of X-rays
- C. Elastic deformation
  - 1. What is the free energy?

2. How is it expressed in terms of the director.
3. How to measure them – Frederiks Transition (Chap 12, sec 12.3)

D. Plastic deformation – disclinations

IV. Theoretical considerations (chap 4, Secs. 4.1, 4.4 - 4.6)

A. Landau – deGennes Theory
B. Pretransitional Fluctuations

Report I on an article that covers sections I – III or IV ~ Mar. ~~5~~ 10

V. Calamitic liquid crystals (chap. 5)

A. Smectic Phases
B. Structure-Property relations (Chemistry): A look at
1. Core structures
2. Terminal groups
3. Linking groups
4. Lateral substituents
C. Examples: How to apply the structure-property relations to applications
D. select portions of Chap 8 – Bent-core liquid crystals)

VI. Discotic liquid crystals (Chap 6)

A. Structures
B. Basic template
C. Examples, applications

VII. Chiral liquid crystals (Chap 7)

A. What is chirality?
B. Chiral nematic phases
C. Chiral smectic phases – examples _Select portions of Chap 8 – Bent-core liquid crystals)

Report on an article that covers Sections IV or V – VI or VII ~ April 7

VIII. Lyotropic liquid crystals (Chap 9)

A. Structures of lyotropic liquid crystals
B. Relation to biology
1. Structure of biological membranes
C. Examples

IX. Polymeric liquid crystals (Chap 10)

A. Main chain polymeric liquid crystals
B. Side chain polymeric liquid crystal (SCPLC)
1. Effect of spacer length on the mesogenic unit
2. Effect of the mesogenic unit on mesomorphic behavior
C. Examples (faculty notes), applications

Presentation I – Papers from VII or VIII – IX Students choose their presentations out of a list of papers. Dr. Martínez-Miranda choose the date (TBA or depending on the number of classes cancelled by weather, the day of final exam)

Dr. Martínez-Miranda probably will be away on February 25. This class will be flipped (recorded). There will be time for questions during the first part of the class on Feb. 27. Note that the class will not be repeated, only questions will be answered.

There will probably another date when I will not be in, TBA, probably by the end of classes.

When classes are cancelled due to the weather, they will be flipped too.

Class organization:
Two reports and one presentation will be required of this class. These take the place of the exams. In addition, homeworks will be distributed as needed, about every two – three weeks depending on the subject covered. *Please read the notes below.
Homeworks- all through the semester – 20%
Reports ~ Mar. ~~5~~ 10, April 7 – 35%
Final presentation, ~ TBA (see note above) – 45% - This presentation will count as your final exam
These days are ***approximate.*** They may occur within a week before or after the dates given. The presentation will take at least two to three days to complete. All presentations ***may include*** a question to turn in the day following the second day of presentation, except the last presentation, when it will be due after the presentations.
***Notes**: **PLEASE READ**
1. There will be NO partial or final exam according to the schedule presented here. You will be asked in detail how does what you learned in class apply to the paper you are assigned (or choose if it is the final paper) and that will be worth 20% of the grade in the class. You must be submit this part in writing, in addition to including it in your presentation. Keep that in mind when preparing for the presentations. Details on the time you need to dedicate to this part in your presentation and how you will write it will be given once your first presentation is assigned.
2. eliminated
3. Homeworks must be turned in at 2:00 PM either in person or sent through Canvas. No late homeworks will be accepted since the solutions will be posted. ***No emailed homeworks will be accepted***.
4. Attendance ***is required*** for all the presentations (and the exam, if voted in) for everybody.
    a. No credit will be given for the group discussions you are not present. The nature of your absence will be evaluated on a case by case basis.
    b. 12% of the presentation grade will be for attendance and for paying attention (no phones, no computers).
    c. 20% of each presentation will be for relating the paper to the class
    d. Make up exams or presentations will be given on a case by case basis.
5. Extra work: There will be **no** extra work outside the work assigned in class.
6. Additional instructions: Please turn off all cellphones or Ipads or any other means of social texting or computing, or put the phones in vibration mode. Do not text during class or the presentations. If you are using the slides you must already be connected to ELMS before the class begins.

Contribution of course to meeting the professional component: This course is an elective course that provides information on soft materials that relate to biomaterials and to applications.
Relationship of course to program objectives: This course provides information on soft materials, and provides a complementary course to the courses in polymers, metals, semiconductors and ceramics.

Instructor:
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Office hours: Tues. 9:30 – 11 AM, Wed. 1 – 2:30 PM

Prepared by L. J. Martínez-Miranda, January 15, 20, 21, 28, February 6, 2020