Course Name: **Polymer Rheology** (高 分 子 流 變 學)

Instructor: 華 繼 中 教授 (工二館 Rm 412 Ext. 33412)

Textbook: R.B. Bird, R.C. Armstrong and O. Hassager, 1987, "Dynamics of Polymeric Liquids. Vol I: Fluid Mechanics", 2nd edition, Wiley-Interscience.

References:

1. R. G. Larson, 1998, "The Structure and Rheology of Complex Fluids", Oxford University Press.
2. M. Doi and S. F. Edwards, 1986, "The Theory of Polymer Dynamics", Oxford Science.
3. C. W. Macosko, 1994, "Rheology—Principles, Measurements, and Applications", Wiley-VCH.
4. G. G. Fuller, 1995, "Optical Rheometry of Complex Fluids," Oxford University Press.

Year 2021/Fall

Course Outline:

- Non-Newtonian Flows: Phenomenology
- Mechanical Characterizations: Measurements and Material Functions
- Optical Characterizations: Flow Birefringence/Dichroism and Light Scattering
- General Analyses: Scaling Laws, Time-Temperature Superposition, Solvent Quality, and Fundamental Material Constants
- Constitutive Equations and Modeling of Complex Flow Processing
- Colloidal Rheology
- Student's Presentation (In this semester, we shall focus on six topics of rheological relevance: 1. Liquid Crystal; 2. Polymer Melt or Solution; 3. Colloidal Suspension; 4. Ink or Paste; 5. Emulsion; 6. Composite; 7. Thixotropic Agent

Essential elements to be included in your presentation:

- The chemical aspects of the material(s)
- The main applications and processing technique(s)
- Principal rheological features that impact the processing and product (quality)
- A list of central notions/measuring protocols/analysis schemes that have been introduced in this class
- Future Perspectives: Challenges and Opportunities
- References (minimum: 5 relevant articles and/or chapters/books)

Grading: Two Exams (60%)
Presentation (40%)

Teaching Assistant: 黃齡嫿 (Rm 413; Ext 33413)

Chapter I. Non-Newtonian Flows: Phenomenology

- Viscosity Thinning/Thickening
- Normal Stress Differences and Elasticity
- Thixotropy
- The Deborah/Weissenberg numbers
- Flow Regimes of Typical Processing
- Secondary Flows and Instabilities

Chapter II. Mechanical Characterizations: Measurements and Material Functions

- Rheometry (Rheometer and Viscometer)
- Basic Vector/Tensor Manipulations: Convection and Notations
- Material Functions in Simple Shear Flows: Viscosity, Normal Stress Difference Coefficients, Relaxation/Dynamic Modulus
- Material Functions in Elongational Flows
- Case Study

Chapter III. Optical Characterizations: Flow Birefringence/Dichroism and Light Scatterings

- Typical Experimental Setups
- Information Retrieval in Individual Measurements
- Comparisons with Mechanical Characterizations
- Case Study

Chapter IV. General Analyses: Scaling Laws, Time-Temperature Superposition, Solvent Quality, and Fundamental Material Constants

- Effects of Solvent Quality
- Molecular-Weight Scaling Laws
- Retrieval of Fundamental Material Constants
- Time-Temperature Superposition: Application and Failure
- Case Study

Chapter V. Constitutive Equations and Modeling of Complex Flow Processing

- Models for Generalized Newtonian Fluids
- Constitutive Equations for Generalized Linear Viscoelasticity
- Objective Differential/Integral Constitutive Equations
- Simulations of Complex Flow Processing
- Case Study

Chapter VI. Colloidal Rheology

- Introduction to Shear-Thickening Fluids
- Lubrication hydrodynamics and hydroclusters
- Controlling colloidal rheology