ME 733 Polymer Nanocomposites
Syllabus (Fall 2023)

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Lecture Hours: 11:00-12:15 PM, Tu and Th
Classroom: Dolve 202
Office Hours: Tuesday 2:00 -3:00 PM or by appointment
Course Credit: 3

Course Description: This course deals with the fundamental concepts and practical applications of nanotechnology, nanomaterials and polymer nanocomposites. Special topics will be focused on polymer nanocomposites processing, characterization, as well as property and process modeling. The course also addresses the challenging issues of polymer nanocomposites, and applications and future trends of polymer nanocomposites. Interactive leaning through hands-on, real-world projects and research article study will be implemented in this course.

Textbook (optional): Fundamentals, Properties, and Applications of Polymer Nanocomposites (by J. H. Koo, Cambridge University Press, ISBN: 9781316094419) will be used as the main textbook. The following books are good references for additional information.

1) Polymer Nanocomposites: Theories and Practice (by S. N. Bahattacharya, M. R. Kamal, R. K. Gupta), Hanser Gardner Publications (2007).
2) Nanostructures and Nanomaterials: Synthesis, Properties and Applications (by Guozhong Cao and Ying Wang, World Scientific, Singapore 2011).
3) Nanomanufacturing Handbook (edited by A. Busnnaina), CRC Press, New York (2006)
4) Scanning Electron Microscopy and X-Ray Microanalysis (by J. Goldstein, D. Newbury, D. Joy, C. Lyman, P. Echlin, E. Lifshin, L. Sawyer, and J. Michael), Springer, New York (2003).

Course Objectives:

1. Students will have the fundamental knowledge of nanotechnology, nanostructured materials and composites, and their development and potential applications.
2. Students will have a basic understanding of main classes of nanostructured materials and composites and relevant mechanical, thermal, and electrical properties, etc.
3. Students will become familiar with the main fabrication techniques for producing nanostructured materials and polymer nanocomposites, and relevant surface treatment.
4. Students will be familiar with the fundamental techniques for structural and mechanical characterizations of nanomaterials and polymer nanocomposites.
5. Students will become familiar with basic nanofabrication techniques.
6. Students will have the opportunity to learn the fundamentals of structural, thermal, and mechanical characterization techniques (e.g. AFM, Nanoindentation, SEM, TEM, XRD, TGA, DMA, TMA, DSC, FTS, etc.).

7. Students will acquire the basic knowledge of computational modeling of mechanical properties of polymer nanocomposites.
8. Students will learn the fundamental skills to develop scientific papers and grant proposals in the field of study.

Prerequisites: Graduate standing.

Course Outcomes: At the completion of this course, students will be able to

(1) Understand the fundamentals of nanotechnology, nanostructured materials and nanocomposites.
(2) Acquire the basic knowledge of nanomanufacturing.
(3) Know the basic polymer nanocomposites processing and surface treatment techniques.
(4) Understand the fundamental techniques for structural, thermal, and mechanical characterization of nanomaterials and polymer nanocomposites
(5) Practice simulation and analysis of properties of polymer nanocomposites
(6) Be familiar with the toughening mechanisms of polymer nanocomposites and challenging issues facing the development of polymer nanocomposites

Course Outline (Tentative, subject to change):

Week		Topics
1	Topic 1	Introduction to Nanotechnology, Nanostructured Materials and Nanocomposites (a) History and current development
2-4	Topic 2	Nanomaterials and Nanomanufacturing (a) Fabrication of CNTs, nanofibers, nanoparticles, platelets, etc. (b) Mechanical and physical properties of nanostructured materials--size effect (c) Overview of nano-sized reinforcements for polymer nanocomposites **Presentation-I**
5-end of the semester	Topic 3	Preparation and Synthesis of Polymer Nanocomposites (a) Methods of nanocomposites preparation and synthesis: Solution dispersion, melt processing, *in-situ* polymerization, roll milling, high-shear mixing, etc. (b) Polymeric matrices for nanocomposites: Thermoplastics, elastomers, thermosets, natural and biodegradable polymers (c) Processing of polymer nanocomposites: Extrusion, injection, blowing molding, foaming, etc. (d) Lab work to prepare polymer nanocomposites using solution dispersion and other methods. Projects will be conducted throughout the semester.
8-end of the semester	Topic 4	Structural, Thermal, and Mechanical Characterization of Polymer Nanocomposites (a) Commonly used techniques for structural, thermal, and mechanical characterization of polymer nanocomposites will be introduced: Atomic Force Microscopy (AFM); Nanoindentation; Nano UTM; Electron Scanning Microscopy (SEM); Transmission Scanning Microscopy (TEM); Wide Angle X-Ray Diffraction (WAXD); Small Angle X-Ray Scattering (SAXS); Thermal Gravimetric Analysis (TGA) (b) Current status and challenging issues on the characterization methods (c) Lab tour of NDSU Electron Microscopy Center (subject to change) (d) Lab tour of NDSU Center for Nanoscale Science and Engineering (subject to change) Projects will be conducted throughout the semester. **Mid-Term Exam/Presentation**
10-12	Topic 5	Mechanics of Polymer Nanocomposites (a) Models of polymer nanocomposites at equilibrium; micromechanics of effective mechanical properties

		(b) Strength theory and toughening mechanisms of polymer nanocomposites; multiscale modeling of mechanical behavior
13	Topic 6	Challenging Issues for the Development of High-Performance Polymer Nanocomposites (a) Treatment of nanoreinforcements; interactions between polymers and nano-reinforcements; dispersion and alignment of nano-reinforcements in the polymers
14	Topic 7	Hybrid Multi-scale High Strength Polymer Nanocomposites
15	Topic 8	Bionanocomposites and Biomimetic Nanocomposites
16		**Final Exam/Presentation/Term Paper Deadline**

Course Grading System: Students are expected to:

a) Take tests: Midterm and final exams;
b) Complete homework assignments on time;
c) Complete projects/term paper and presentations on time.

The course grades will be determined as follows:

Homework	**20%**
Mid-term exam & presentations	**30%**
Project/Term paper	**30%**
Final exam	**20%**
Total	**100%**

Final course grade will be assigned according to the following scale:

A 90% or greater
B 80% to less than 90%
C 70% to less than 80%
D 60% to less than 70%
F Less than 60%

Homework: Classical homework problems will be assigned during the lectures. It is essential for the students to do homework problems to learn how to apply the fundamental concepts and principles of polymer nanocomposites.

Term Paper: The term paper will consist of an exhaustive review of one of the important sub-areas of polymer nanocomposites on a topic assigned by the instructor. The paper must be typed, single-spaced, and be no less than 8 pages excluding references. Diagrams, flow charts, figures and tables should be used wherever appropriate for presentation and illustration of the concepts and ideas involved.

Attendance Statement:

- According to NDSU Policy 333 (www.ndsu.edu/fileadmin/policy/333.pdf), attendance in classes is expected.
- Veterans and student service members with special circumstances or who are activated are encouraged to notify the instructor as soon as possible and are encouraged to provide Activation Orders.

Americans With Disabilities Act for Students with Special Needs:

Any students with disabilities or other special needs, who need special accommodations in this course, are invited to share these concerns or requests with the instructor and contact the Disability Services Office (www.ndsu.edu/disabilityservices) as soon as possible.

Academic Honesty Statement:
The academic community is operated on the basis of honesty, integrity, and fair play. NDSU Policy 335: Code of Academic Responsibility and Conduct applies to cases in which cheating, plagiarism, or other academic misconduct have occurred in an instructional context. Students found guilty of academic misconduct are subject to penalties, up to and possibly including suspension and/or expulsion. Student academic misconduct records are maintained by the Office of Registration and Records. Informational resources about academic honesty for students and instructional staff members can be found at www.ndsu.edu/academichonesty.

Additional Resources for Students:

Students are encouraged to use support resources

- As a member of the NDSU community, resources are available for you should you need help in dealing with adverse reactions to things happening in the world today. A variety of resources are listed below:
  For students on campus and remotely (telehealth):
  Counseling Services: 701-231-7671; https://www.ndsu.edu/counseling/
  Disability Services: 701-231-8463; https://www.ndsu.edu/disabilityservices/
  Student Health Service: 701-231-7331; https://www.ndsu.edu/studenthealthservice/
  Dean of Students Office: 701-231-7701; https://www.ndsu.edu/deanofstudents/
  In a crisis or emergency situation:
  Call University Police: 701-231-8998
  Call 9-1-1
  Go to a Hospital Emergency Room
  Go to Prairie St. Johns for a Needs Assessment: 701-476-7216 (510 4th St. S.)
  Call the FirstLink Help Line: 1-800-273- TALK (8255) or 2-1-1
  Call Rape and Abuse Crisis Center: 701-293-7273