# Development of a Manufacturing Process for Nanocomposite Thin Films

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MATE 198A

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# Overview

- Motivations
- Project goals
- Background
- Literatures review
- Project refinement
- Feasibility studies
- Tasks/time-line
- Accomplishments
- Plans for next semester

# Motivations

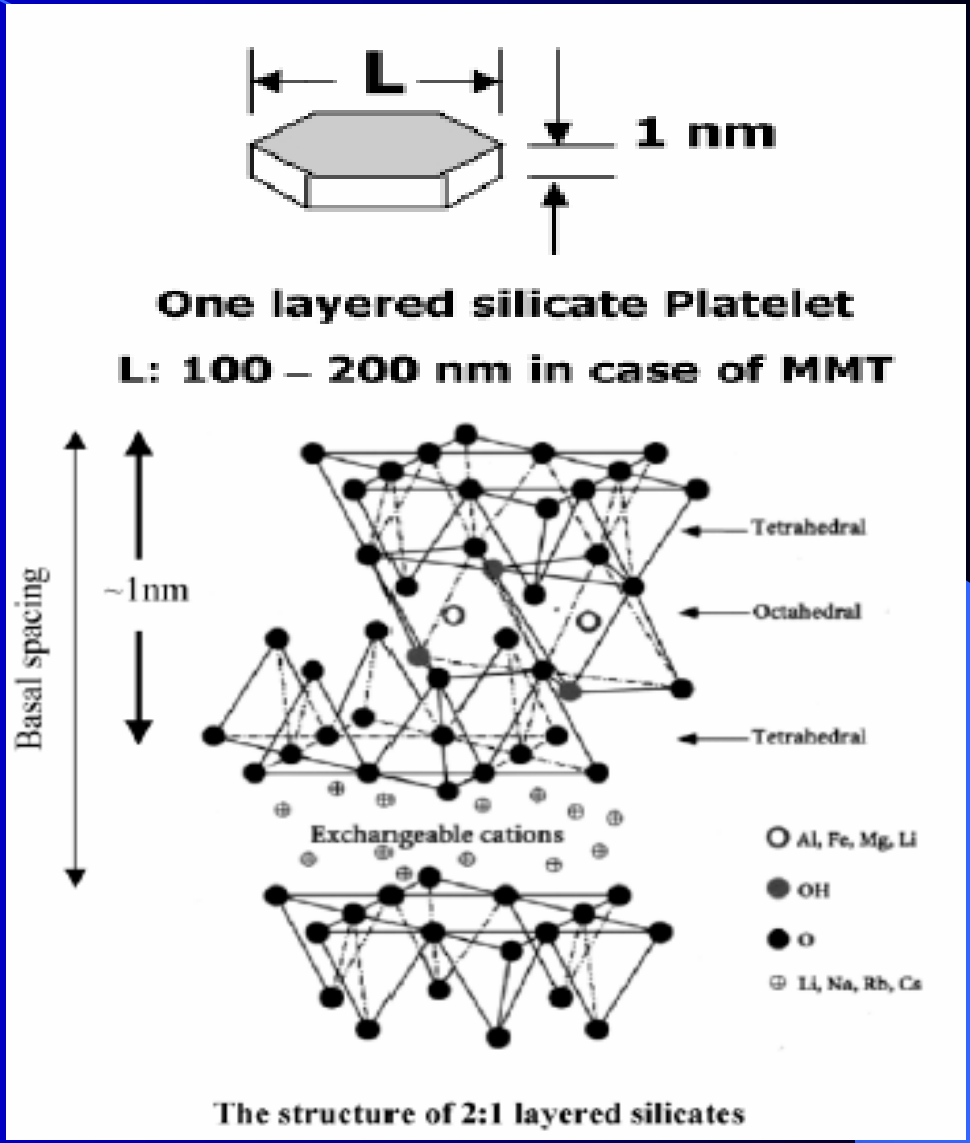
- Nano-technology field
- Industrial applications of nanocomposites thin film
- Apply obtained knowledge to design a process
- Explore organic/inorganic interfacial interactions (polymer/silcates clay)
- Requirement for senior project design

# Project Goals

- Develop a manufacturing process
- Generate process specifications
- Determine important factors
- Study polymer/silicates interfacial interactions
- Characterize film structure
- Optimize process parameters

# Background

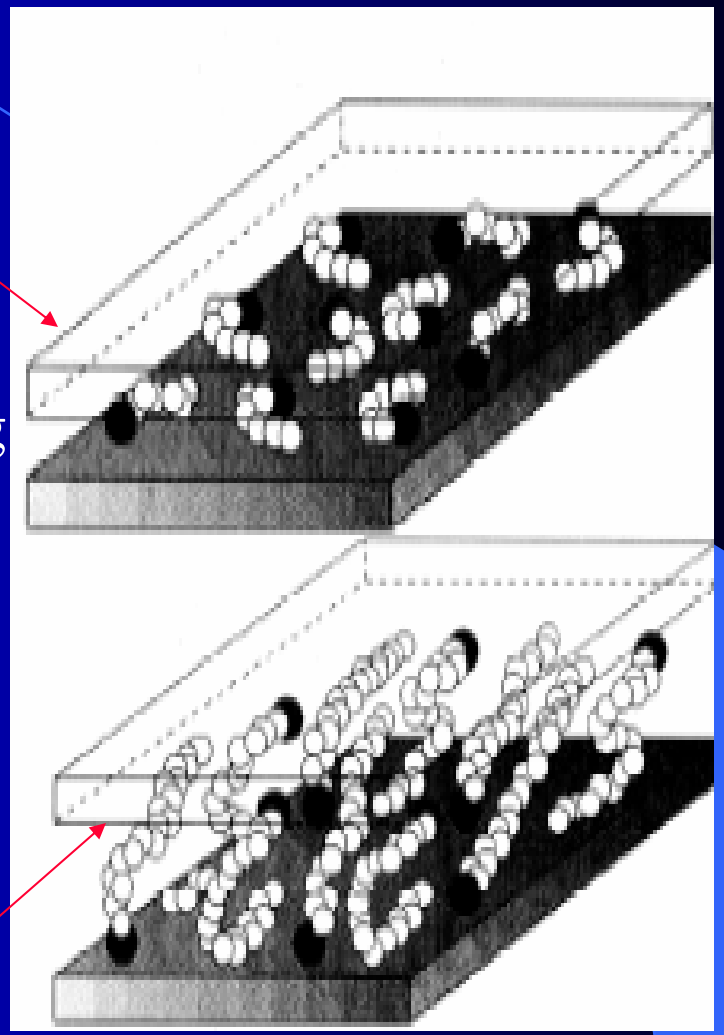
- Nanocomposites
  - A two phase material with one of the phase having nanometer scale dimension (1nm-10-nm)
- Layered Silicates Clay
  - Two dimensional layers formed by fusing two silica tetrahedral sheets with an edge-shared octahedral sheet




*Supraskas, Polymer (2003)*

# Modification of Silicates Surface

- Cationic Reaction
  - Mixing the Silicate Clay with Surfactant solutions of constituents (Ammonium Salt) that modified the surface of the silicates. The precipitate (modified silicates) are then filtered, wash and dry.



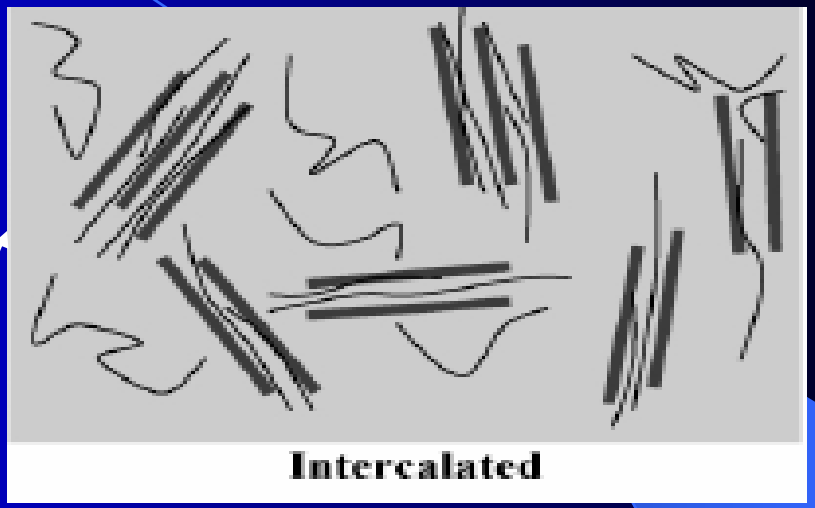

*Vaia et al., Chem. Mater., 1994*

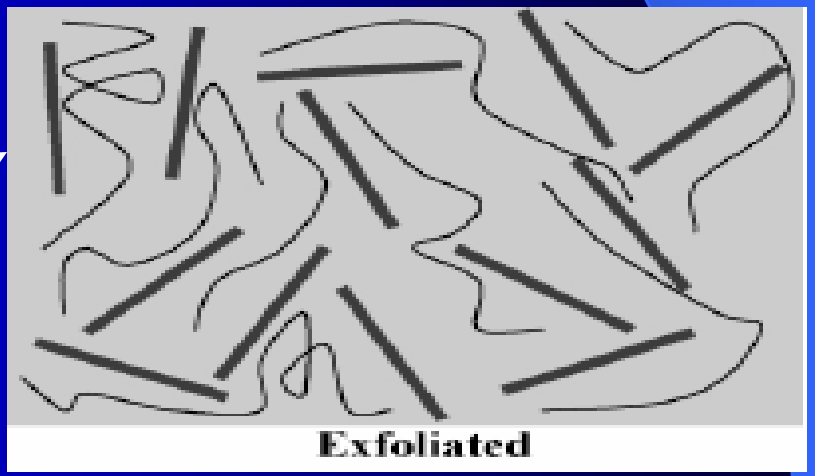
# Literatures Reviewed

- Manufacturing methods
  - In-Situ Polymerization
    - Intercalation of polymer & subsequent polymerization
  - Solution Polymerization
    - Dissolving of polymer in an organic solvent
    - Adding desire % wt. of silicate clay
    - Solvent are driven off
  - Melt Blend Polymerization
    - Physically mixing silicates & fine polymer pellets
    - Heating the mixture to polymer melting temperature
    - Pour the melts into an extruder

# Characterization of Nanocomposites

- Structures of Nanocomposite
  - Tactoids Structure
  - Intercalated Structure
  - Exfoliated Structure




*Suprakas, Polymer 2003.*

# Compatibility of Clay-Polymer

- Thermodynamic approach:

$$\Delta F = F(h) - F(h_0) = \Delta E - T\Delta S$$

  - Silicates structure
    - d-spacing
  - Surfactants
    - Length of carbon chains
  - Interfacial interactions
    - Polymer & silicate surface
    - Polymer & surfactants
    - Surfactants & silicate surface

# Decision Matrix

| Order of Importance | Considerations | Melt | Solution |
|---|---|---|---|
| 1 | Dimension | + | - |
| 2 | Equipment | + | - |
| 3 | Fabricability | - | + |
| 4 | Morphology | + | - |
| 5 | Environmental | + | - |
| 6 | Cost | - | + |
| 7 | Based Matrix | - | + |
| | | 4 vs. 3 | 3 vs.4 |

# Project Refinement

| Items | Initial Plan | Revised Plan |
|---|---|---|
| **Processes** | Melt or Solution Method | *Melt method* |
| **Materials** | Thermoset/Thermoplastics, Solvents, and Cloisite clay,Nanocor | *Thermoplastic and Cloisite clay* |
| **Equipment** | Blender, Extruder, TGA, and Vacuum System | *Extruder and Mechanical Revolving Stage* |
| **Characterization Tools** | TEM, SEM, AFM, XRD, and TGA | *XRD and AFM* |

# Feasibility Studies

- Design Constraints
  - Thin film
    - Thickness (< 100nm)
    - Structure: Intercalated/Exfoliated
    - Facility: At San Jose State University
- Environmental Impact
  - Materials
    - Polymer matrix: thermoplastic (PE, PS and PP)
    - Silicates clay: Cloisite 15A, 20A & 25A
- Cost
  - Methology
    - Equipment (heating element,extruder, and spin cast stages)
    - Facility (polymer lab in IS building and the metal in E-231)

# Tasks/Time-Line

- Allocating characterization tools:XRD (SAXS or WAXS mode) and SEM/AFM.
  - ***Current--Jan. 27-2004. On-going***
- Establishing operational procedure/safety protocols:
  - ***Nov. 8--Nov. 25-2003. Done***
- Characterizing of polymer thermal flow (determining film thickness).
  - ***Nov. 25--Dec.15-2003. On-going***
- Defining experimental parameters.
  - ***Nov. 25--Feb. 01-2004. On-going***
- Executing experimental plans.
  - ***Feb. 08-2004--April 15-2004.***

# Accomplishments

- Project goals are defined
- Literatures were reviewed
- Feasibility study was conducted
- Method and materials were selected
- Project limitations and issues were addressed

# Plan for Next Semester

- Characterization of experimental parameters **(2wks)**
  - Operational temperature
  - Mixing time required
  - Compatibility of polymer-clay systems
- Process Optimization **(4wks)**
  - Process parameters
  - Operational time/temperature
- Proposed interaction mechanisms **(3wks)**
  - Polymer-Silicate surfaces
  - Silicate surfaces-Surfactants
  - Polymer-Surfactants
- Written report with future recommendations (1wk)

# References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