Summary

• Coatings and Polymeric Materials overview

• Research of:
  – Stuart Croll
  – Dean Webster
Coatings and Polymeric Materials Personnel ~ 50

- 25 (?) Graduate Students
- 5 (?) undergraduate students
- 3 Full-time Administrators
  - 2 part-time helpers
- 1 Research Scientist
- 1 Laboratory manager
- 2 Laboratory technicians
- 5 (?) Post Docs.
- 4 Research Professors
- 3 Tenure Track Faculty
  - 2 openings
We all occupy more than one category.

We all make and characterize materials (usually polymeric, for coatings) and polymer-composite systems (usually coatings) from the nano to macro scales.
Dept. Instrumentation

- UV-vis-NIR, Raman, FTIR spectrometers
- Spectrofluorimeter
- Atomic force & other scanning probe microscopy, optical microscope
- GC-MS
- Gel permeation chromatography
- Electrochemical instrumentation
- Comprehensive thermal analysis equipment
- Colloid Characterization
- Particle size measurement
- Accelerated weathering chambers
- Coating application equipment
Research Interests
Other CPM Faculty Members

• Professor Gordon Bierwagen
  Corrosion Control by Coatings, Particle Packing, Physical Chemistry of Coatings, Conservation of Bronze Sculptures

• (Research) Professor Dennis Tallman
  (used to be in Chemistry Dept)
  Corrosion, Electrochemistry, electrochemical methods, Conductive Polymers

• Research Asst. Professor Victoria Johnston Gelling
  Corrosion Control, Conductive Polymers, Coatings Characterization
Research Other Faculty Members (cont.)

• Research Asst. Professor Brian Hinderliter
  Modeling & Prediction of Coating Durability, Computer simulations, Coatings Characterization
• Research Asst. Professor Kerry Allahar
  Corrosion Control by Coatings, Electrochemical modeling, Coatings Characterization

I am now going to focus on research by Dean Webster and myself.
• **Overall:**
  - Experiment and Modeling
  - Durability, corrosion protection, nanoscale characterization, flocculation mechanisms in coating systems, art conservation and film formation processes

• **Currently:**
  - Polymeric Coating Durability
  - Polymer Physics
  - Modified Amino Acid
Stuart Croll Research
Polymer Degradation during Weathering

- Degradation Chemistry

- Size of a degradation event
  - Atomic Force Microscopy
**Modeling**

*Monte Carlo simulations*

Very flexible and useful approach.

Models microscopic morphological changes.

Predictions of Deterioration in Fracture Strength

We can model changes in macroscopic properties

Computational chemistry
Molecular dynamics
Corrosion Protection: Modelling and Measuring Performance

There is a capacitance and resistance in parallel for each part of the coating. The interface resistance may vary from infinite to zero depending on how the coating transports water.
Polymers gradually approach equilibrium in their glassy, non-equilibrium state.

Effect of the thermal transitions on the molar volume [3]
Modified Cysteines
(Amino Acid with Thiol)

• At first we were looking for materials:
  – Based on biomaterials
  – For smart, self-healing coatings
  – Possibly might make micelles or lipid membranes
    • To act as vessels
  – and/or self-crosslinking temporary repair coating material
    (contents of vessels)
• Now we think there may be other non-coating possibilities
  – Drug delivery systems
• These compounds crystallize, make micelles, vesicles and
  have synergistic mixing behavior
Research Areas: Polymer synthesis, crosslinking chemistry, structure-property relationships, combinatorial and high throughput experimentation

Current Projects:

- Novel Fouling-Release Coatings
  - Office of Naval Research
- Glycidyl Carbamate Chemistry
  - US Navy, Air Force
- Polymer Templating for Spintronic Devices
  - National Science Foundation – ND EPSCoR
- Novel Materials for Microelectronic Devices
  - Defense Microelectronics Activity, CNSE
- Smart Coating Systems for Aerospace
  - NASA
Materials for Microelectronics

• Laser Ablatable UV-Curable Coatings
  – Use of a laser to cut vias through planarization layer
  – Nd:YAG Laser @ 355 nm
  – UV cured epoxy coatings are transparent and ablate poorly
  – Novel additives were designed resulting in efficient laser ablation


Screen-printed Conductive Inks
• Zero VOC
• UV or Thermal Cure

Multifunctional Glycidyl Carbamate Functional Oligomers

Carbamate: Toughness, adhesion

Epoxy: Reactivity

Self-Crosslinking with Amines

150°C


JCT Research 2(7), 517-528 (2005)

Coatings have excellent hardness, flexibility, adhesion
Many marine organisms grow on surfaces

Any Surface!

Fouling by marine organisms
- Creates increased drag
- Degrades performance
- Increases fuel consumption

Transport of organisms to non-native habitats is also a problem
Marine Biofouling

Critical Issue:
- Economic impact
  - Ship operation, fuel consumption
- Environmental impact
  - Transport of non-indigenous species
New non-toxic coatings are needed

Diagram courtesy
Univ. of Birmingham

Self-stratified siloxane-urethane coatings

Coatings with surface microstructure

PDMS
Polyurethane
Epoxy Primer

Macromolecules 2005, 38, 5857-5859

NDSU has the most comprehensive high throughput laboratory in the world for polymer and coatings research