

Application-Centered Nanotechnology Experiments for First-Year Students

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Why Nanotechnology for *Freshmen*?

- Maintain students' interest
 - Interdisciplinary
 - Cutting edge
- Get students in the lab
 - Involves new skills, techniques and instruments
- Prepare students for their careers
 - A driving force of future economic development
 - Some products already available



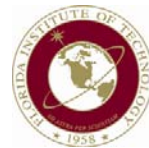
Application-Centered Experiments

- Make nanomaterial then test it
 - Synthesis is chemistry-focused
 - Application is not
- See the nanomaterial “in action”
 - Requires simple, inexpensive testing equipment
- Discuss feasibility of nanomaterial’s application
 - Cost vs. alternative materials
 - Environmental, societal impacts



Where to put them?

- General Chemistry lab
 - Wide exposure to science and engineering students
 - Synthesis illustrates chemical principles
- Lab course related to application
 - Students need chemistry refresher
 - Chemical safety issues
- Nanotechnology lab course
 - Best option
 - Relatively few



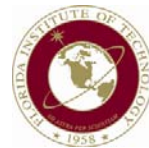
Florida Tech's Intro to NST Lab

- 1 credit lab course
 - Taught spring semester, freshman year
 - Team-taught by phys, chem, chem eng faculty
- Experiments cover variety of nanotech topics
 - Individual hands-on STM and AFM
 - Synthesis (CNT, Au, CdS, ferrofluid, porous carbon foam, thin films, STM tips)
 - Nanotech lab tours, guest speakers
 - Paper and presentation
- Encourages students to participate in UG research



Polymer Nanocomposites

- Overview
 - Synthesize polymer nanocomposites
 - Test flexibility
 - Generate stress-strain curves
 - Determine composition with best properties



Polymer Nanocomposites

- Background
 - Dispersed nanomaterial within polymer
 - Improved mechanical properties
 - Brittle fracture
 - Strain to failure
 - Impact strength, etc.
 - Economic value compared to metal
 - Lower material cost
 - Greater strength : weight ratio



Polymer Nanocomposites

- Background
 - Interactions between particle surface and PMMA stronger than interactions between individual polymer strands
 - More particle surface area increases strength of material
 - Too many particles weakens material due to particle-particle interactions
 - More large particles are needed for high surface area
 - Larger particles negatively affect material processing
 - Too many particles makes material inhomogeneous



Polymer Nanocomposites

- Procedure
 - Prepare sample molds
 - Flame-seal narrow end of Pasteur pipets in Bunsen burner
 - Mix benzoyl peroxide, MMA monomer, Al_2O_3 nanoparticles
 - Heat samples 80°C for 1 – 2 hrs
 - Wrap sample molds in paper towels and tap with hammer
- Benzoyl peroxide initiates polymerization
- Nanoparticles
 - Commercially available
 - 13 nm diameter w/ organic coating



Polymer Nanocomposites

- Procedure



Polymer Nanocomposites

- Testing
 - Research-grade flexural testing instrument
 - Apply 5 lb force / 30 sec
 - Instrument measures deflection
 - “Homemade” testing apparatus
 - Apply force using C-clamp, force related to # turns of clamp
 - Measure deflection using ruler mounted behind sample



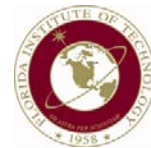
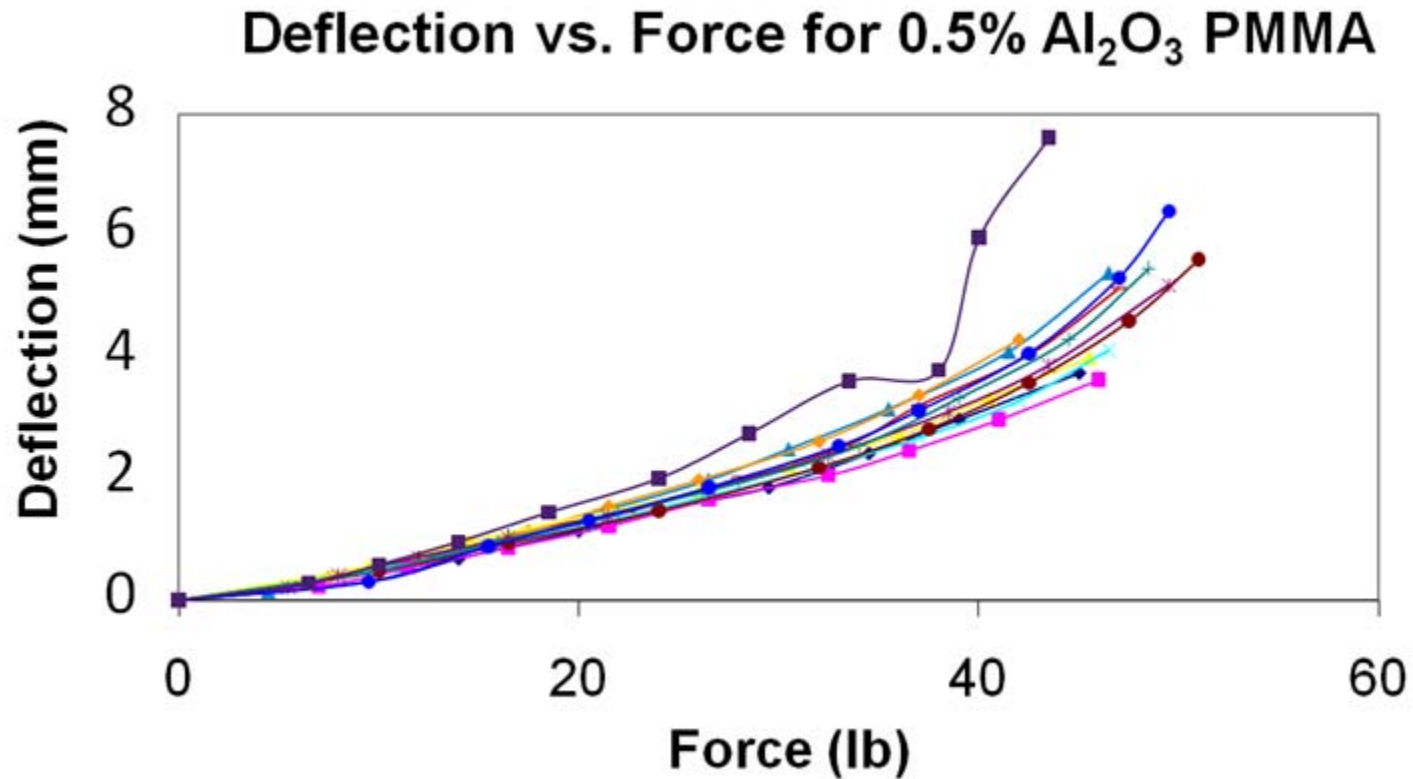
Polymer Nanocomposites

- Testing



Polymer Nanocomposites

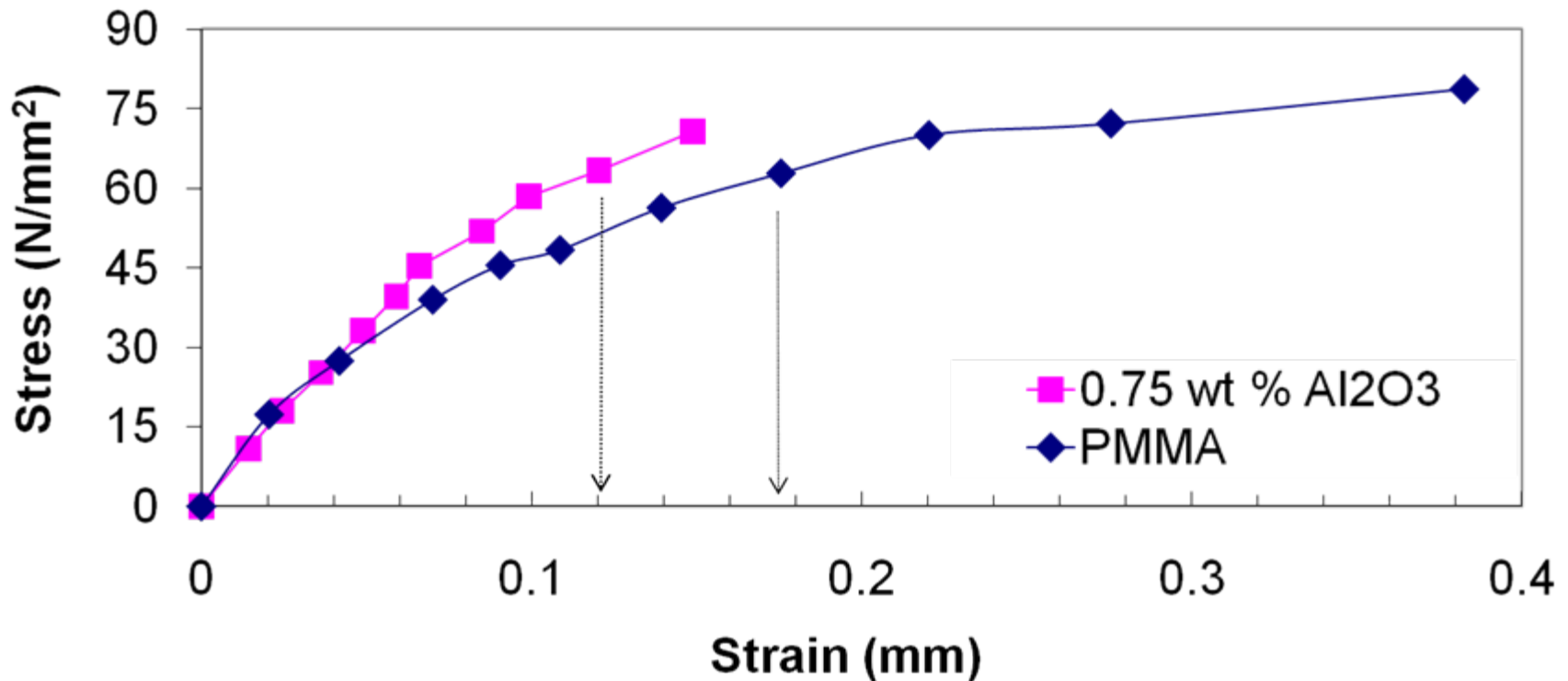
- Results (research grade instrument)



Polymer Nanocomposites

- Results (research grade instrument)

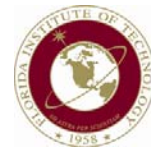
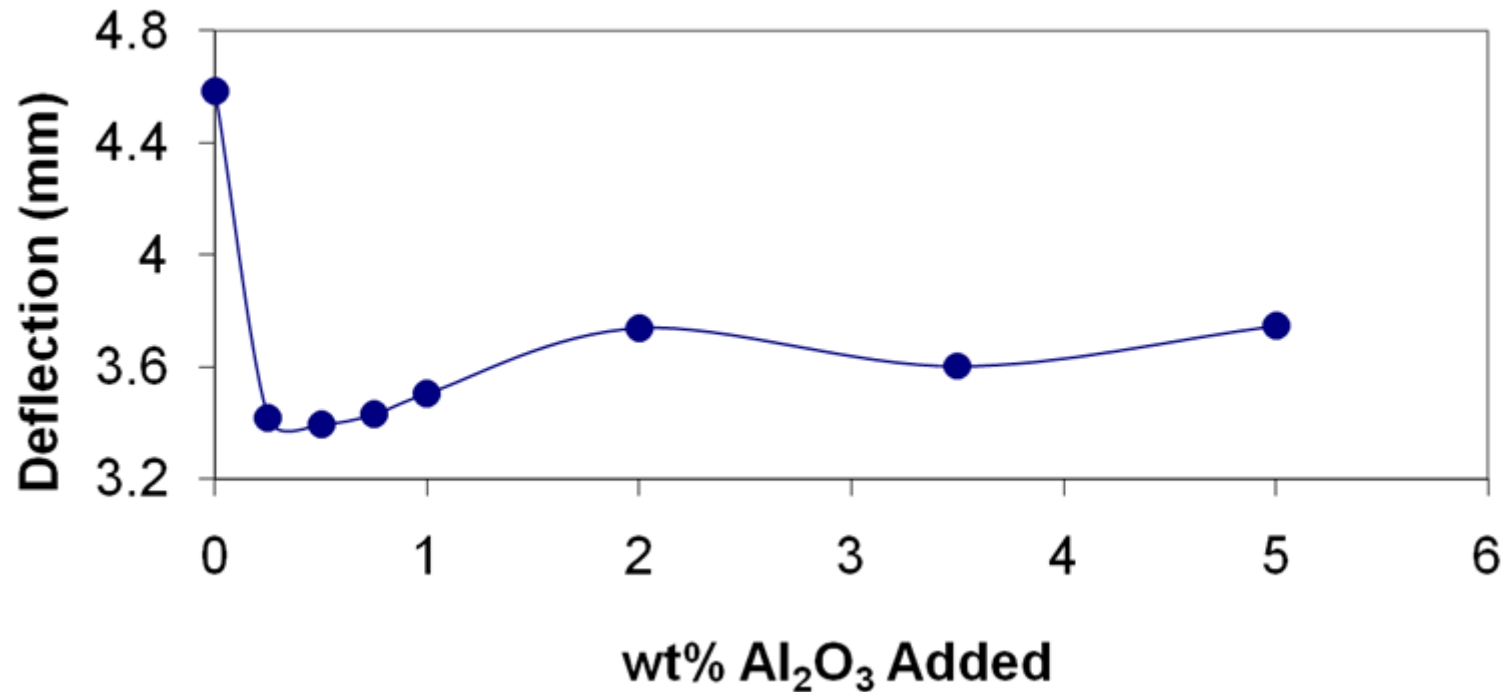
Flexural Stress vs. Flexural Strain



Polymer Nanocomposites

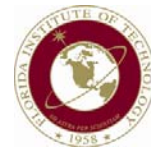
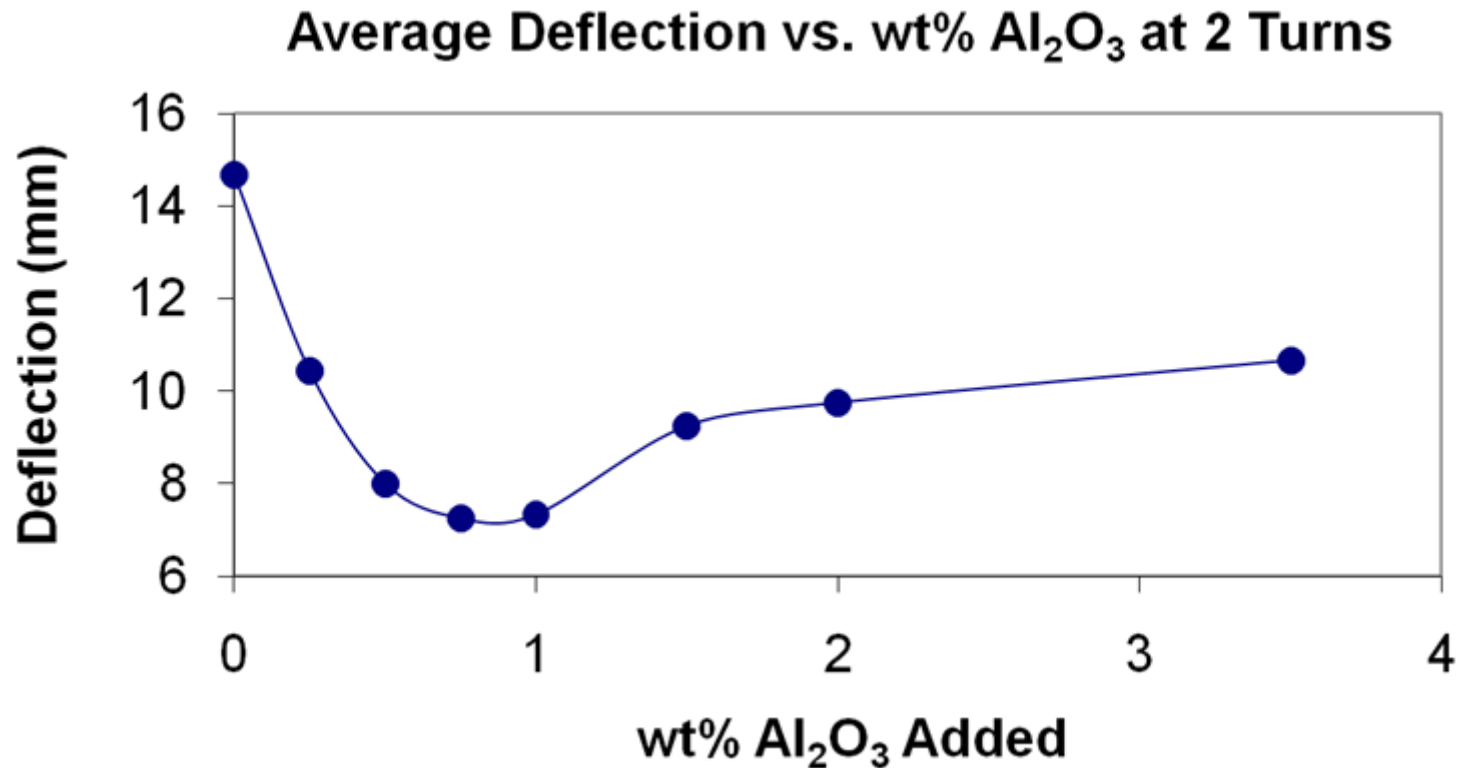
- Results (research grade instrument)

Average Deflection vs. wt% Al_2O_3 at 40 lb



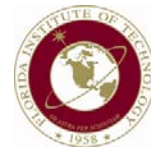
Polymer Nanocomposites

- Preliminary Results (homemade instrument)



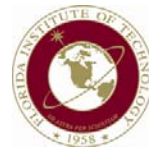
Polymer Nanocomposites

- Future work
 - Collect more data using homemade instrument
 - Improve homemade instrument
 - Standardized construction
 - Calibrate force applied
 - Allow more accurate deflection measurements
 - Shorten MMA polymerization time



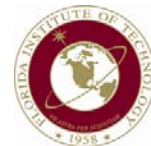
Antibacterial Silver Nanoparticles

- Overview
 - Synthesize silver nanoparticles using a variety of methods
 - Tollens' reaction
 - Borohydride reduction
 - Geranium extract
 - Various microwave initiated reactions
 - Add nanoparticles to bacteria
 - Measure antibacterial properties, depending on
 - Particle size
 - Preparation method
 - Bacteria species



Antibacterial Silver Nanoparticles

- Background
 - Silver cations are known to have antibacterial properties
 - Ag^+ reacts with thiol groups
 - Nanoparticles show similar properties
 - Mechanism still not fully understood
 - Disrupts cell wall structure
 - Enters cell, then kills cell through reduction reaction
 - Enters cell, becomes oxidized, then kills cell as Ag^+
 - Medical applications
 - Maintaining sterile equipment and instruments
 - Fighting antibiotic-resistant bacteria
 - Commercial products
 - Washing machines
 - Socks



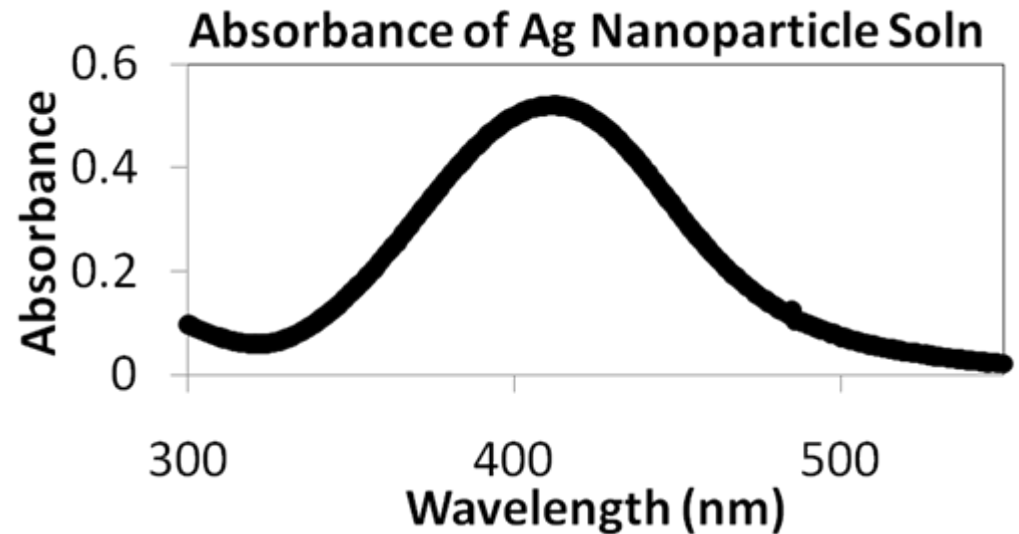
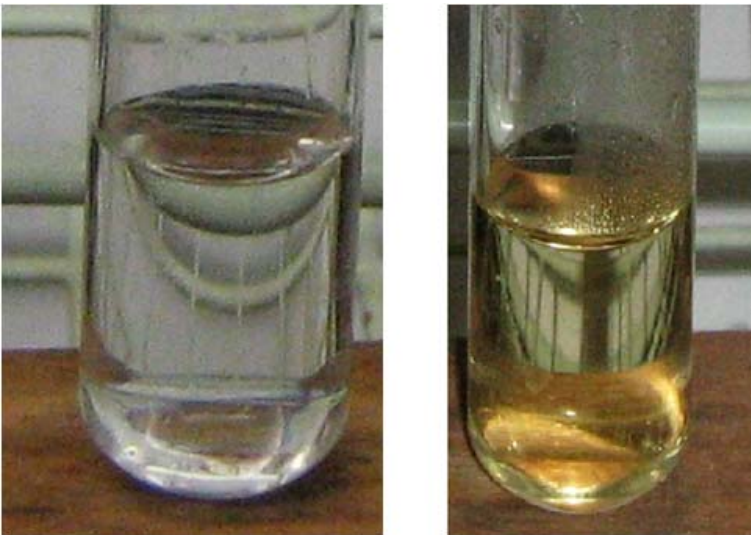
Antibacterial Silver Nanoparticles

- Background
 - Silver salts are unstable to light
 - Proteins can attach to nanoparticles for targeting specificity
 - Nanoparticles can be more easily incorporated into other materials
 - Fabrics
 - Plastics
 - Metal surfaces



Antibacterial Silver Nanoparticles

- Procedure
 - Mix glucose and AgNO_3 solutions
 - Microwave for 10 sec
 - Particles are approx 25 nm diameter



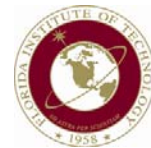
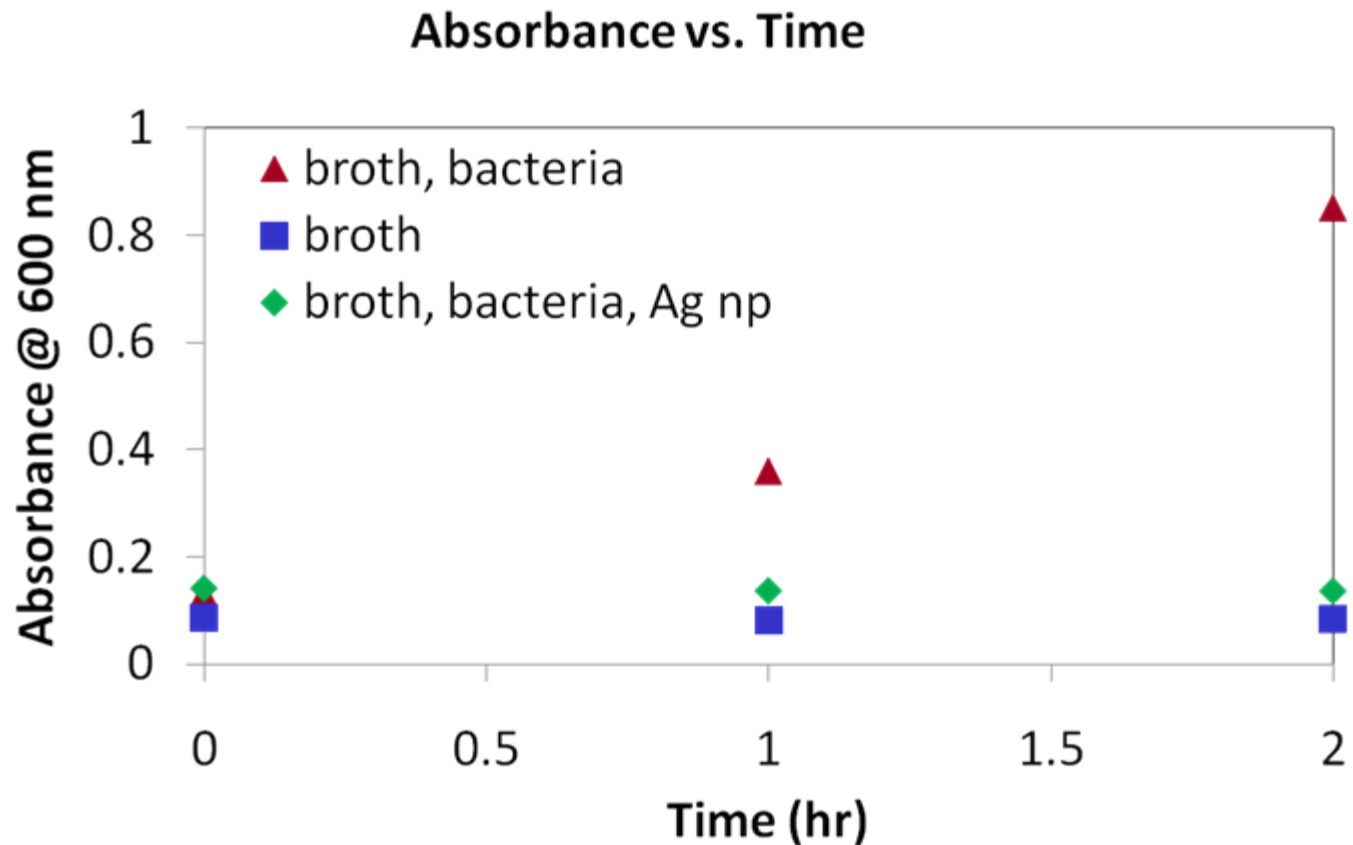
Antibacterial Silver Nanoparticles

- Procedure
 - Grow high concentration of *E. Coli* bacteria
 - Add small volumes of bacteria and Ag solutions to broth
 - Allow to shake at 37.5 °C
 - Measure absorbance
 - Absorbance is proportional to turbidity
 - Perform similar tests with blanks
 - Broth: no foreign bacteria contamination
 - Broth + bacteria: bacteria are healthy



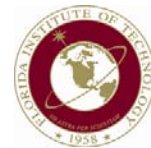
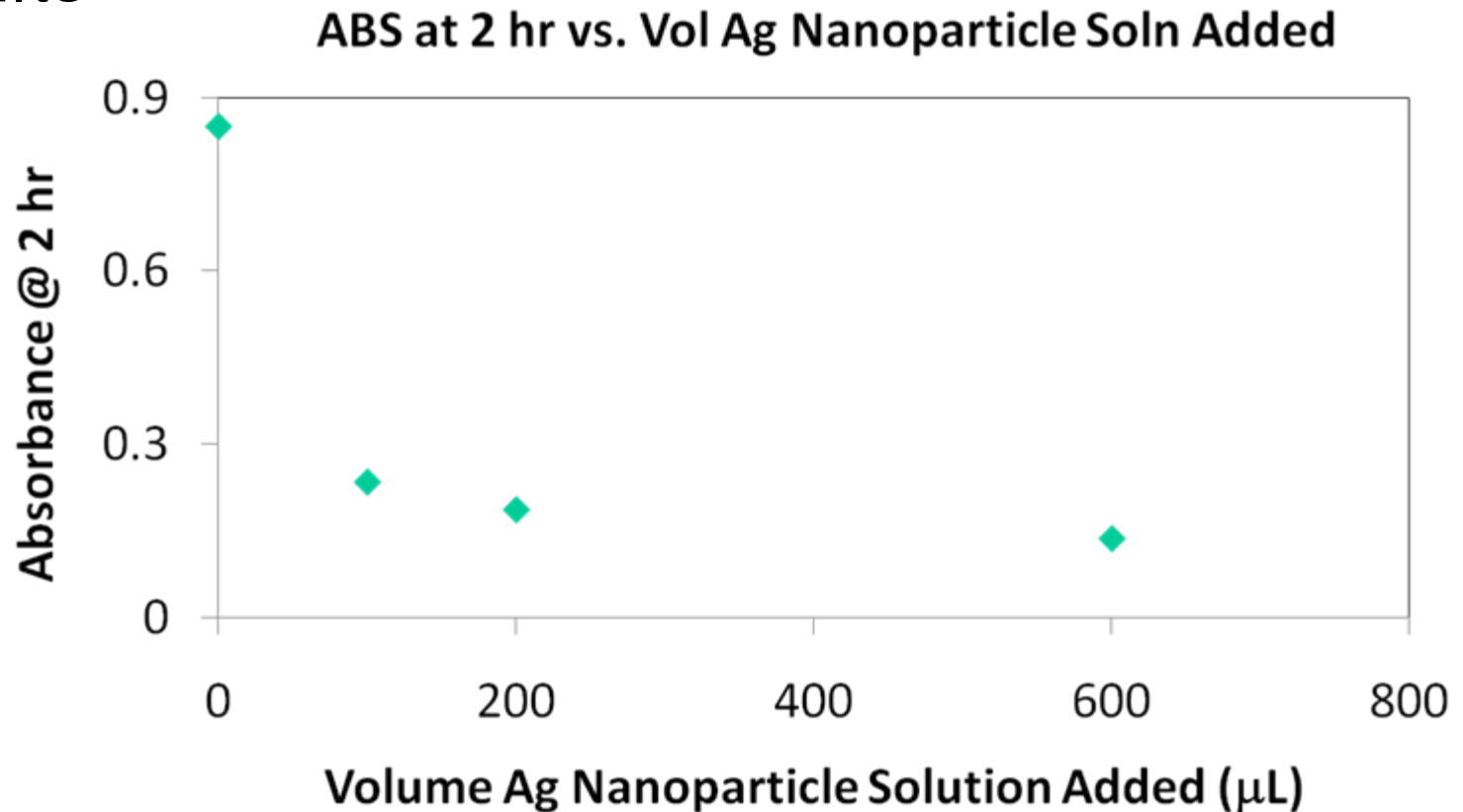
Antibacterial Silver Nanoparticles

- Results



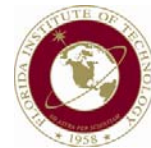
Antibacterial Silver Nanoparticles

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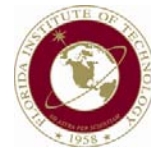
Antibacterial Silver Nanoparticles

- Results



Antibacterial Silver Nanoparticles

- Future Work
 - Evaluate other bacteria
 - Determine if bacteria are dead or not reproducing
 - Incorporate Ag nanoparticles into thin films, fabrics, etc and test vs. bacteria



Conclusions

- Practical applications of nanotechnology can be incorporated into experiments
- Experiments and applications should interest a variety of students
- Since nanotechnology is expanding, new experiments are becoming available



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NCLT for organizing symposium and invitation



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Grand Challenge Q & A

- What is the most important lesson learned about nanotechnology education?

Challenging process of adapting research to the teaching lab

- 3 hour time limit
- Common equipment
- Simple explanations of concepts
- Interesting applications
- Safe procedures
- Multidisciplinary approach



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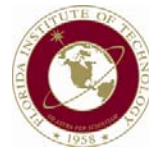
Grand Challenge Q & A

- What is the most critical challenge facing undergraduate nanotechnology education?

Structure of academia does not favor multidisciplinary approach to teaching and research

- What does the future hold for nanotechnology education?

More curriculum resources, new models of instruction, additional networking opportunities



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