Synthesis of Vanadium Dioxide Nanowires with Varying Acid and Vanadium Sources

Intern: Peter LaCorte

Mechanical Engineering

Santa Barbara City College

Mentor: Kinson Kam

Faculty Advisor: Prof. Anthony K. Cheetham

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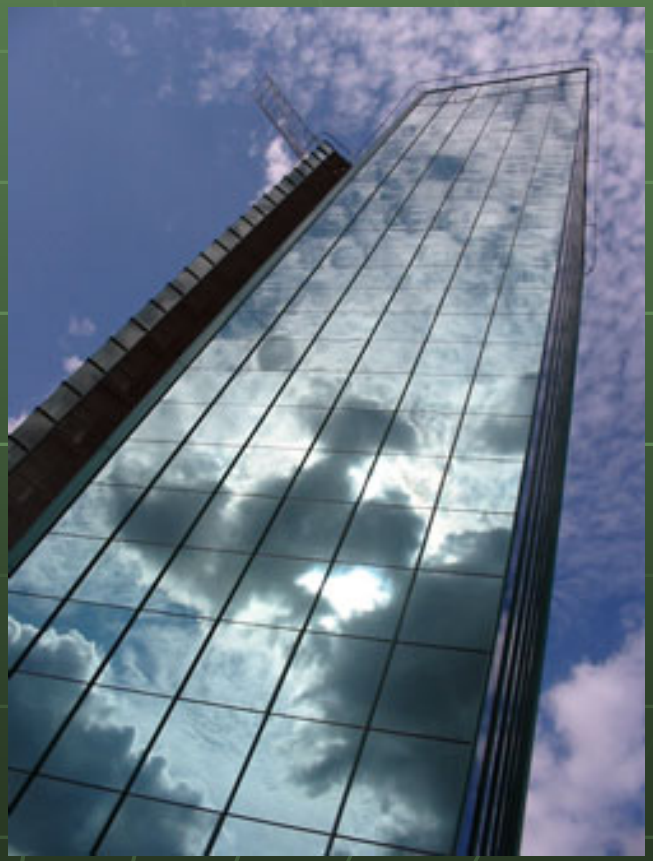
INSET

Internships in Nanosystems Science, Engineering and Technology

Vanadium Dioxide:
Changing phases

Thermal phase change from a semiconductor to a metal

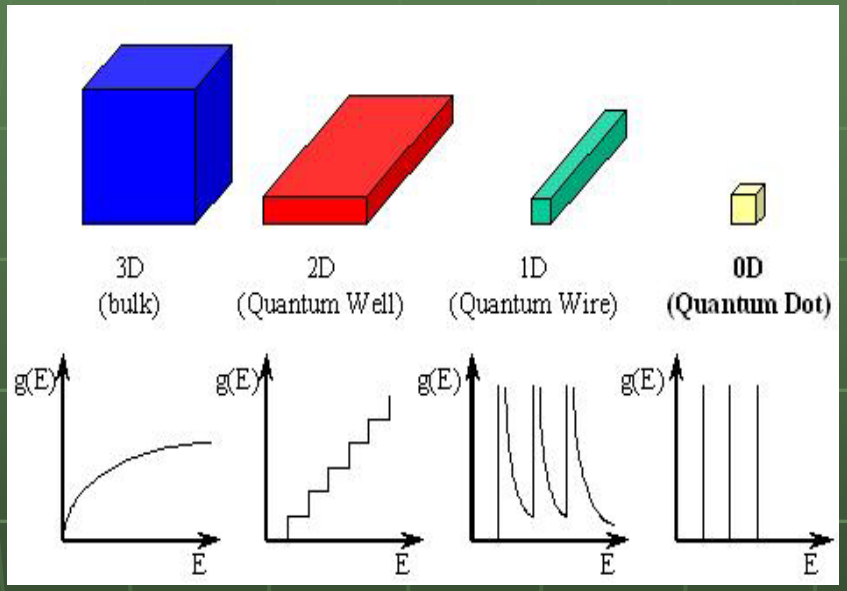
- Occurs at 67˚C
- Ultra fast switching(20 ns)
- Blocks infrared light as a metal and not as a semiconductor
- Possible Applications
  - Thermochromic coatings (“Smart” Windows)
  - Fiber Optic Switching



Courtesy of www.balticsww.com

Bulk vs. nano, what is the difference?

Dimension on the nanoscale



Electrical change: Conductivity

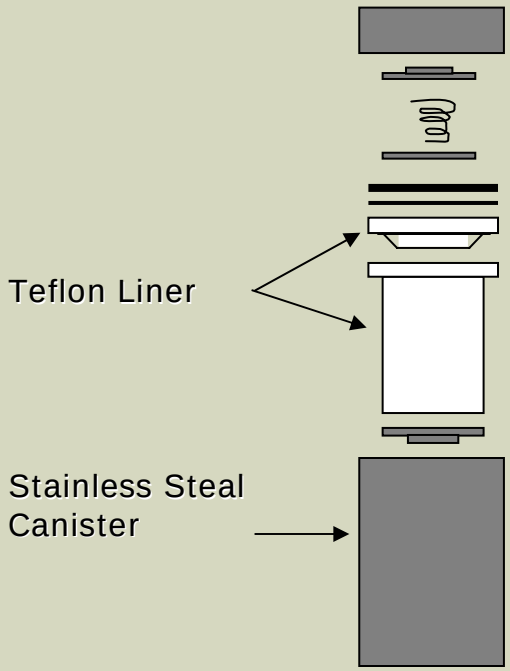
Optical change: Visible color

Thermal change: Temperature at which a phase change occurs

Hydrothermal Synthesis

- **Procedure**
- Solution:
  Vanadium Source
  + Carboxylic Acids
  + 10ml H_2O
- 1 mmol vanadium
  (NH_4VO_3, $VOSO_4 \cdot xH_2O$, V_2O_5)
- Acids added drop wise to pH ~2.5
- 180˚C at 2 days
- Washed with Ethanol
- Centrifuged
- Dried in vacuum 60˚C for 4hrs

The Autoclave

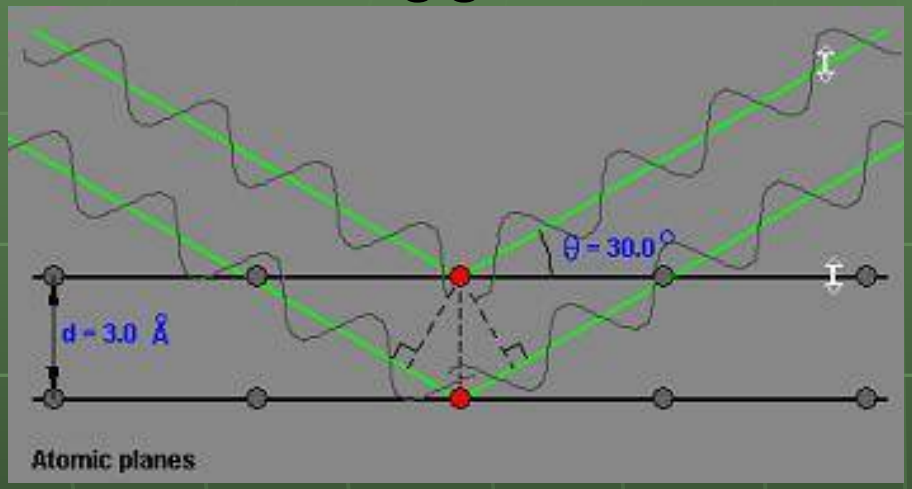


Schematic Diagram

Powder X-ray Diffraction:

A way of identifying the crystal structure

Bragg's law



$$n\lambda = 2d\sin\theta$$

EQUATION LEGEND

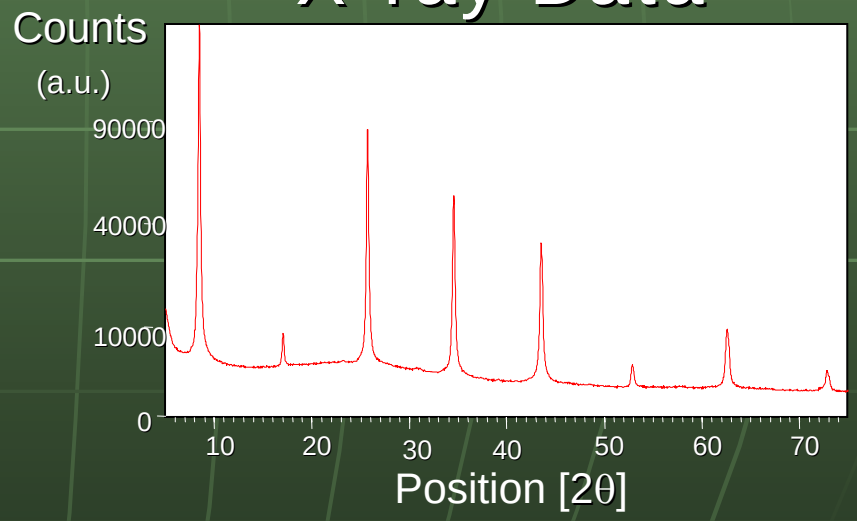
n = Integer value

λ = Wavelength of X-ray(1.54Å)

d = Spacing of atomic planes

θ = Angle of diffraction

X-ray Data

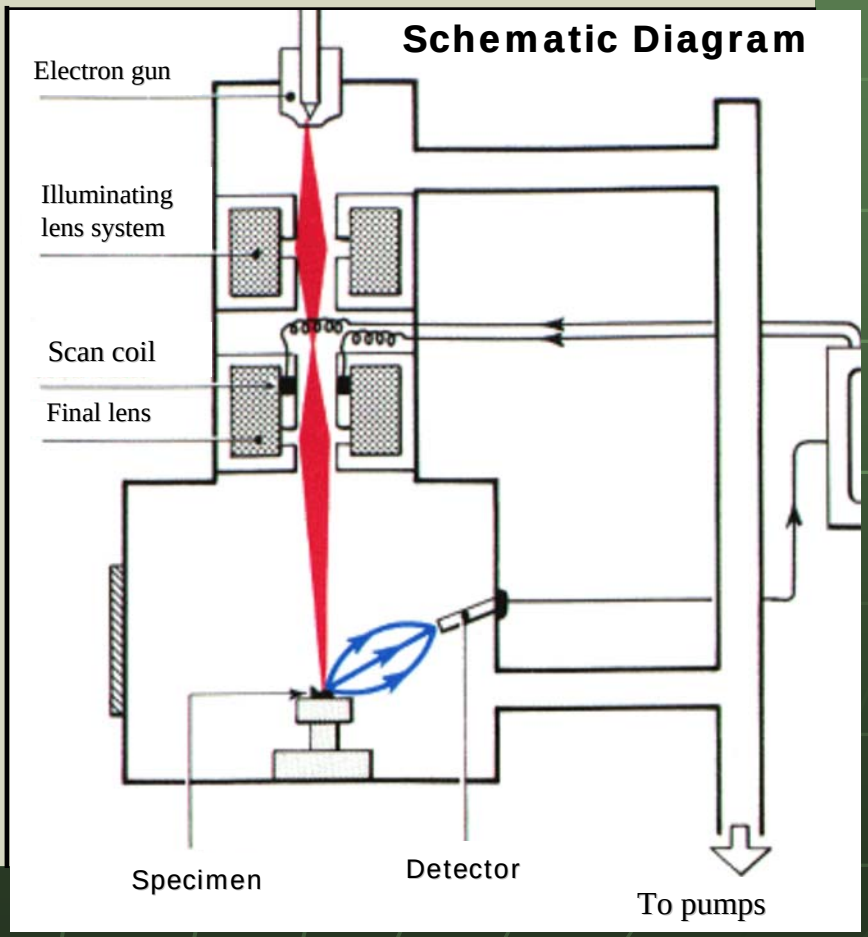


Scanning Electron Microscopy

Taking advantage of the wave nature of the electron

- Wave length = ~1Å
- Details as small as 10nm can be distinguished

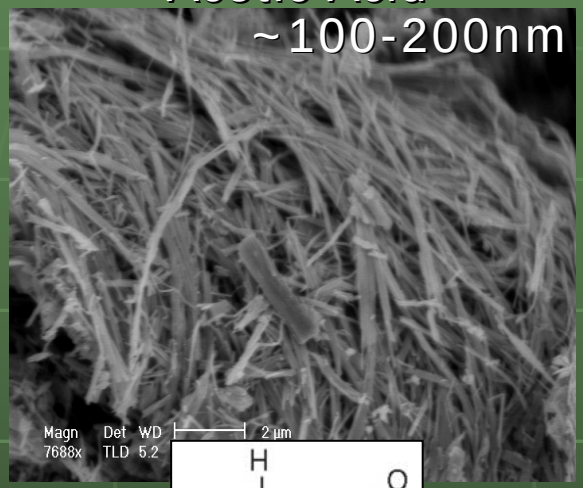
Courtesy of www.geos.ed.ac.uk



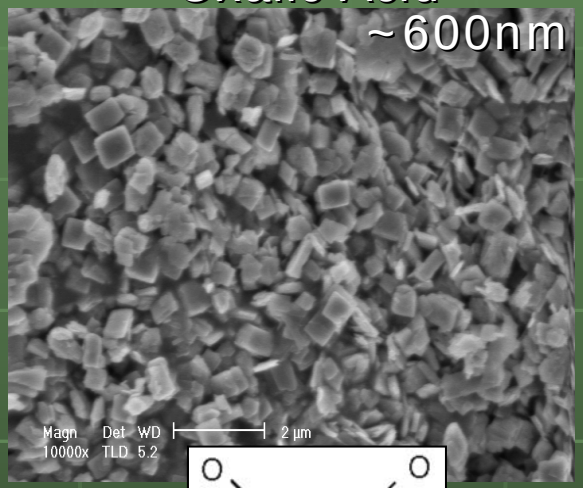
Ammonium Metavanadate

(NH_4VO_3)

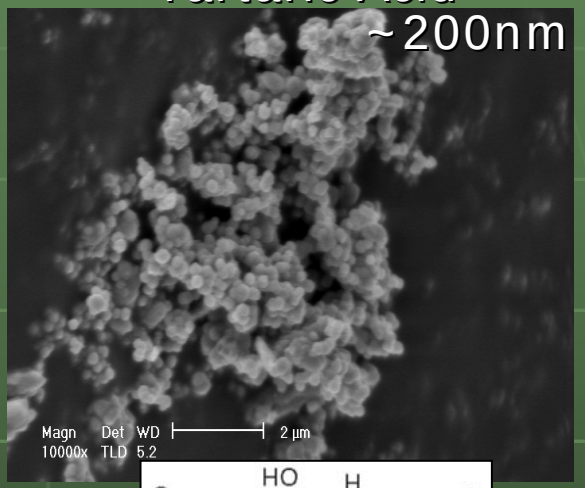
Acetic Acid

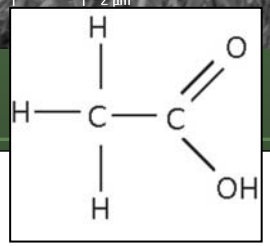


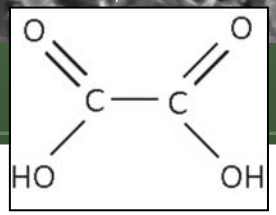
Oxalic Acid

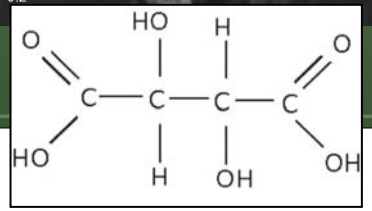


Tartaric Acid

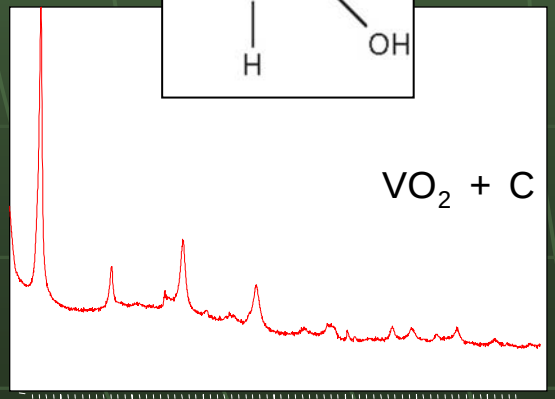


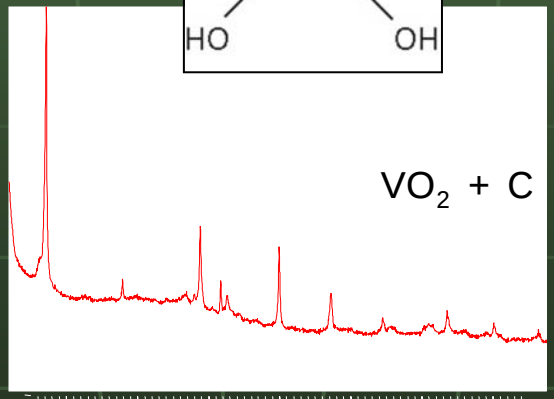


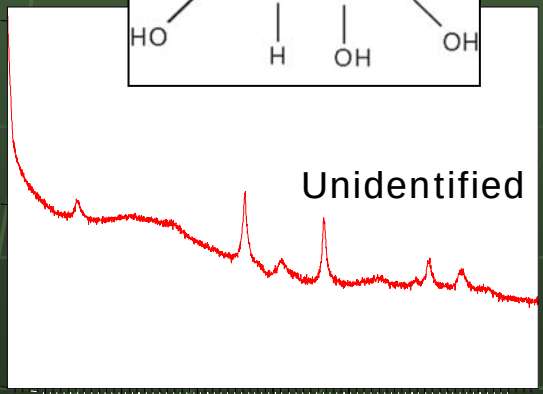




Intensity
(a.u.)







10 20 30 40 50 60 70

10 20 30 40 50 60 70

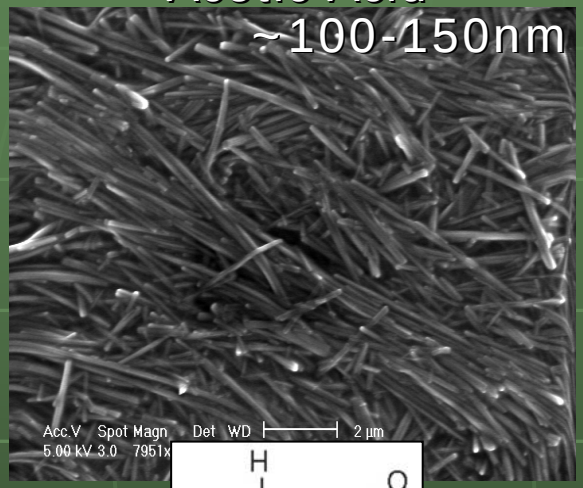
10 20 30 40 50 60 70

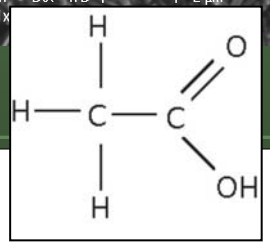
Position [°2Theta]

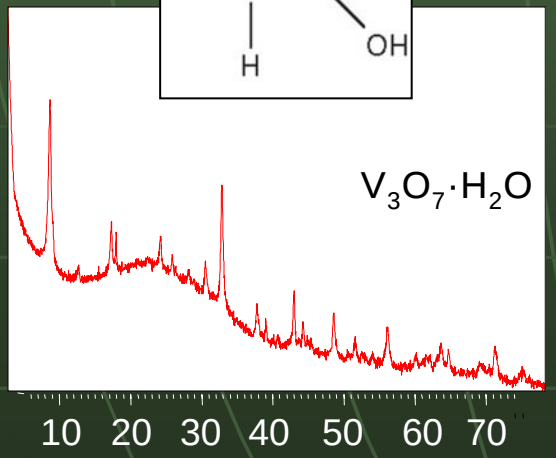
Vanadyl Sulfate Hydrate

($VOSO_4 \cdot H_2O$)

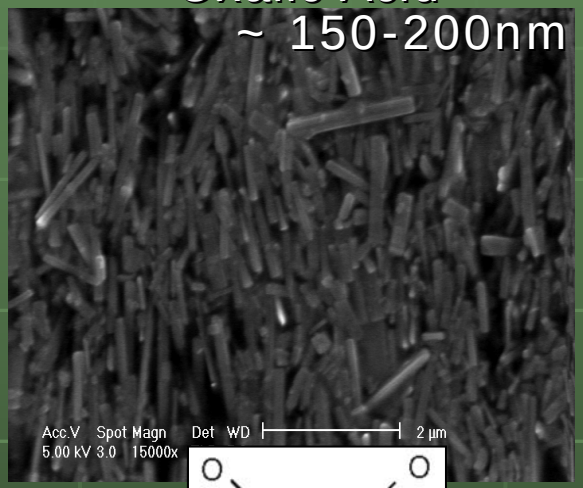
Acetic Acid

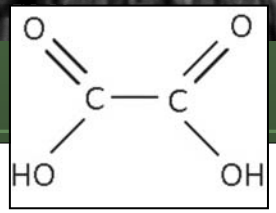


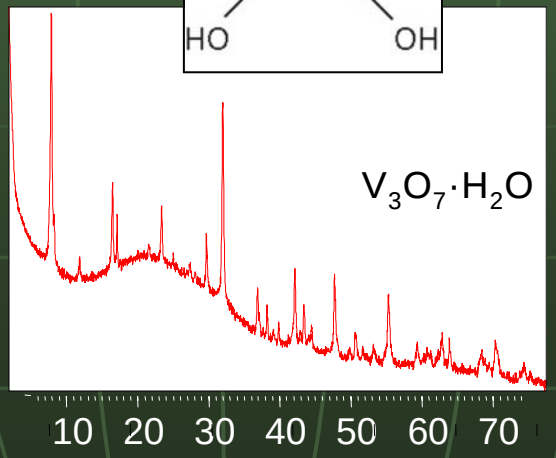




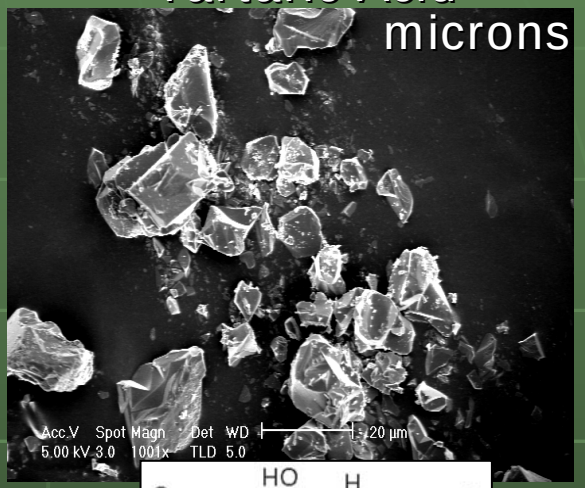
Oxalic Acid

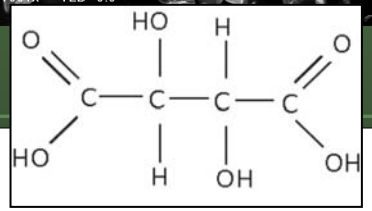


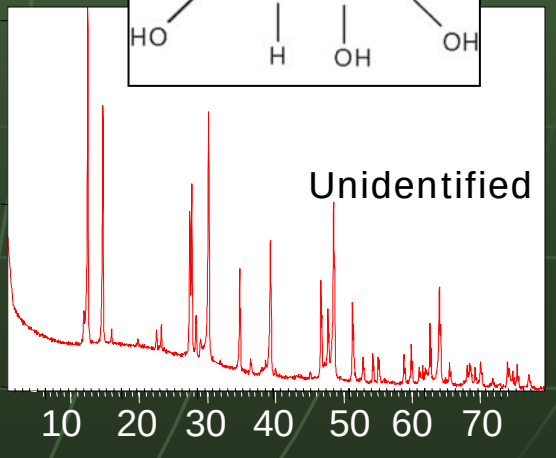




Tartaric Acid







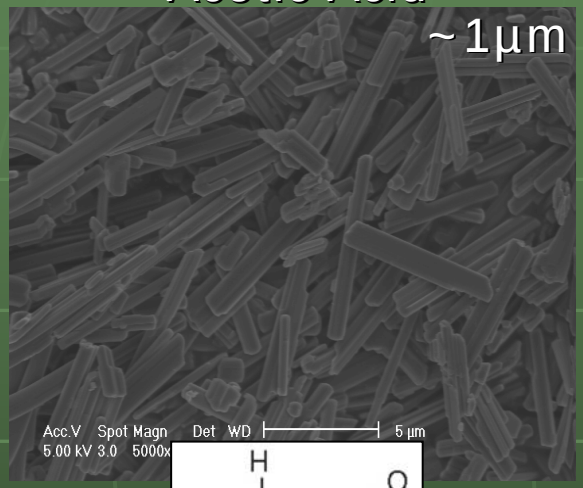
Intensity
(a.u.)

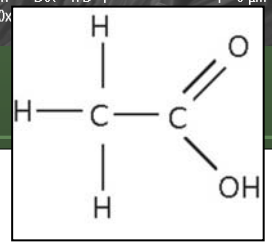
Position [°2Theta]

Vanadium Pentoxide

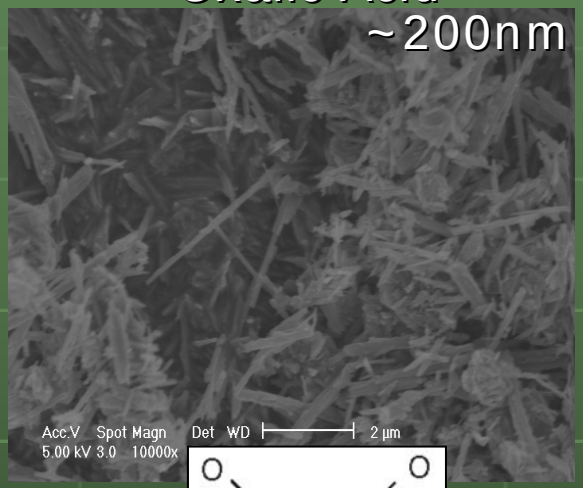
(V_2O_5)

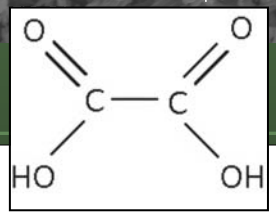
Acetic Acid



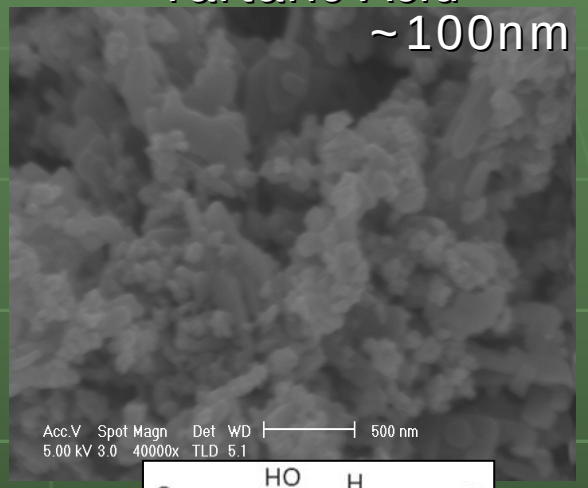


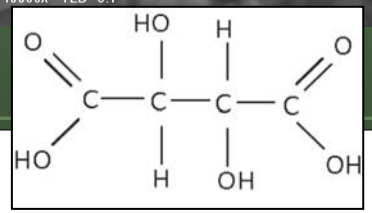
Oxalic Acid

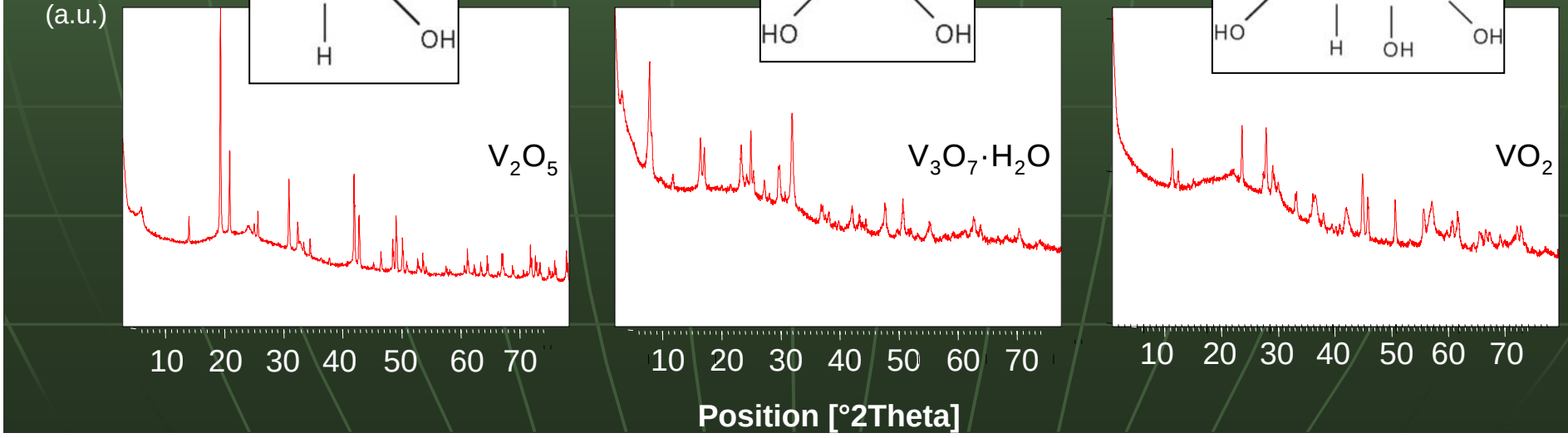




Tartaric Acid







Conclusions

Synthesis of nanowires explored using different vanadium sources and carboxylic acids

Samples characterized by X-ray diffraction and Scanning Electron Microscopy

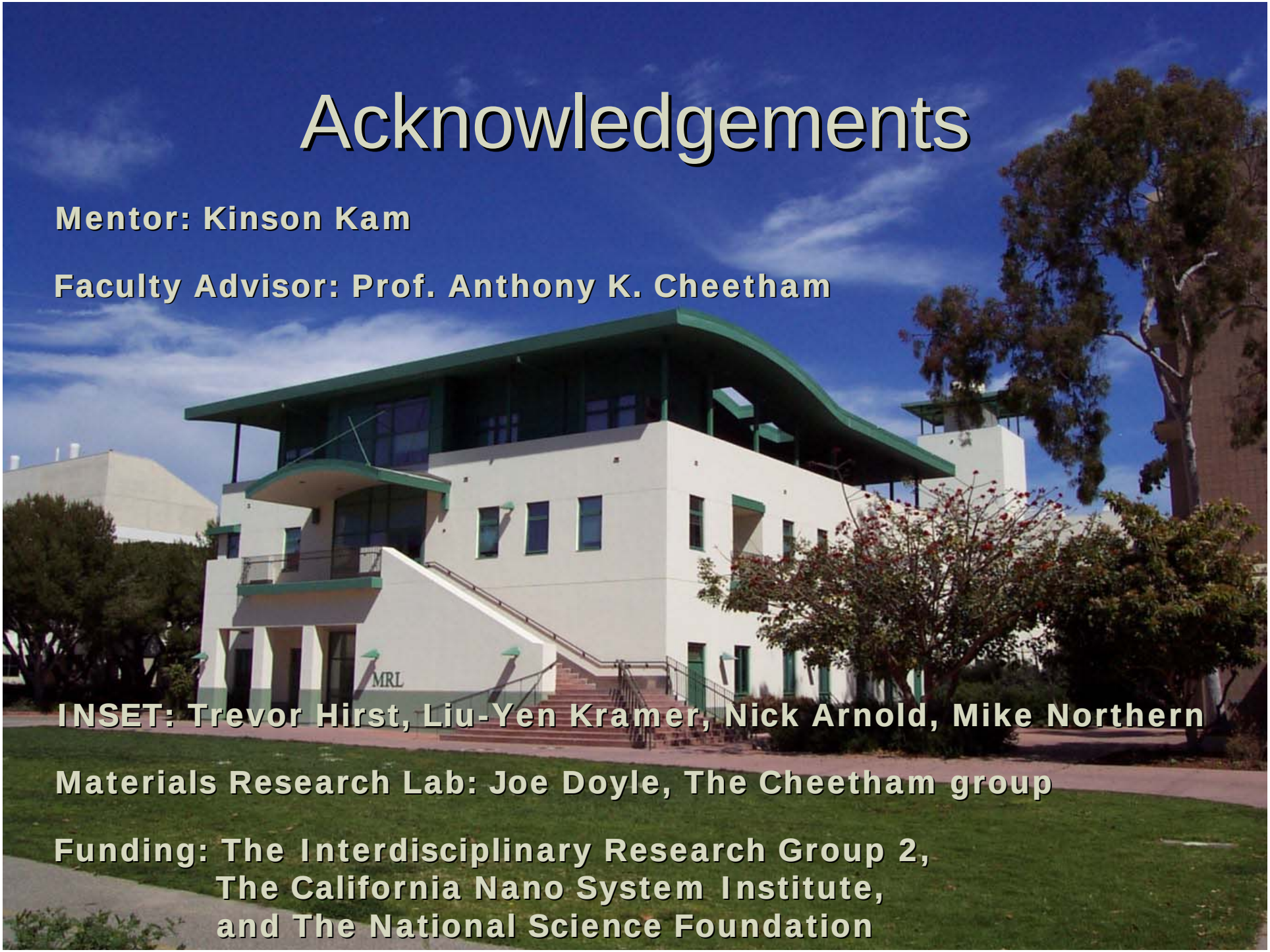
Future Research

- Affects of changing length of carbon chains on the morphology
- Characterization of the different morphologies
  - Photoluminescence
  - Conductivity
- The effective implementation of these materials in new technologies

Acknowledgements

Mentor: Kinson Kam

Faculty Advisor: Prof. Anthony K. Cheetham



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