
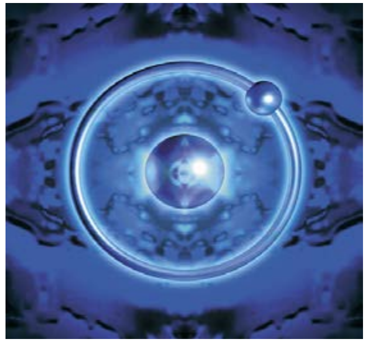


Solar Energy Utilization

Using (1) TiO_2 nanotubes (T_NT), (2) T_NT /CdSe, and (3) TiO_2/CdS/Pt

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Presenter | Vaidyanathan (Ravi) Subramanian

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Overview

Timeline
- 1/1/2011-12/31/2011
- 1/1/2012- 9/30/2012 (no cost extension)

Budget*
- Total funding
  - 258,235.00 (UNR)
    - 53,402.00 (cost share)

Personnel
- 1 post-doc
- 2 graduate students
- 4 undergraduates

Barriers
- Develop cost effective approach to growing TiO_2 nanotubes with added architectural flexibility
- Improve efficacy of coating visible light harvesters
- Determine effects of pollutants in hydrogen generation using traditional photocatalysts

Partners
- Desert Research Institute
- University of Nevada, Reno

Milestones

Barriers	Progress	% activity completed
(Barrier 1) Cost effective approach	• Method development • Testing the nanotubes physical features • Testing the photocatalytic activity	100 % (manuscript published)
(Barrier 2) Improve coating process	• Solvothermal coating • Examining coat density • Develop mechanism • Test activity	80 % (manuscript submitted)
(Barrier 3) H_2 generation + waste treatment	• Develop assembly • Gather preliminary data • How does pollutant influence H_2 yield • Mechanistic studies	60 % (Research continuing)

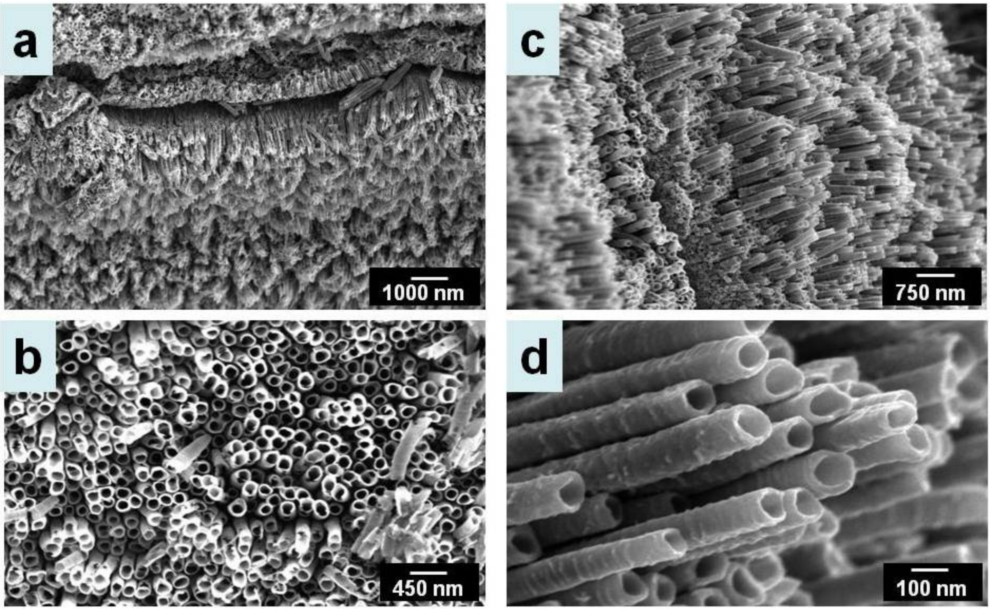
Barrier 1 – Cost
(Method for synthesis)

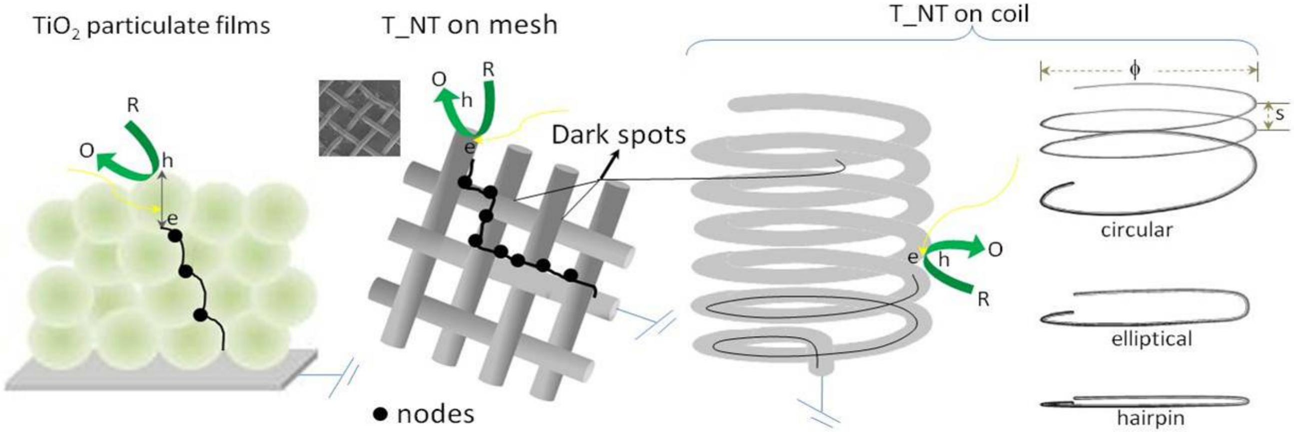
- Objective - evaluate if the nanotubes can be grown on flexible substrates with minimal usage of electrolyte
  - Goal – To study the anodization conditions with the intent to minimize Ti and electrolyte usage (reduce cost) without compromising on TiO_2 nanotube quality and properties

Performance measure	Method I	Method II	Outcome
Electrolyte volume	~300 ml	~25 ml	TiO_2 nanotubes
Geometry independence	foil	coil	TiO_2 nanotubes

Barrier 1 – Cost (SEM images)

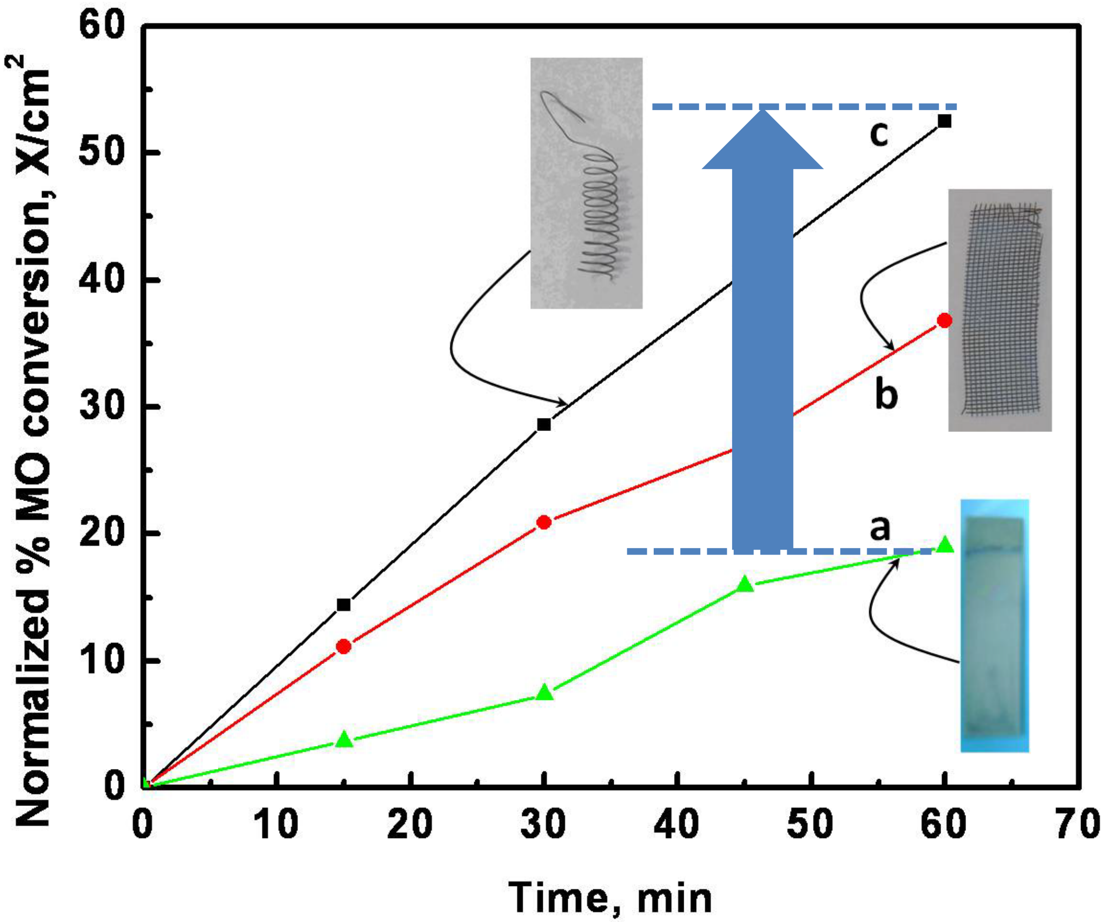
- TiO_2 nanotubes (T_NT) formed on coil using 25 ml electrolyte instead of 300 ml electrolyte
- Progressive images indicate clearly the formation of nanotubes
- Similar nanotubes have been demonstrated on foil, mesh, and wires





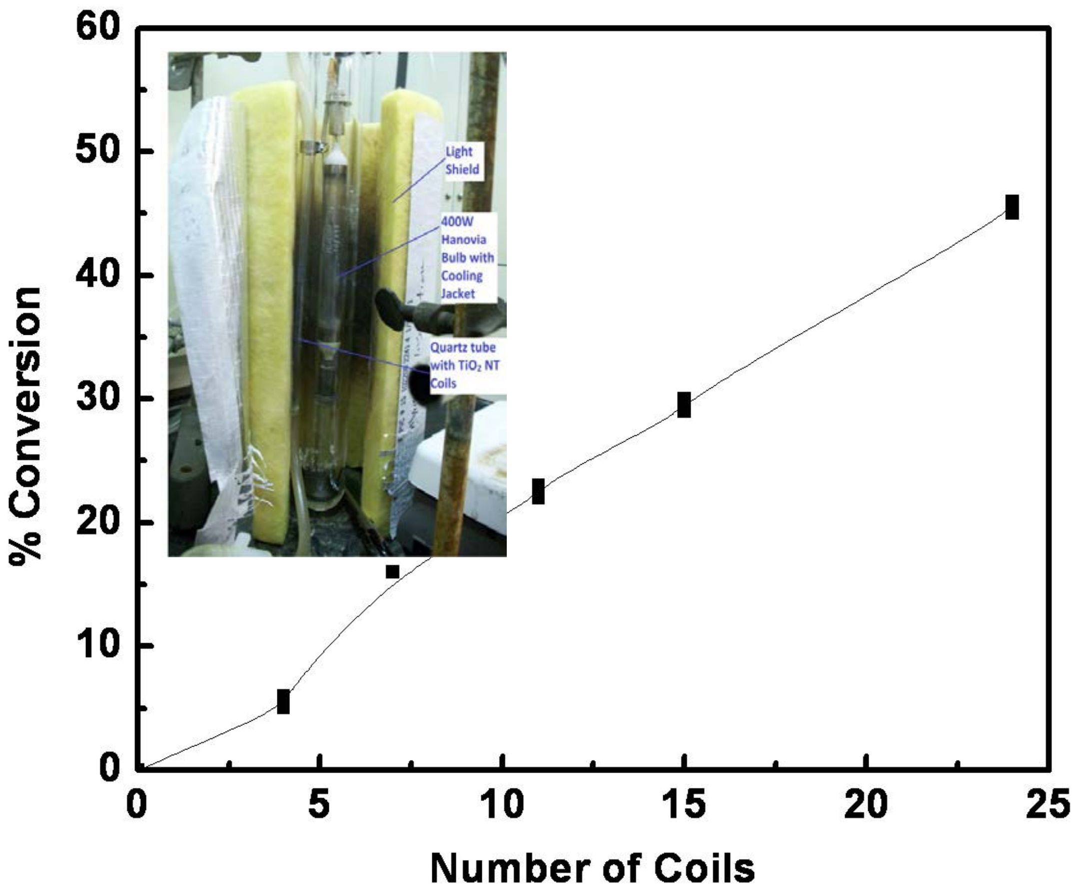
Barrier 1 – Cost (Photoactivity: Liquid)

- Photoactivity of the T_NT on coil is compared with nanotubes on other substrates prepared using method I
- Test compound: methyl orange
- x 2.5 times increase in photodegradation is observed with T_NT on coils. [*Normalized to geometrical surface area of illumination*]



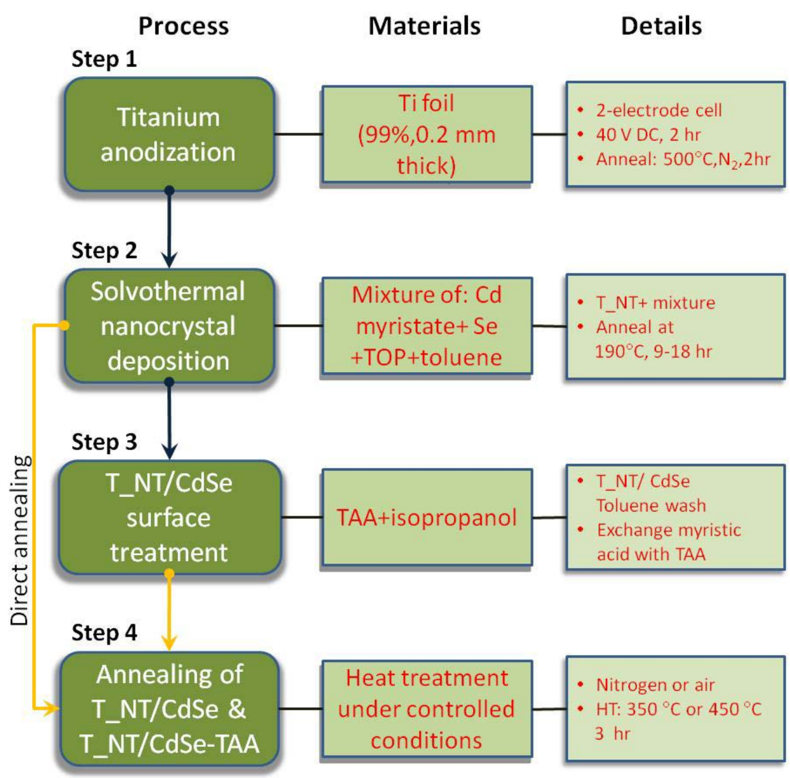
Barrier 1 – Cost
(Photoactivity: Gas phase)

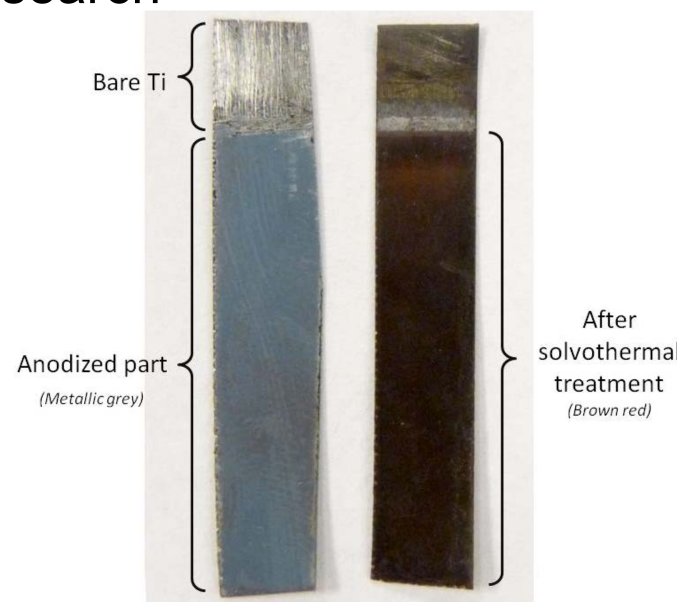
- The applicability of T_NT as a photocatalyst on coil for gas phase catalysis has also been studied
- Test compound: 2,3-butanedione
- Up to 40% conversion of the gas phase pollutant is demonstrated (un-optimized) in a single pass gas phase photocatalytic reactor



Barrier 2 – Coating (Solvothermal approach)

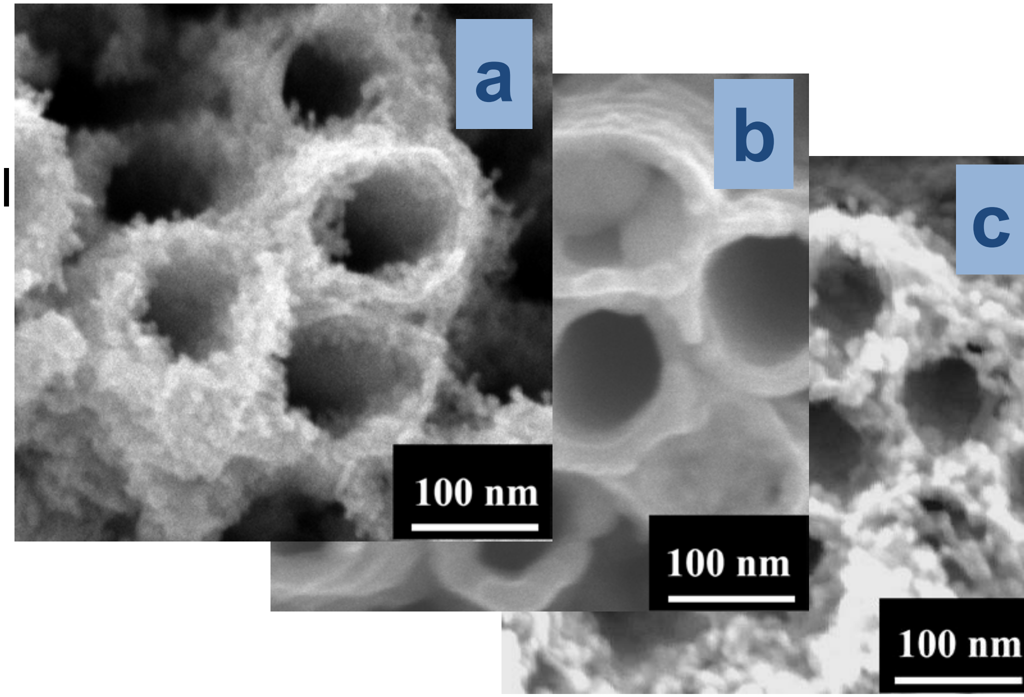
- Objective – To develop an efficient coating strategy
  - Goal – To determine if a solvothermal approach with a ligand treatment can form dense CdS deposits on the T_NT walls
  - A review of literature followed by compilation of an article has been carried out as the basis for this research

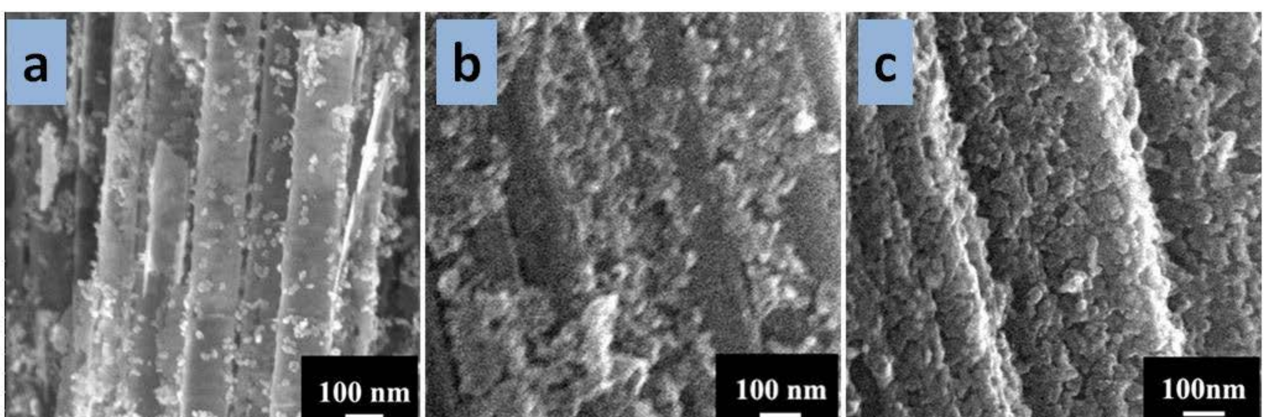




Barrier 2 – Coating (SEM images)

- The SEM images indicate a uniform coating on the T_NT walls under solvothermal conditions
- A ligand treatment assists with maintaining dense coating and particle size
  - a- T_NT/CdSe
  - b-T_NT/CdSe-no exchange
  - c- T_NT/CdSe-ligand exchange





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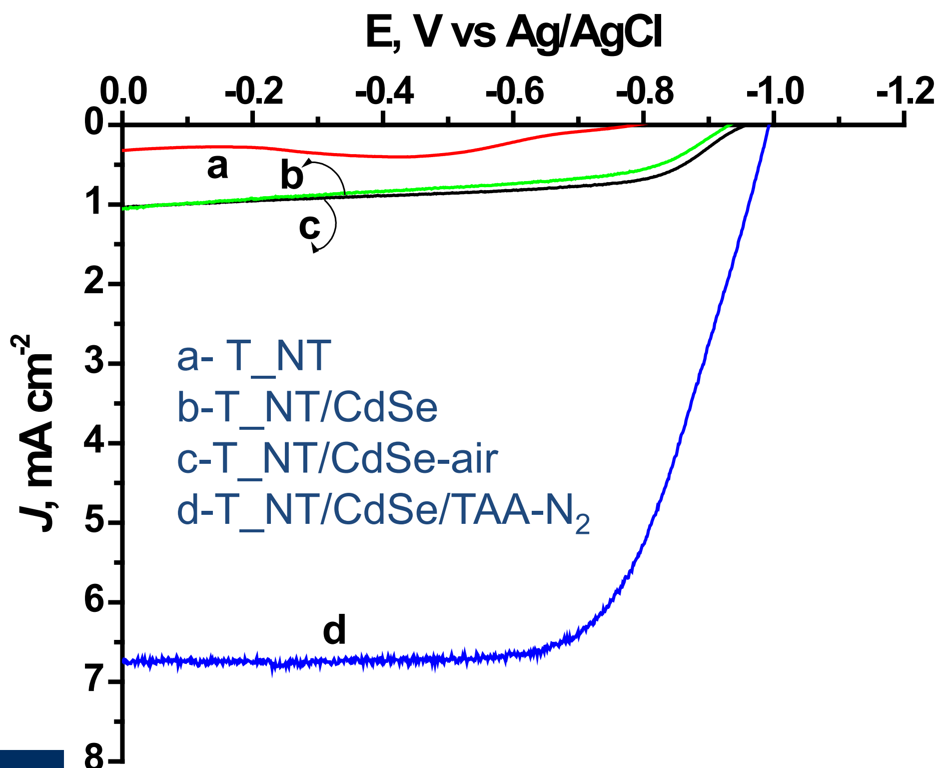
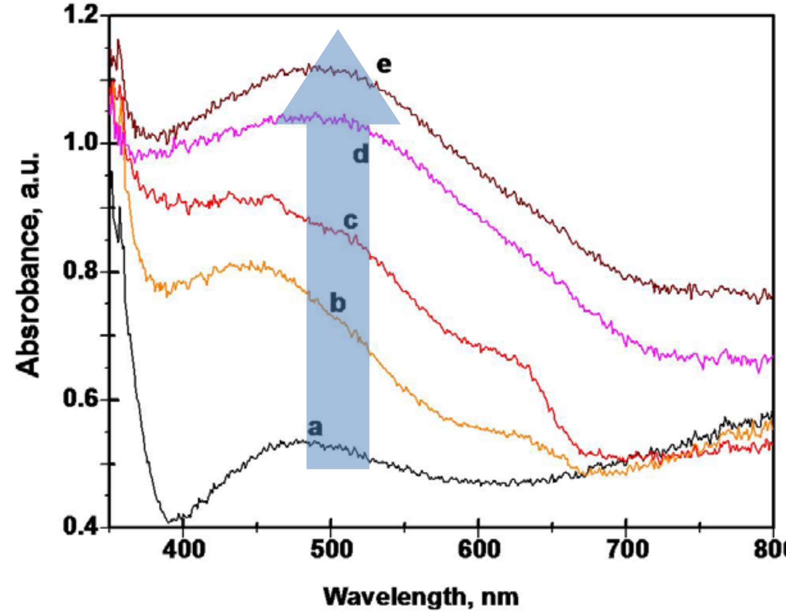
Barrier 2 – Coating (optical & electronic activity)

- The CdSe deposits via a solvothermal approach followed by a ligand exchange gives maximum photocurrent

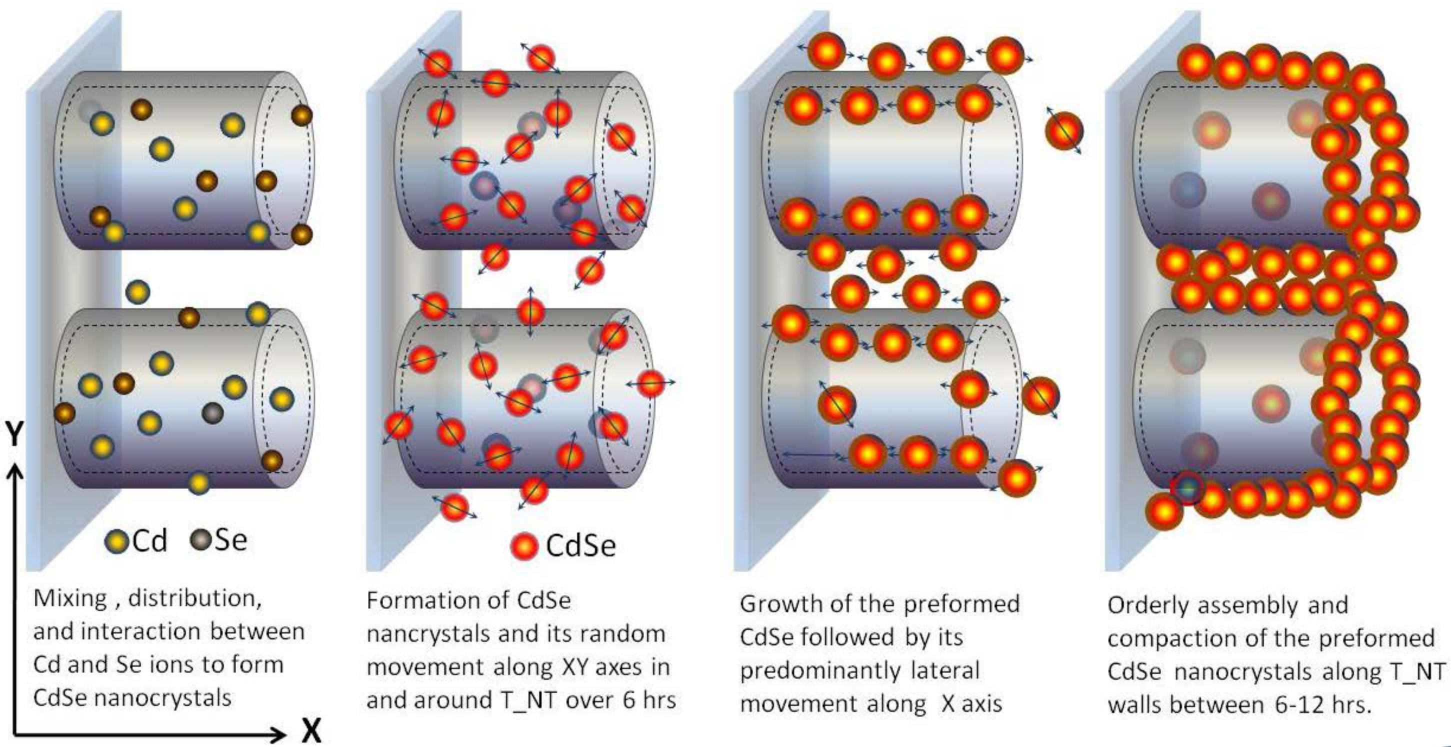


More exposure to solvothermal conditions leads to increase in CdSe deposits



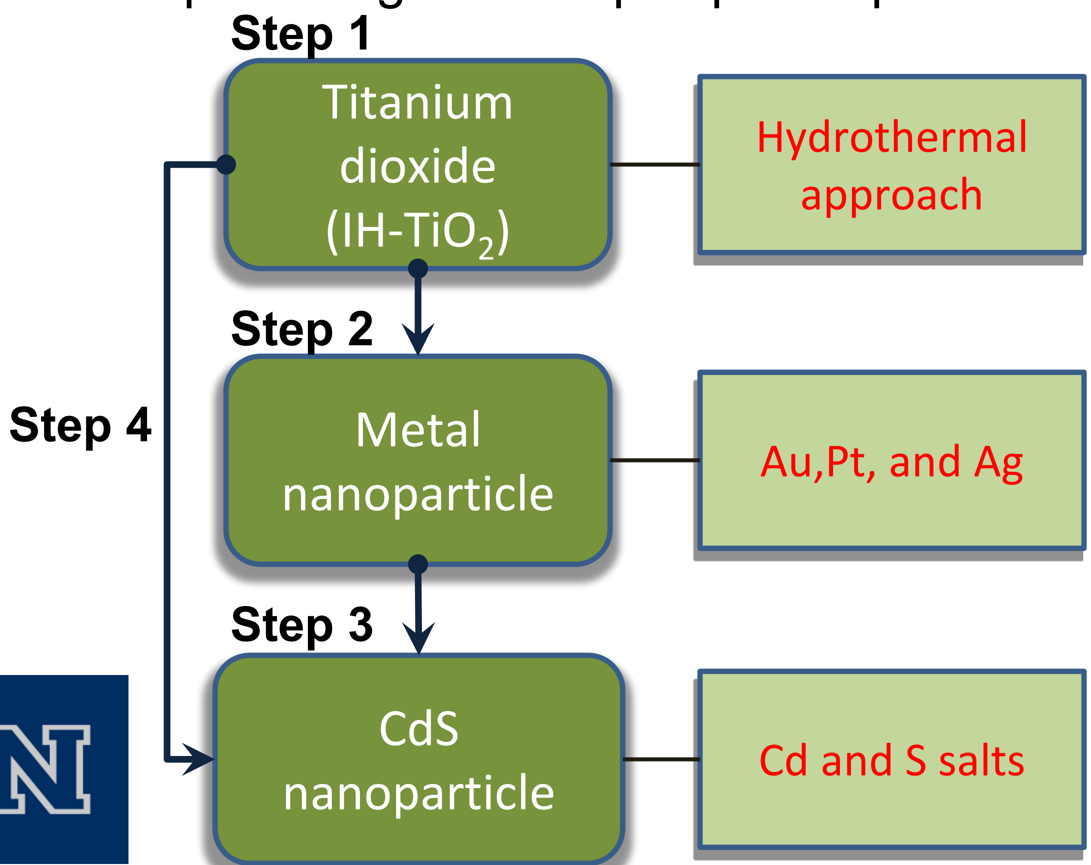
Barrier 2 – Coating (Coating mechanism)

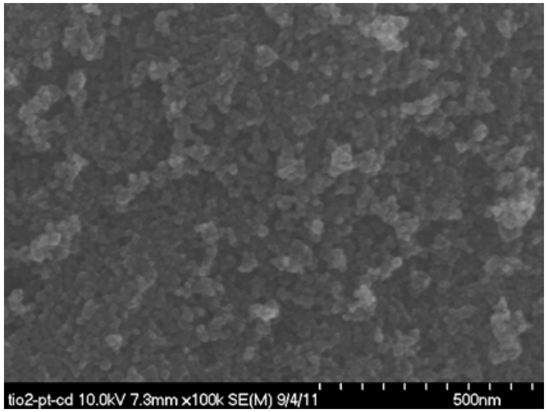
- A 4-step process is believed to take place during CdSe deposition on T_NT when the solvothermal treatment is followed by annealing under nitrogen after ligand treatment



Barrier 3 – Fuel+waste (Photocatalyst synthesis)

- Objective – To examine strategies to improve photocatalytic hydrogen generation and waste treatment - simultaneously
  - Goal – To determine if a photocatalyst can produce hydrogen and photodegrade a liquid phase pollutant





Sample	Surface Area (m^2/g)
IH-TiO_2	~130
P25	~53

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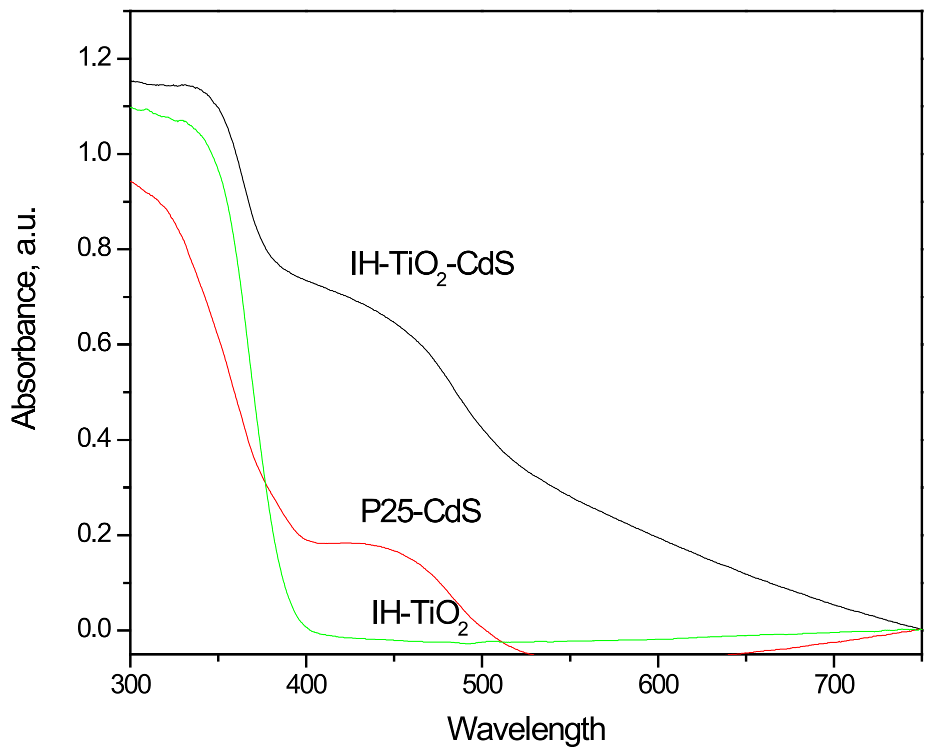
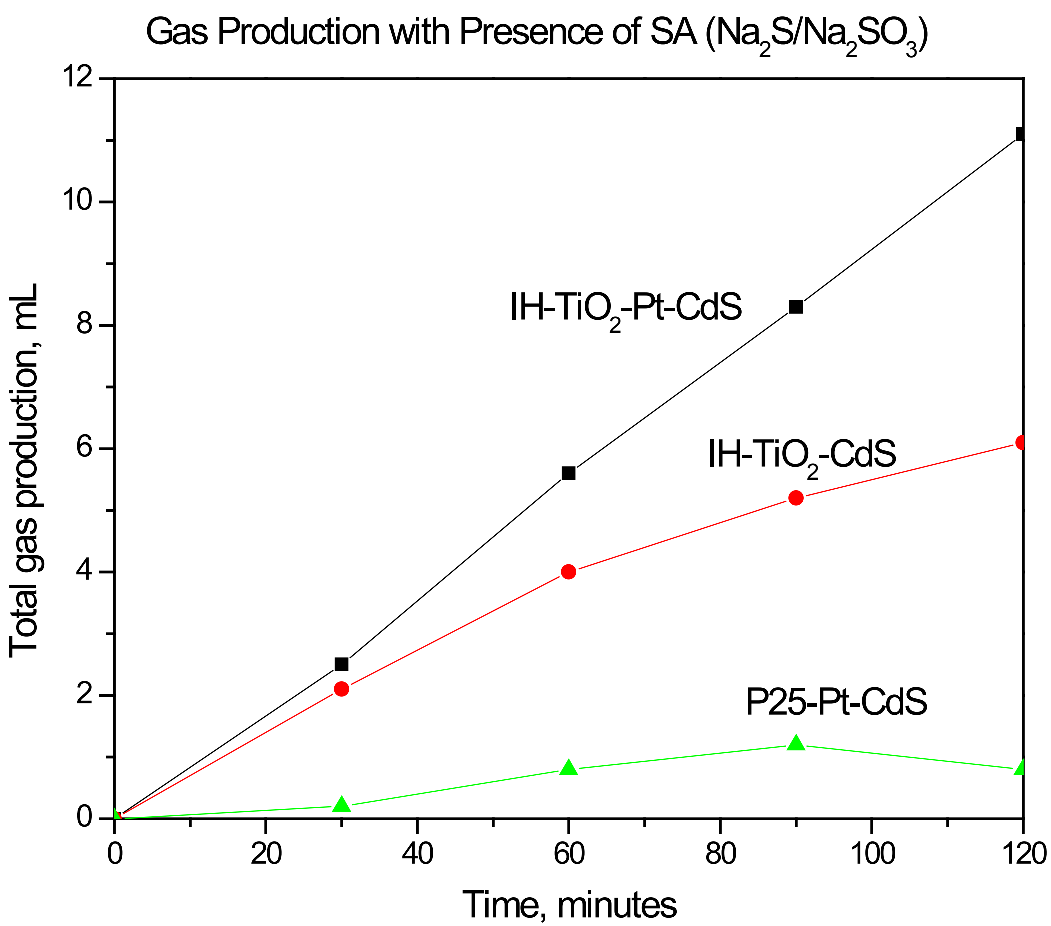
Barrier 3 – Fuel+waste (Optical properties)

- The IH TiO_2 allows for greater deposition of CdS (due to higher surface area)
- The absorbance (of CdSe) is also noticed to increase farther into the visible part of the solar spectrum



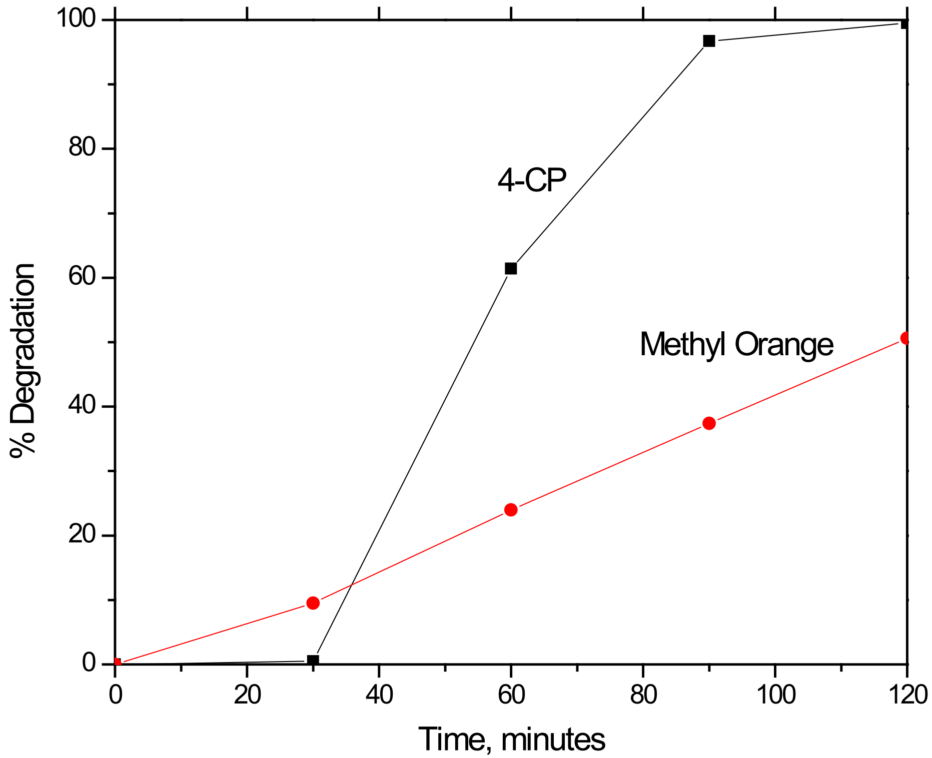
Barrier 3 – Fuel+waste (H_2 generation data)

- The IH-TiO_2-Pt-CdS photocatalyst shows the maximum hydrogen yield
- The electrolyte has counter sulfide ions to maintain the stability of CdS

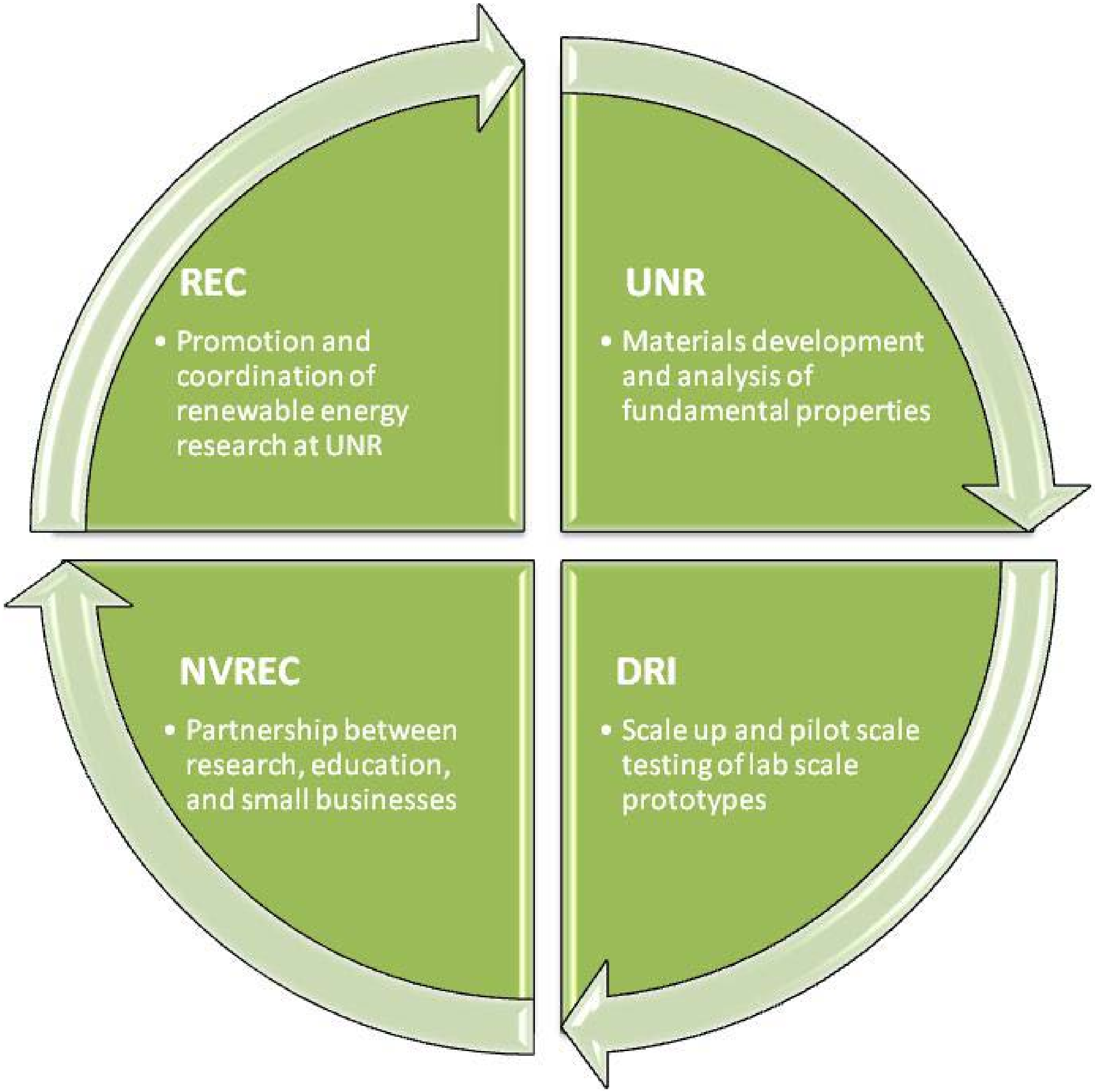


Barrier 3 – Fuel+waste (Photodegradation)

- The addition of pollutants such as methyl orange or 4-chlorophenol shows pollutant degradation indicating a synergistic activity of the photocatalyst
- How does this assist with hydrogen generation?
- What is the stability of the photocatalyst?



Collaborations



Summary

- Relevance – Examine feasibility of
  - synthesizing nanotubes efficiently,
  - depositing visible light harvesting material effectively, and
  - testing hydrogen generation and photodegradation – simultaneously.
- Approach – Proof-of-concept has been demonstrated using
  - low volume solvent for nanotube synthesis and
  - solvothermal process for CdS deposition.
- Technical accomplishments – Results suggest that
  - T_NT nanotubes can be synthesized effectively using a reduced electrolyte volume.
  - solvothermal is a good technique to deposit and pack light harvesting chalcogenide.
  - Preliminary data indicates hydrogen production and photodegradation could be possible simultaneously.
- Collaboration
  - DRI – Alan Gertler
  - UNR – Ravi Subramanian