



THE UNIVERSITY OF
NEW SOUTH WALES



SYDNEY • AUSTRALIA

Flaming down under: A southern hemisphere story

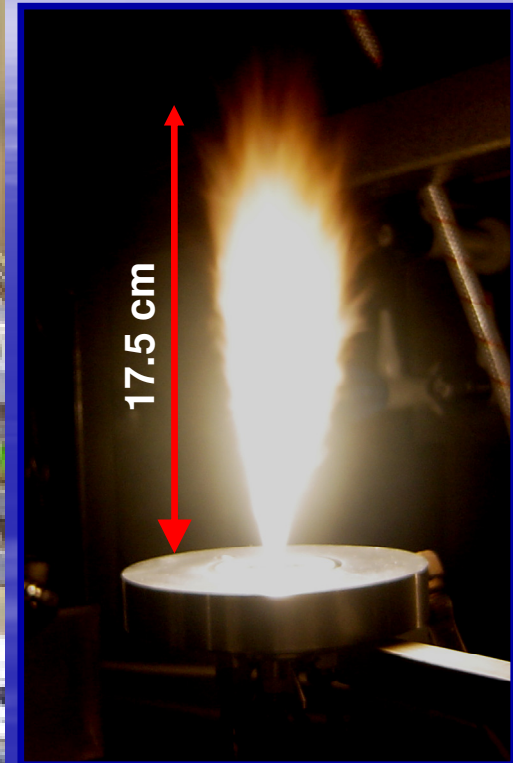


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FSP Facility @ UNSW

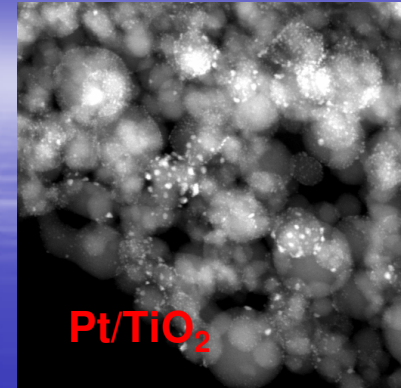
The story begins here,
May 2004...



Outline

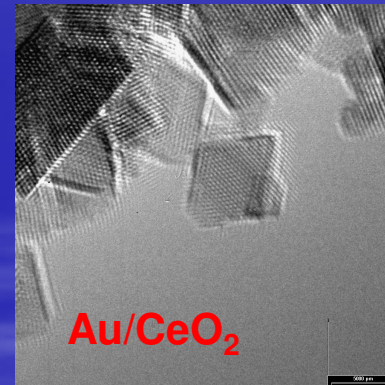
Environmental applications

- UV/TiO₂ Photocatalysts
- Visible-light photocatalysts



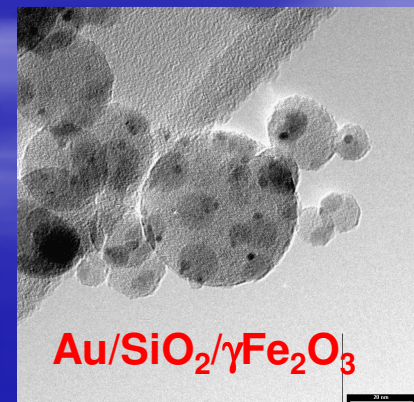
Energy applications

- Photocatalytic water splitting
- Preferential CO oxidation



Bio-applications

- Protein separation
- Enzyme immobilisation
- Photo-switchable antimicrobial agent

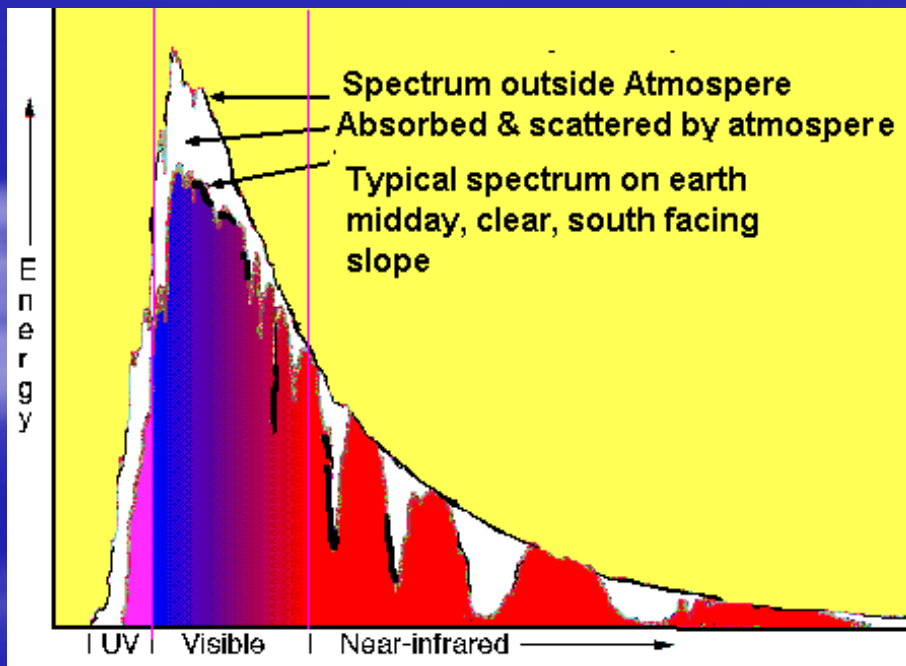
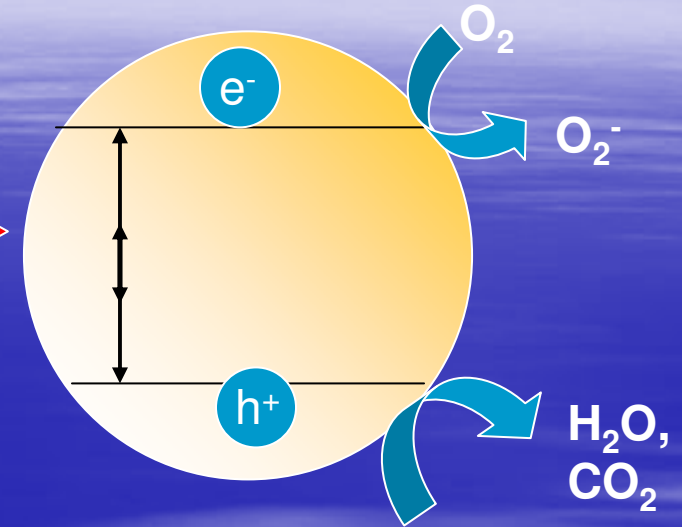


Conclusions

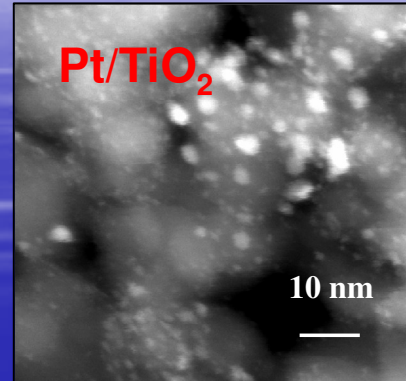
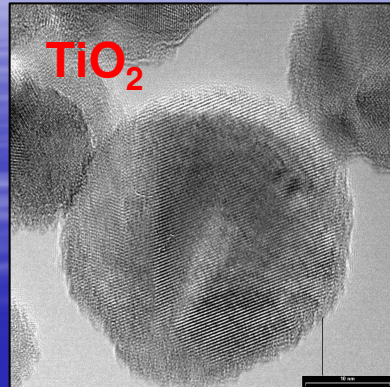
Environmental Photocatalysts



$$E \geq E_{bg}$$



UV activated photocatalyst ($\lambda < 400$ nm)



Aqueous

Saccharides

Alcohols

Carboxylic acids

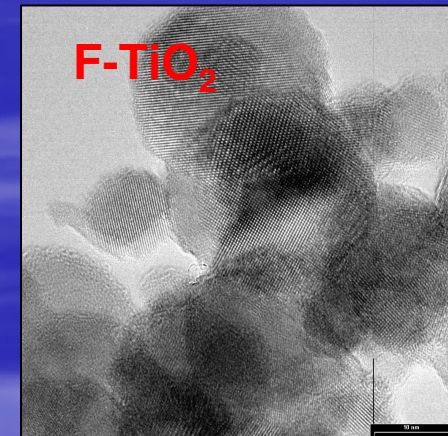
Aromatics

Textile dyes

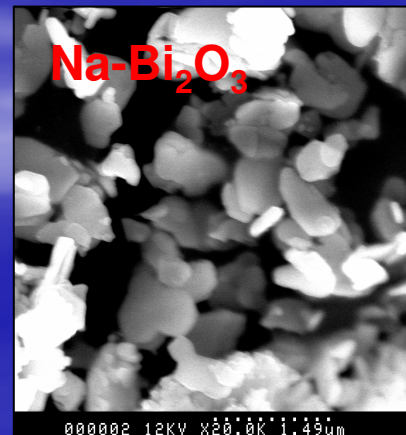
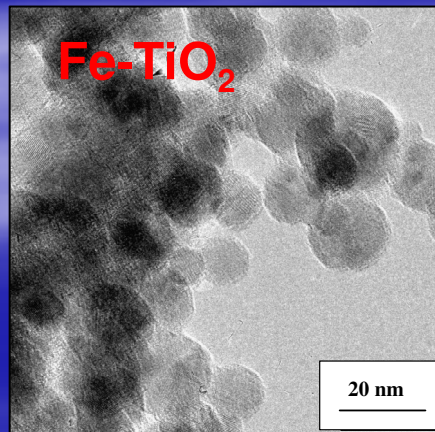
Gas

Aldehyde

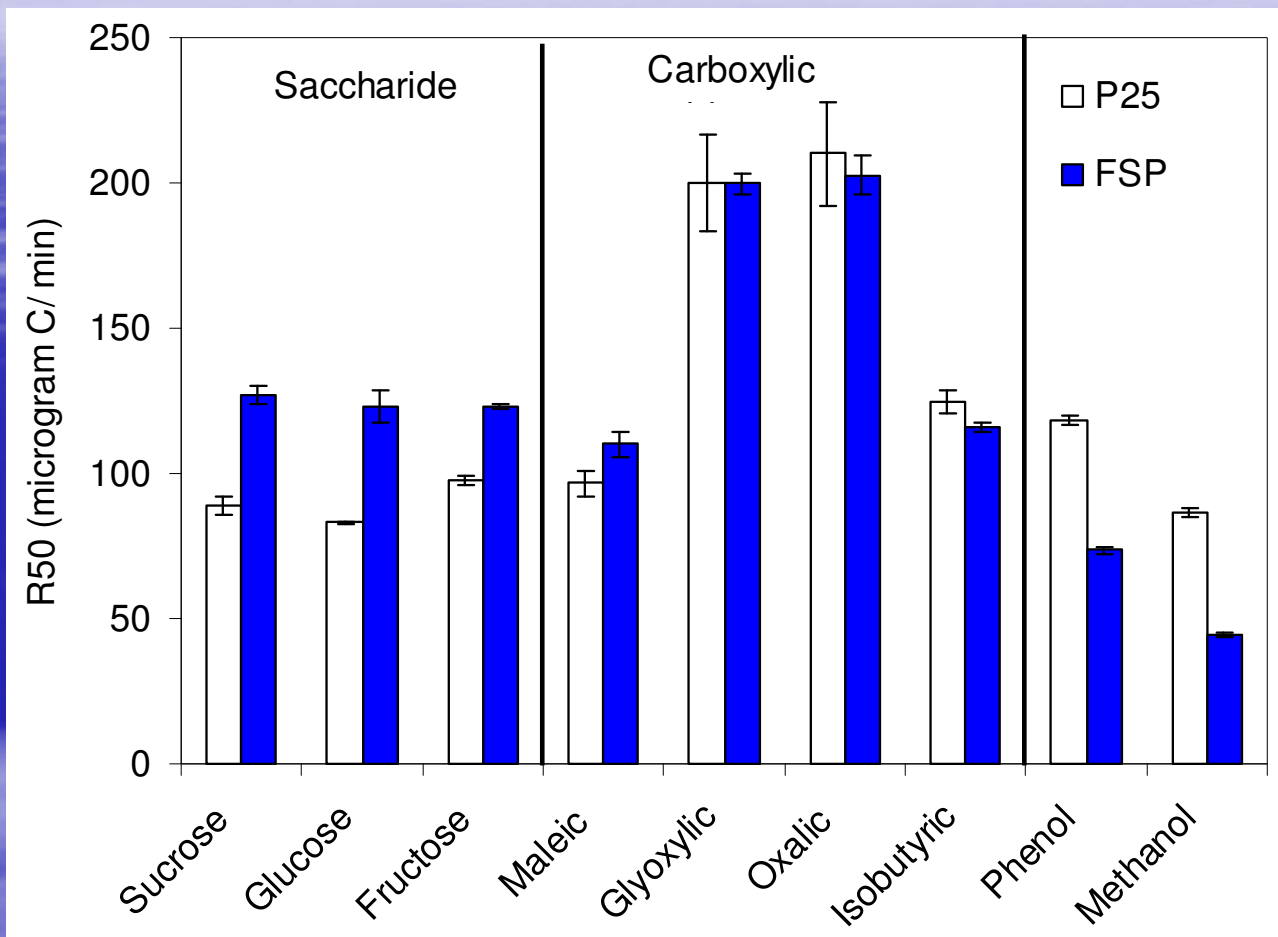
Aromatics



Visible light photocatalyst ($\lambda > 400$ nm)



Photoactivity of FSP TiO₂



- **Saccharides:**

FSP TiO₂ has higher efficiency for direct charge transfer

- **Carboxylic acids:**

Less affected due to fast mineralisation

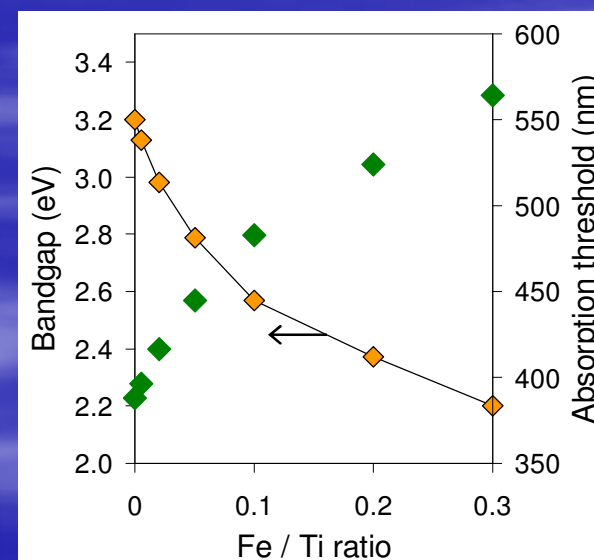
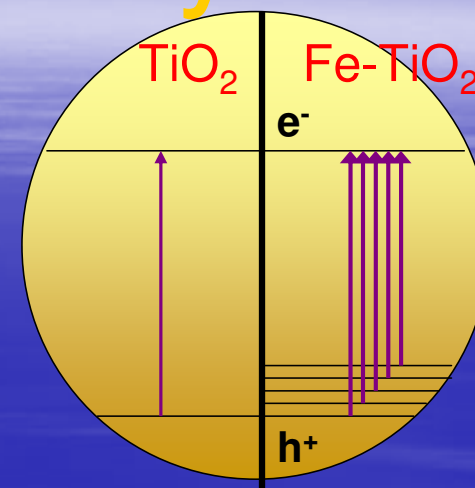
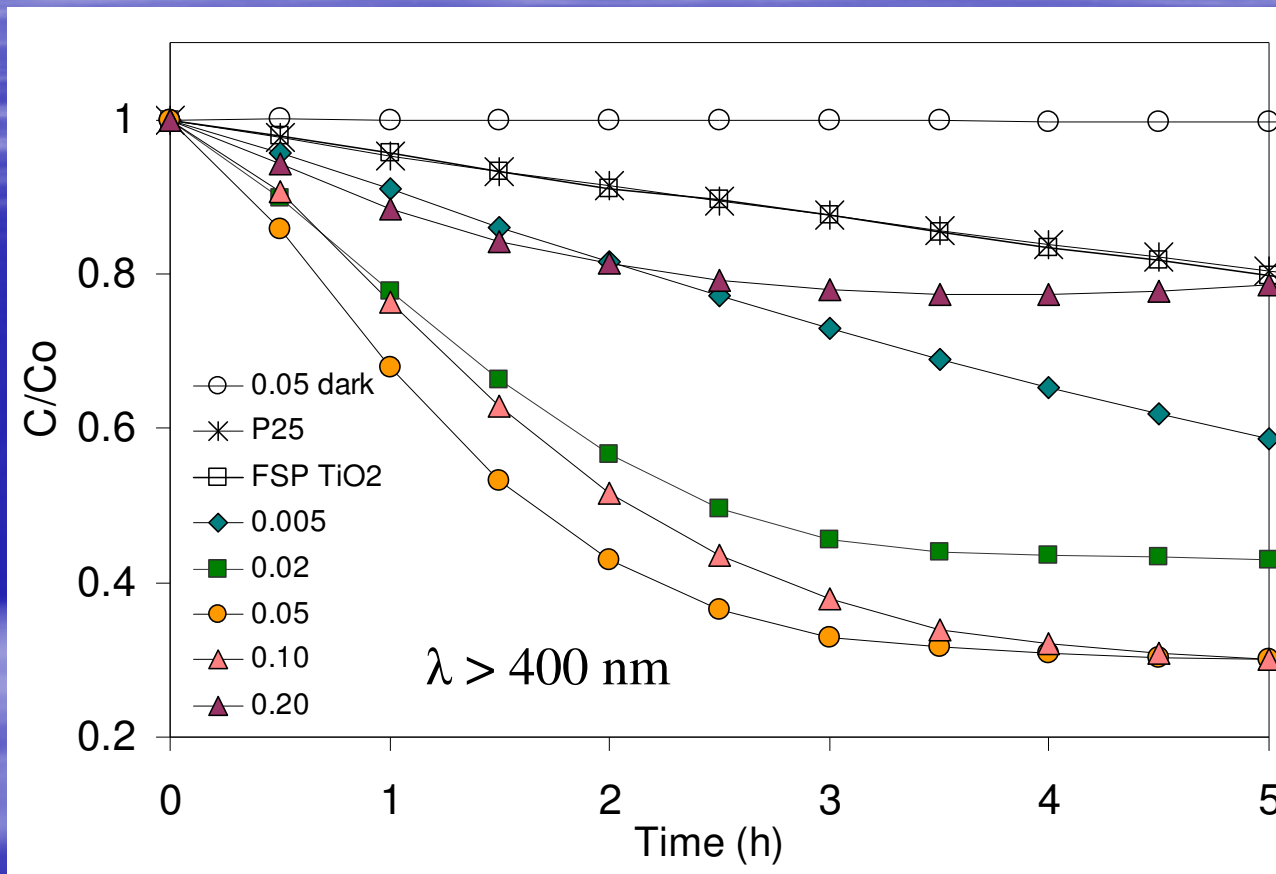
- **PhOH and MeOH:**

P25 produces greater amount of OH•

10 ppm C, pH 3.5, UV-A

Similar anatase content (~82%)

Fe-TiO₂ Photoactivity

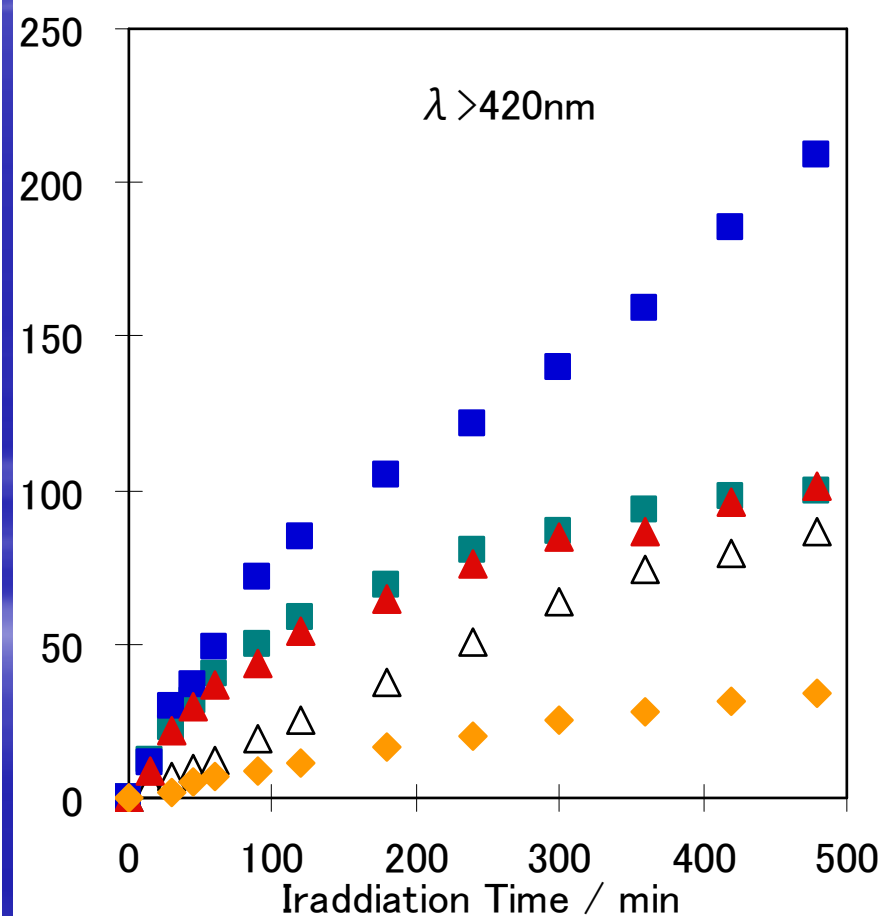
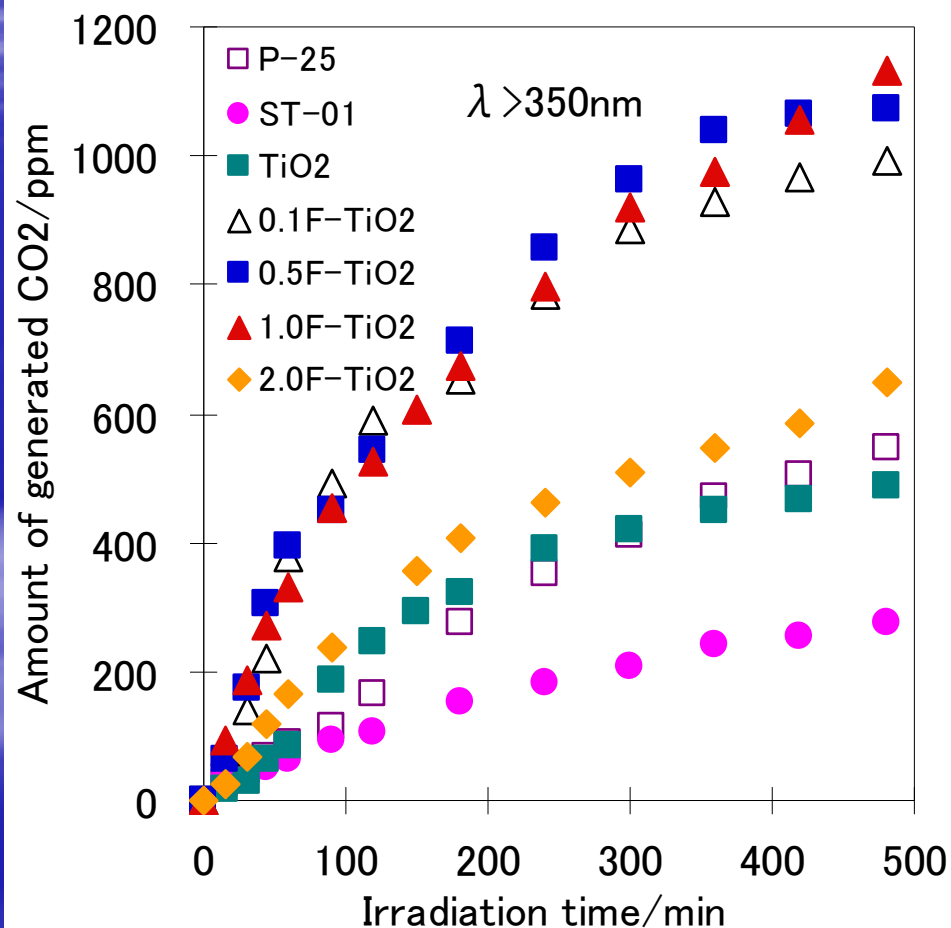


- Improvement of 6.4 times for photocatalytic mineralisation of oxalic acid

F-doped TiO₂ for air purification

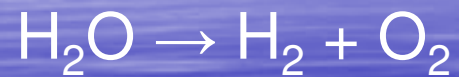
Acetaldehyde is a common VOC contaminant in indoor air

Causes “sick building” syndrome and suspected carcinogen

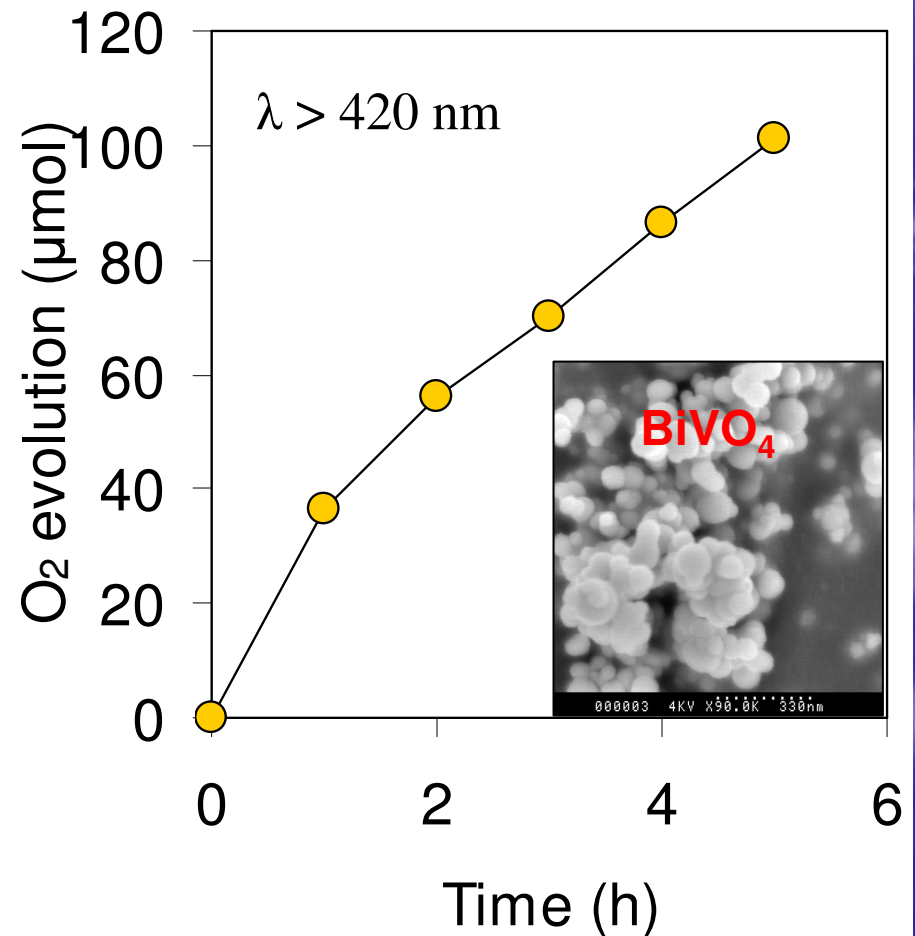
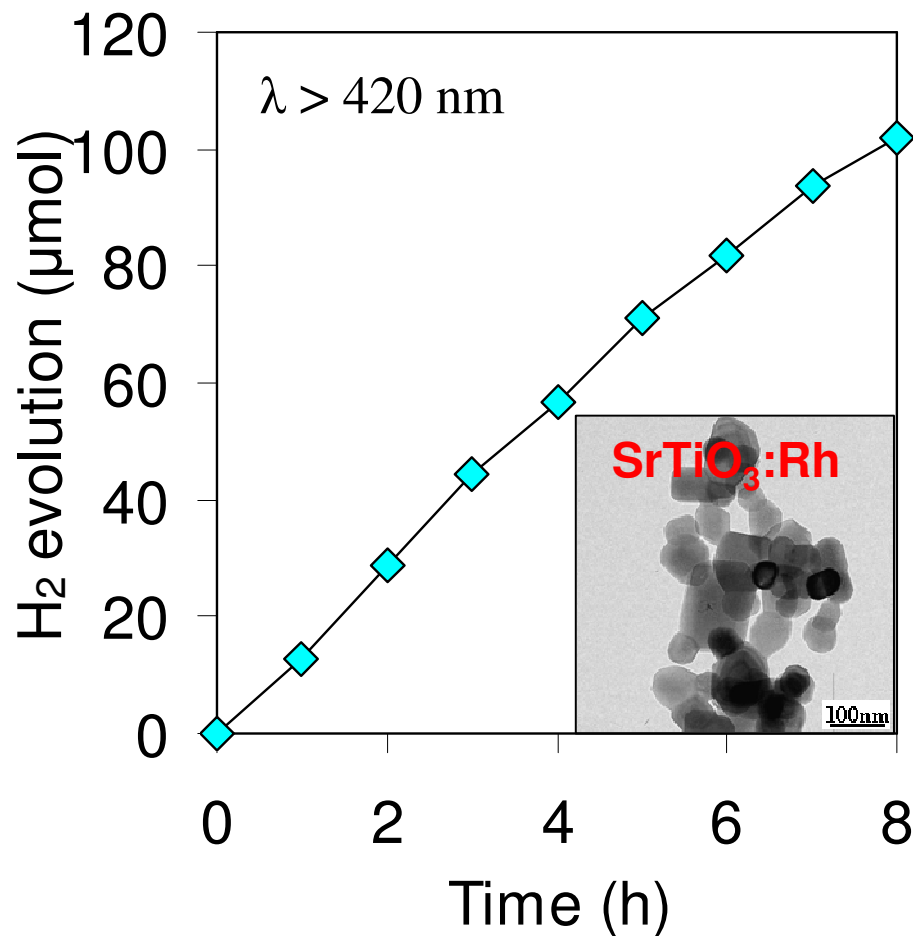


Visible light water splitting

Abundance of solar/visible light and sea water

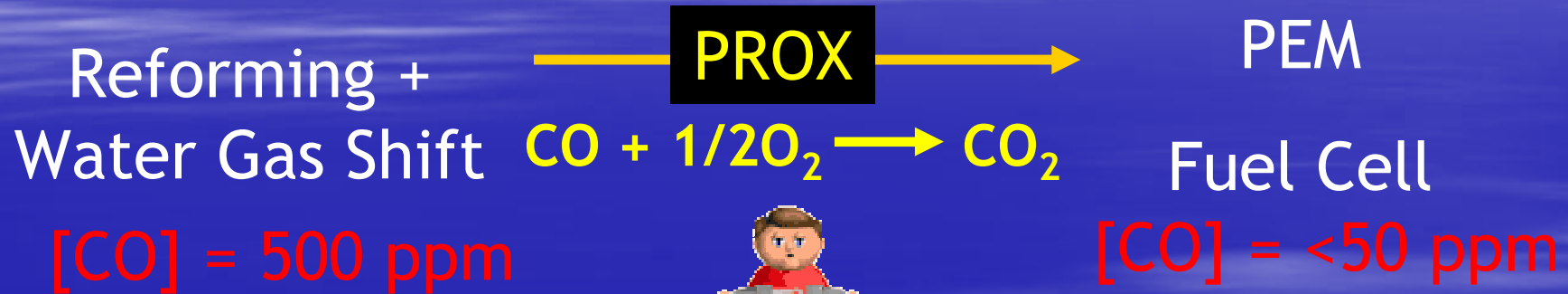


$$\Delta G^\circ = +237 \text{ kJ/mol}$$



Low temperature CO oxidation

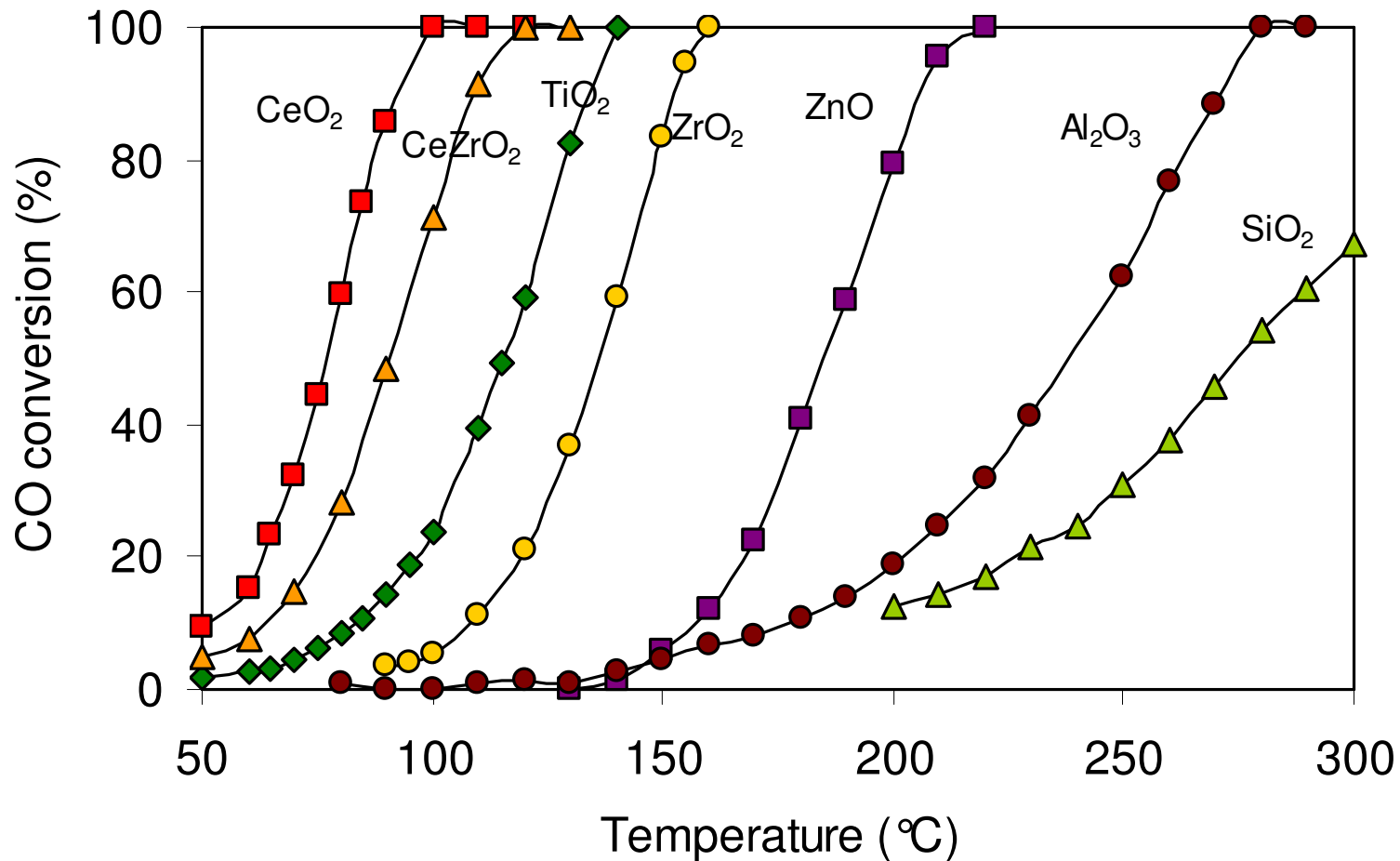
H₂ stream from WGS contains a small amount of CO (2-0.5%)
 Poisonous to the Pt electrode in PEM fuel cells



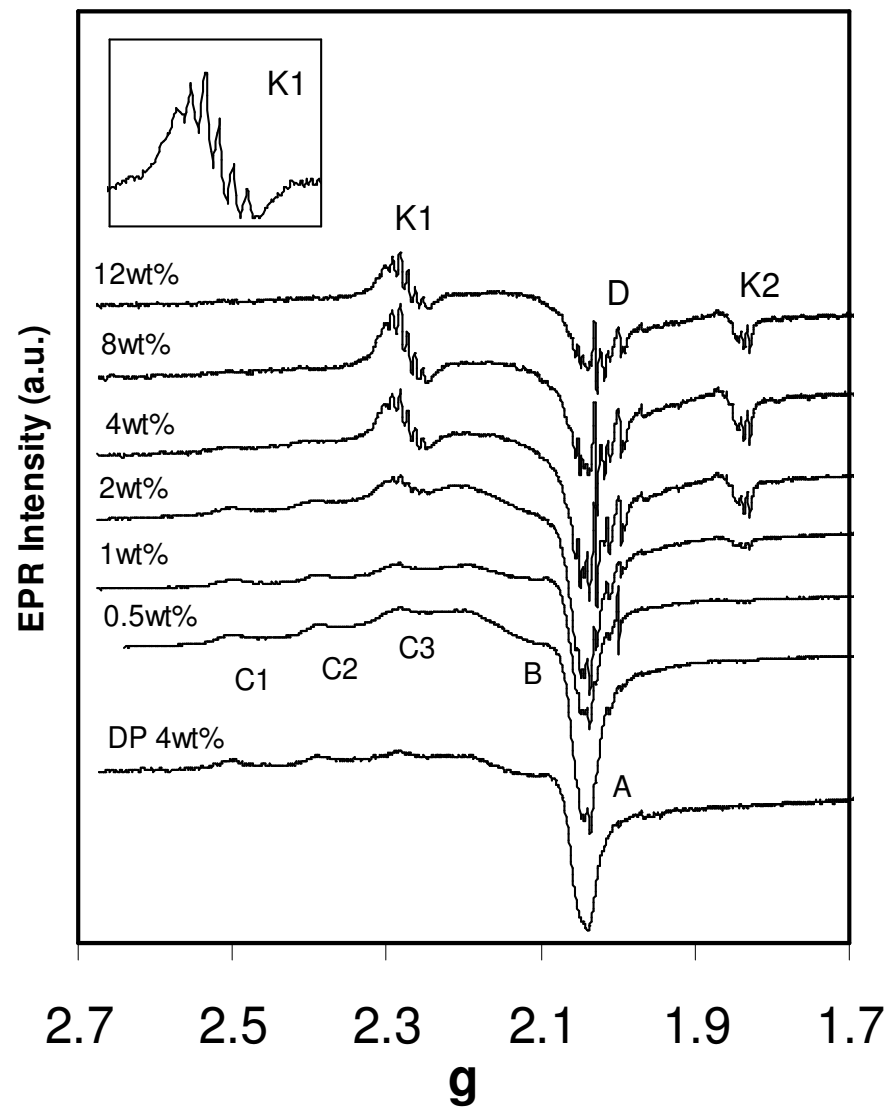
Metal	Criteria	Pt/TiO ₂	Au/CeO ₂	Cu/CeO ₂
Activity	$< 80^\circ \text{C}$	✓	✓	✓
Selectivity	CO only, no H ₂	✗	✗	✓
Stability	1000 h	✓	✗	✓
Price	Minimal	✗	✗	✓

Low temperature CO oxidation

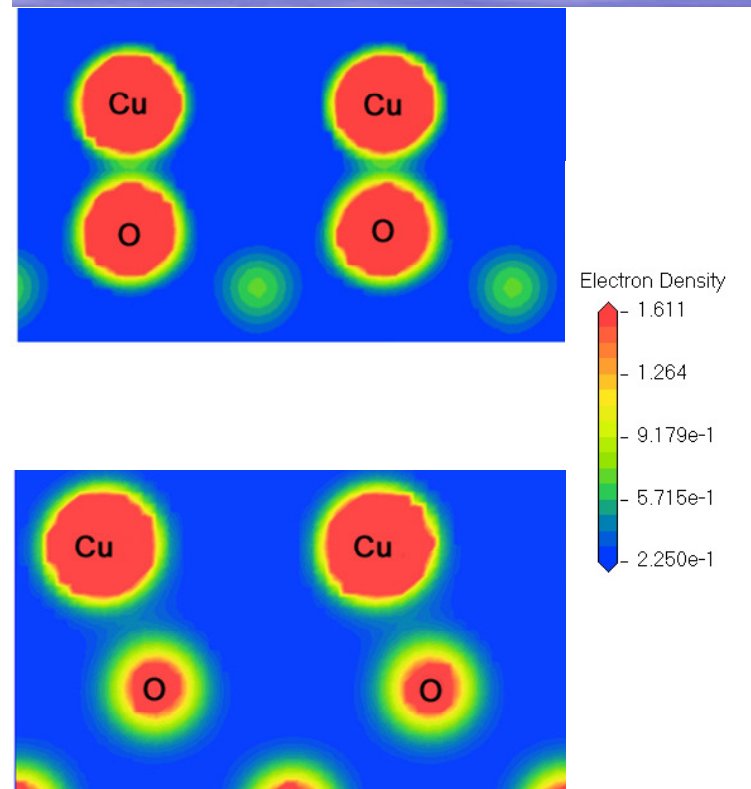
4% Cu on CeO₂ is the most active CO-PROX catalysts compared to other metal oxide supports



Morphology of Cu on CeO₂



Cu monomer



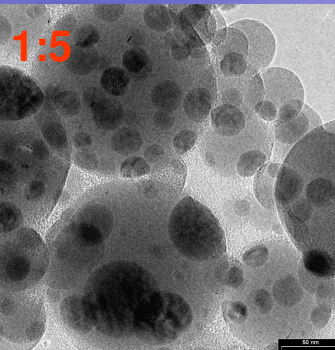
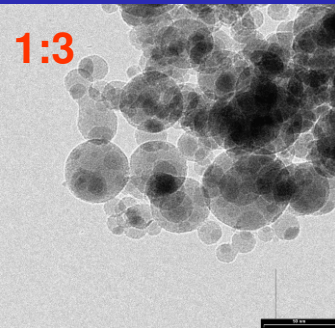
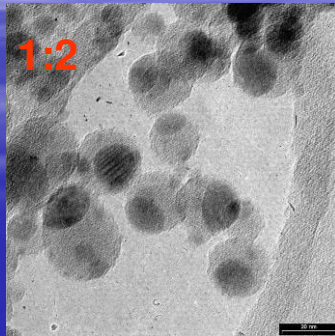
Cu dimer

Magnetic Nanoparticles

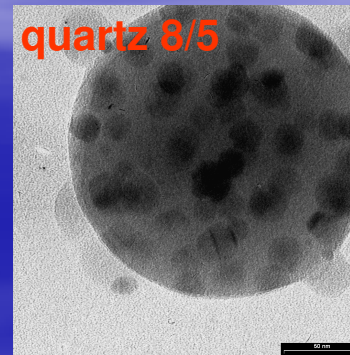
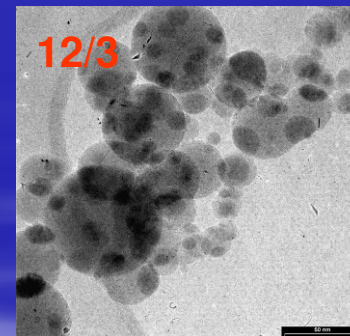
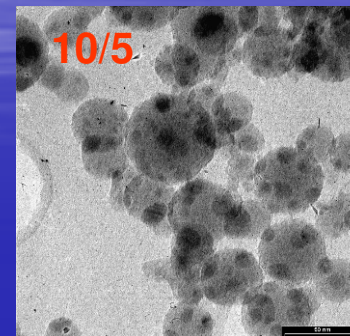
Silica coated $\gamma\text{-Fe}_2\text{O}_3$

$\gamma\text{-Fe}_2\text{O}_3$

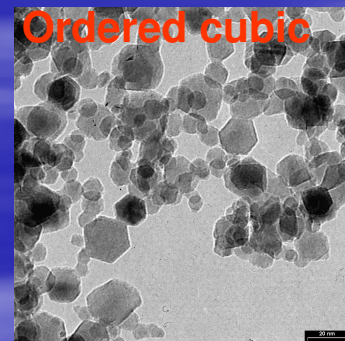
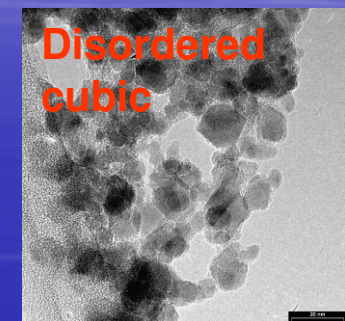
Increasing Fe:Si ratio



Increasing size

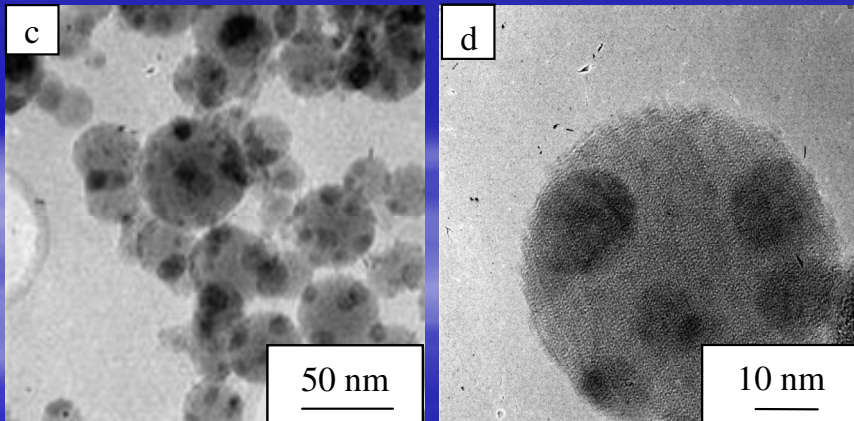
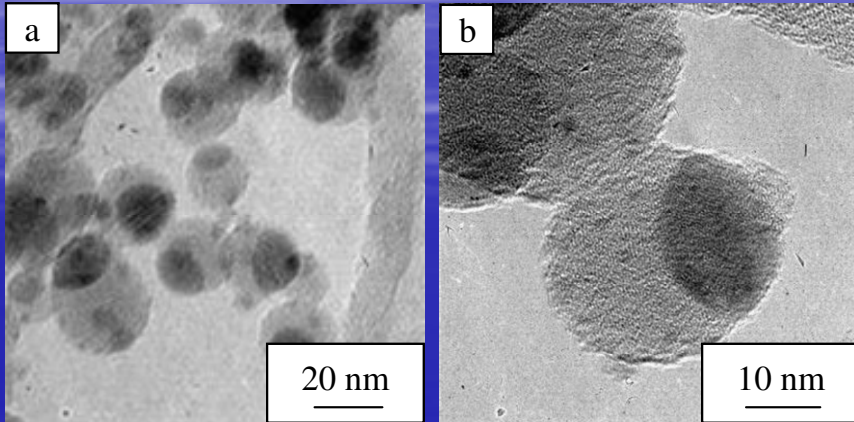


Increasing crystallinity

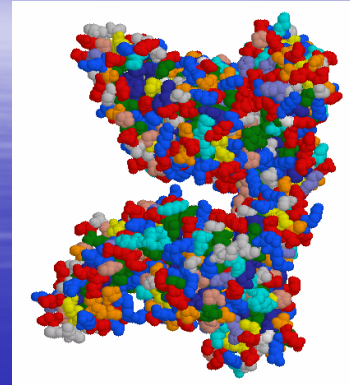


Magnetic protein bioseparation

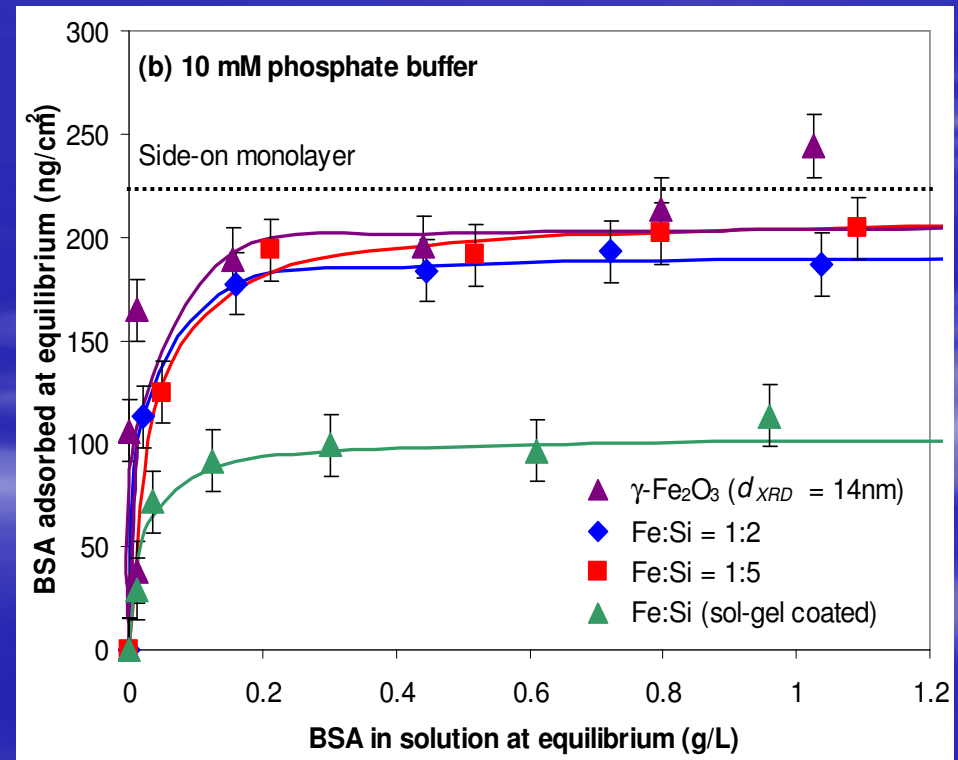
Fe:Si 1:2



Fe:Si 1:5



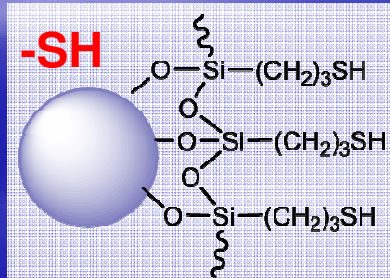
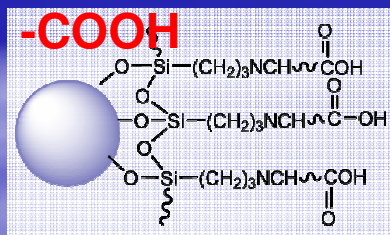
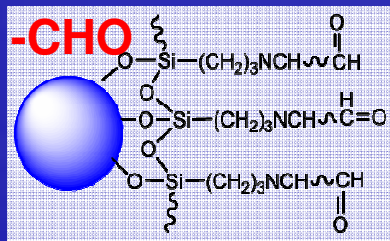
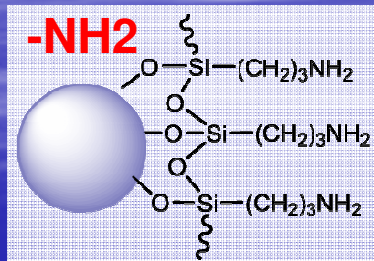
Bovine Serum Albumin (BSA)



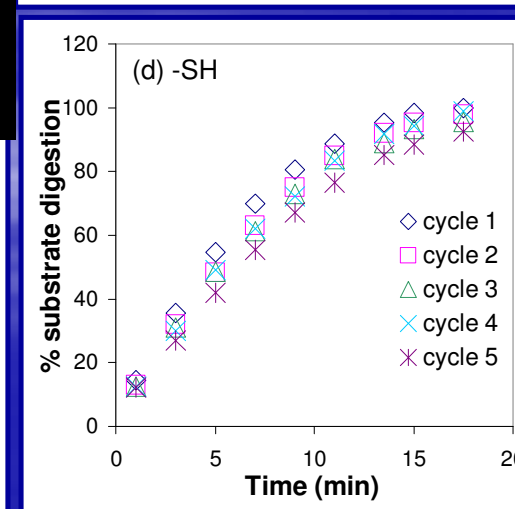
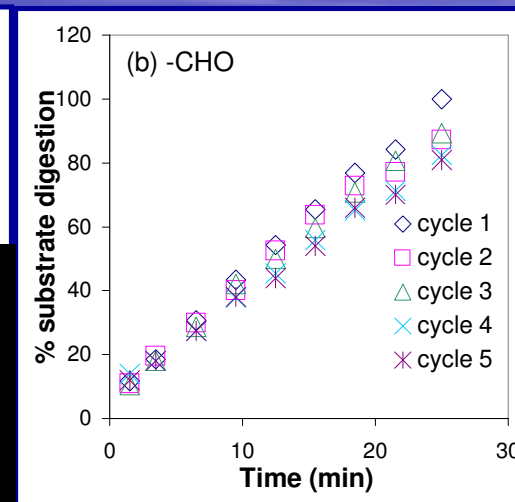
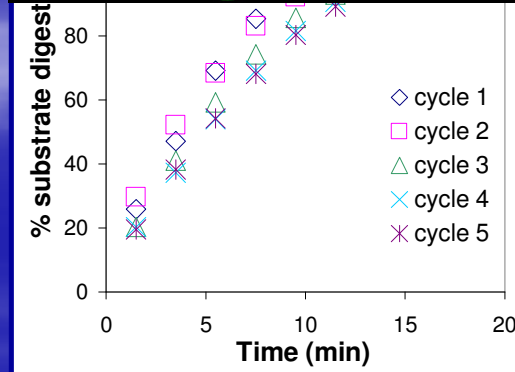
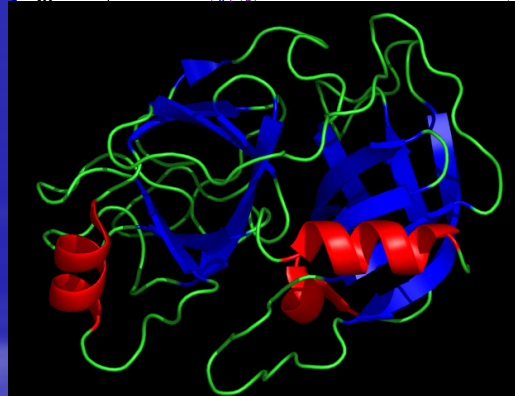
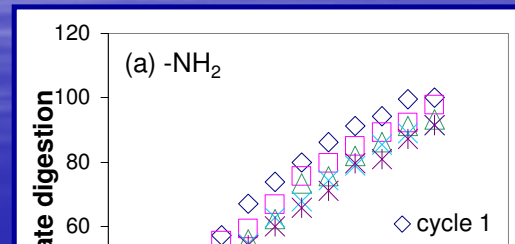
Immobilisation of enzyme

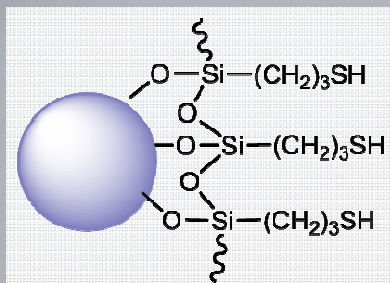
Surface chemical functionalisation of magnetic particles

Trypsin as model enzyme for protein digestion and mapping



+



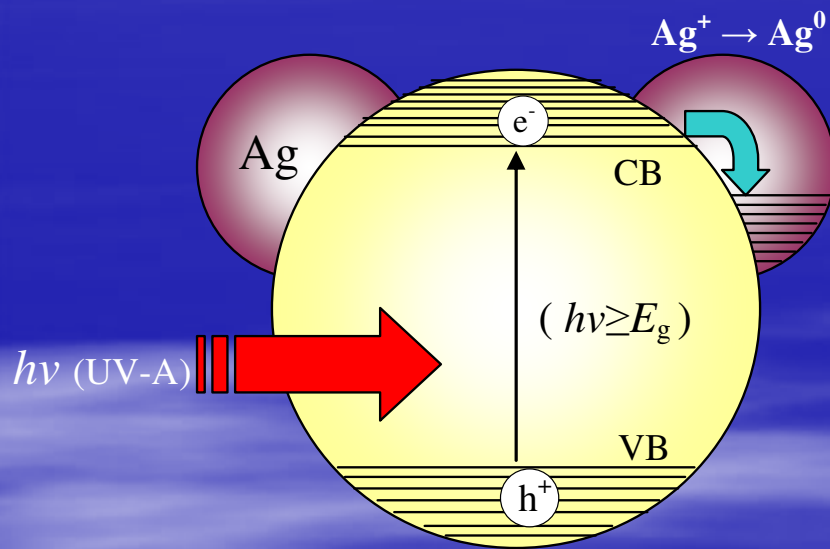


-SH functionalised iron oxide NPs

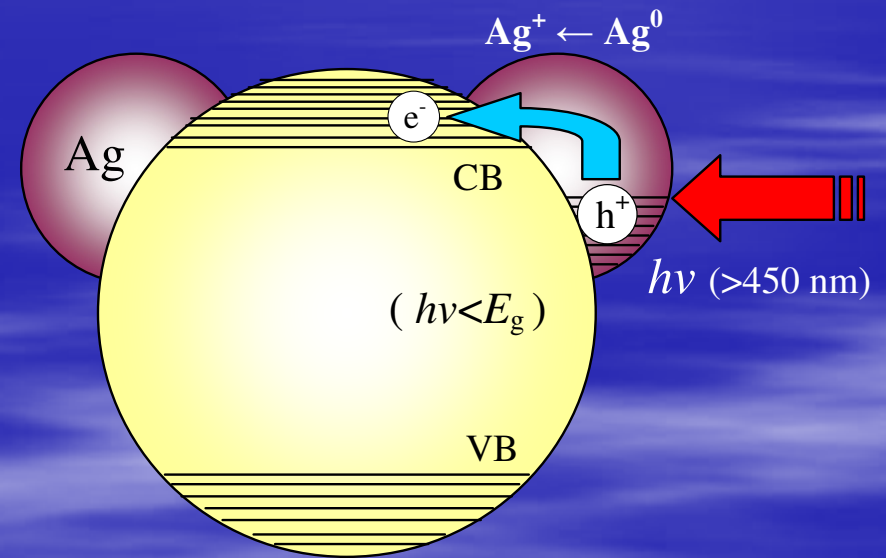


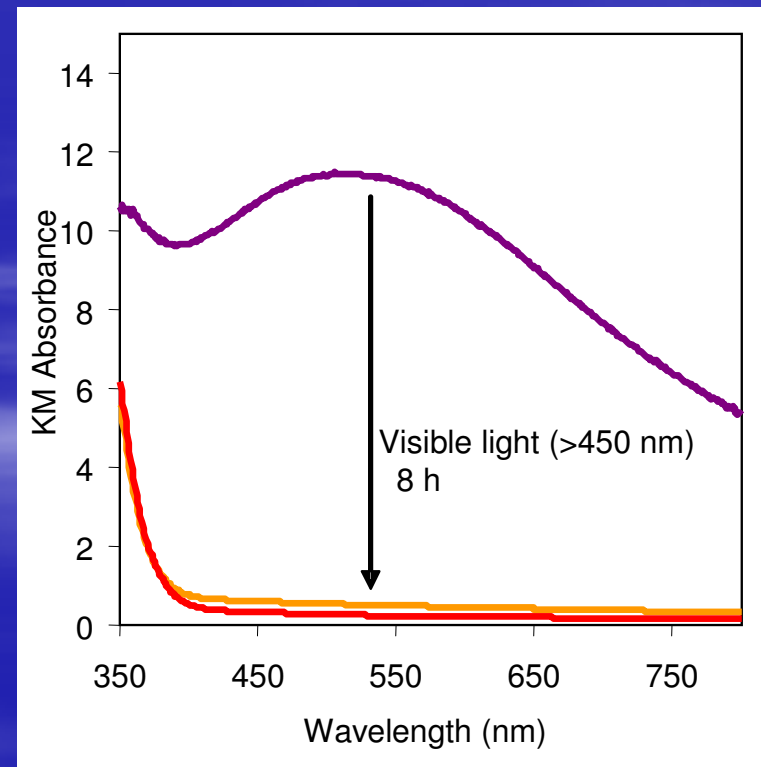
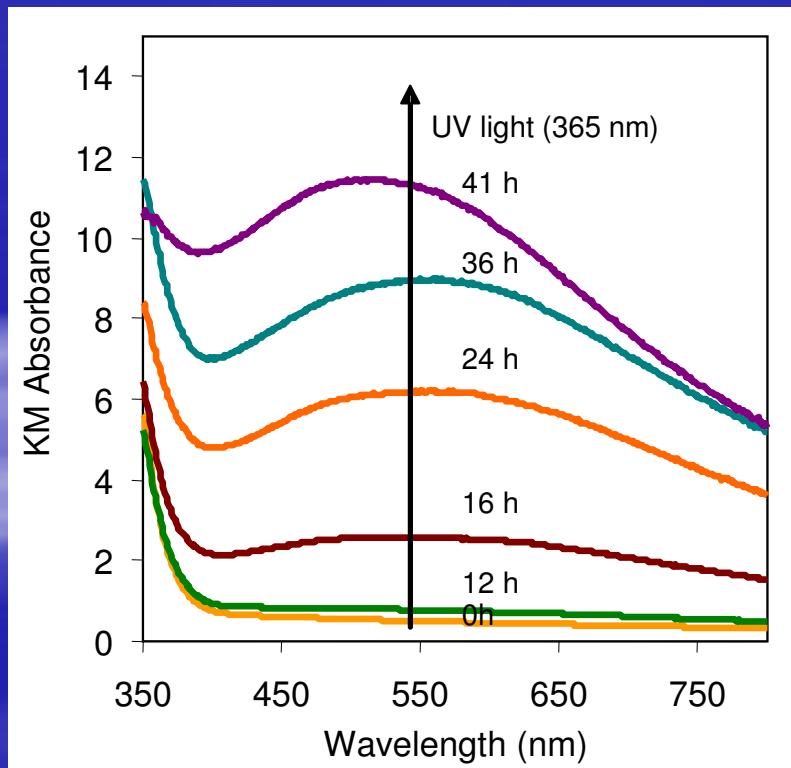
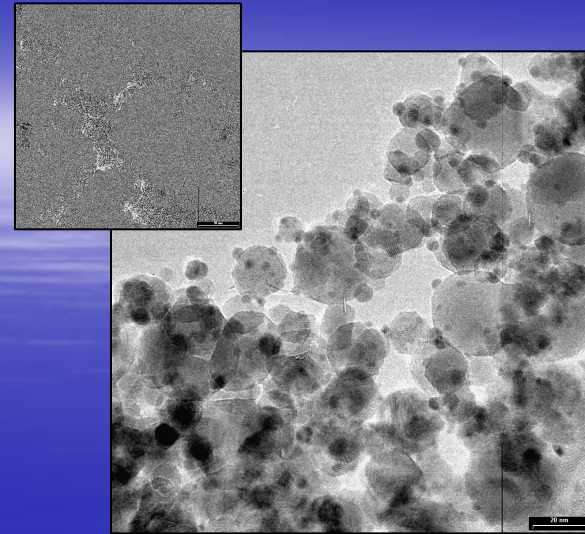
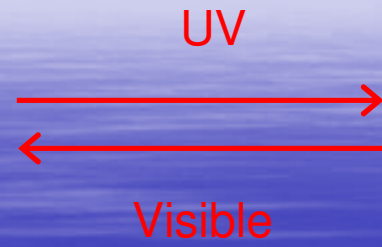
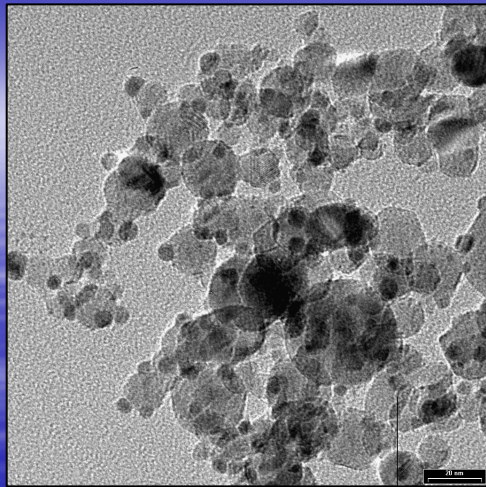
Antimicrobial photoswitching

Under UV illumination

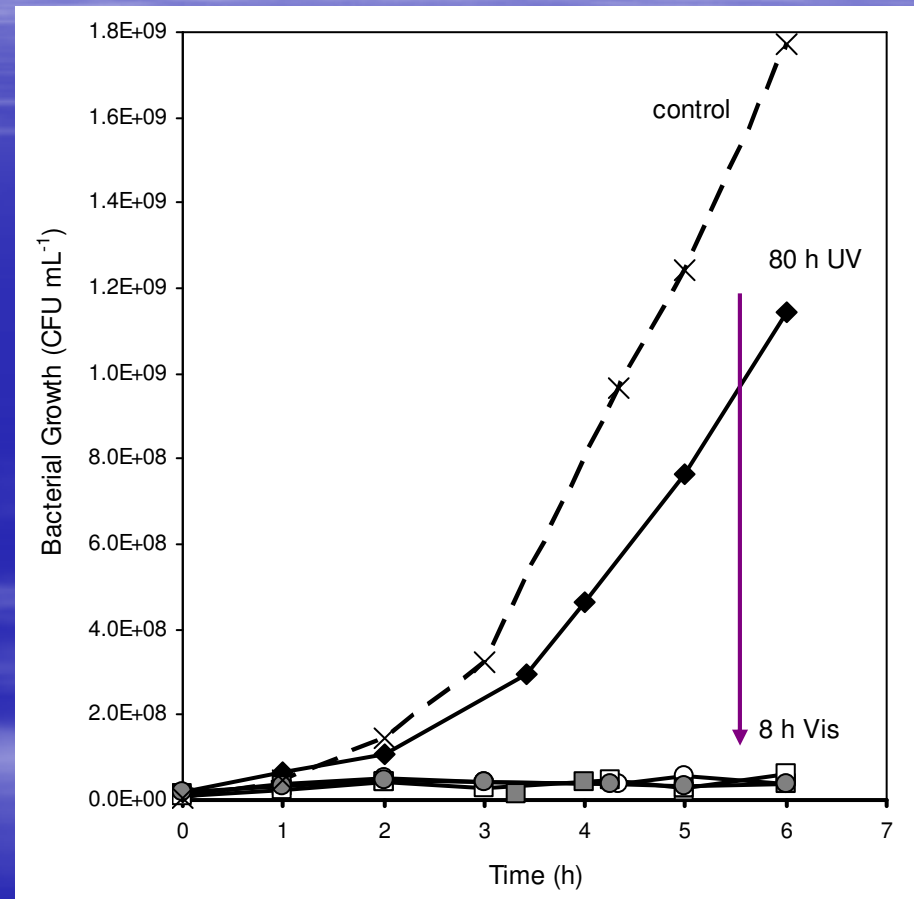
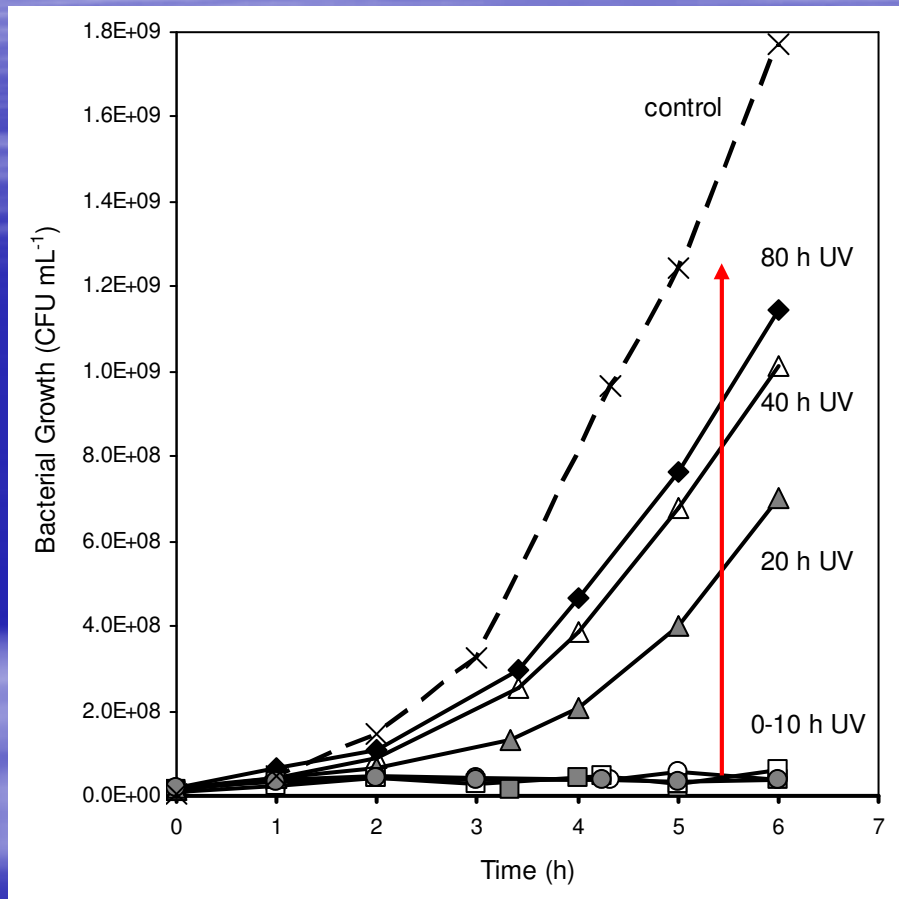


Under visible illumination



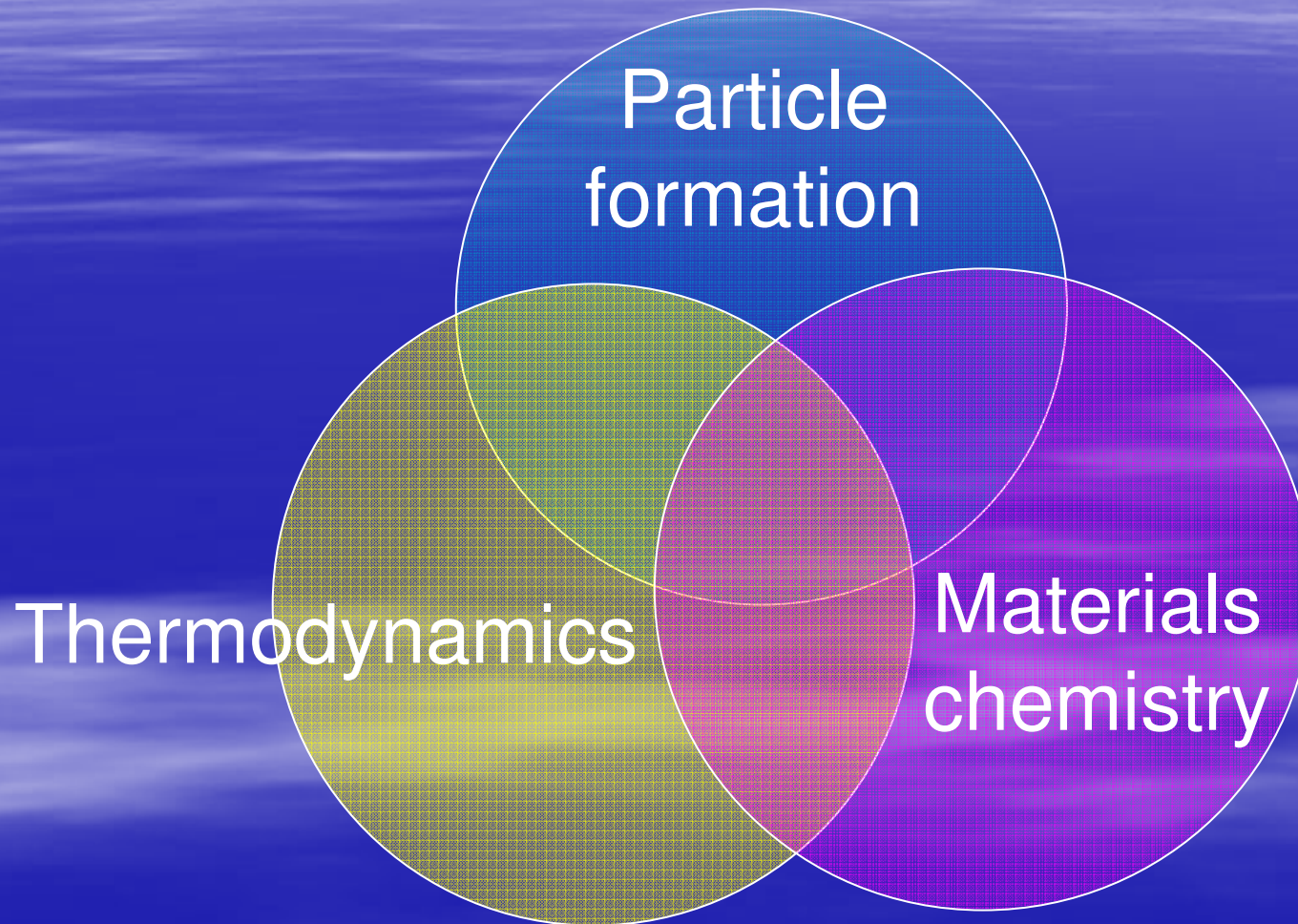


Antimicrobial photoswitching



Wild type E-coli strain HB101, LB broth

Conclusion



THANK YOU

5 nm

