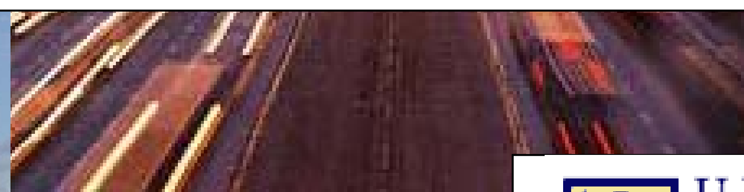
Current Energy Research at Notre Dame

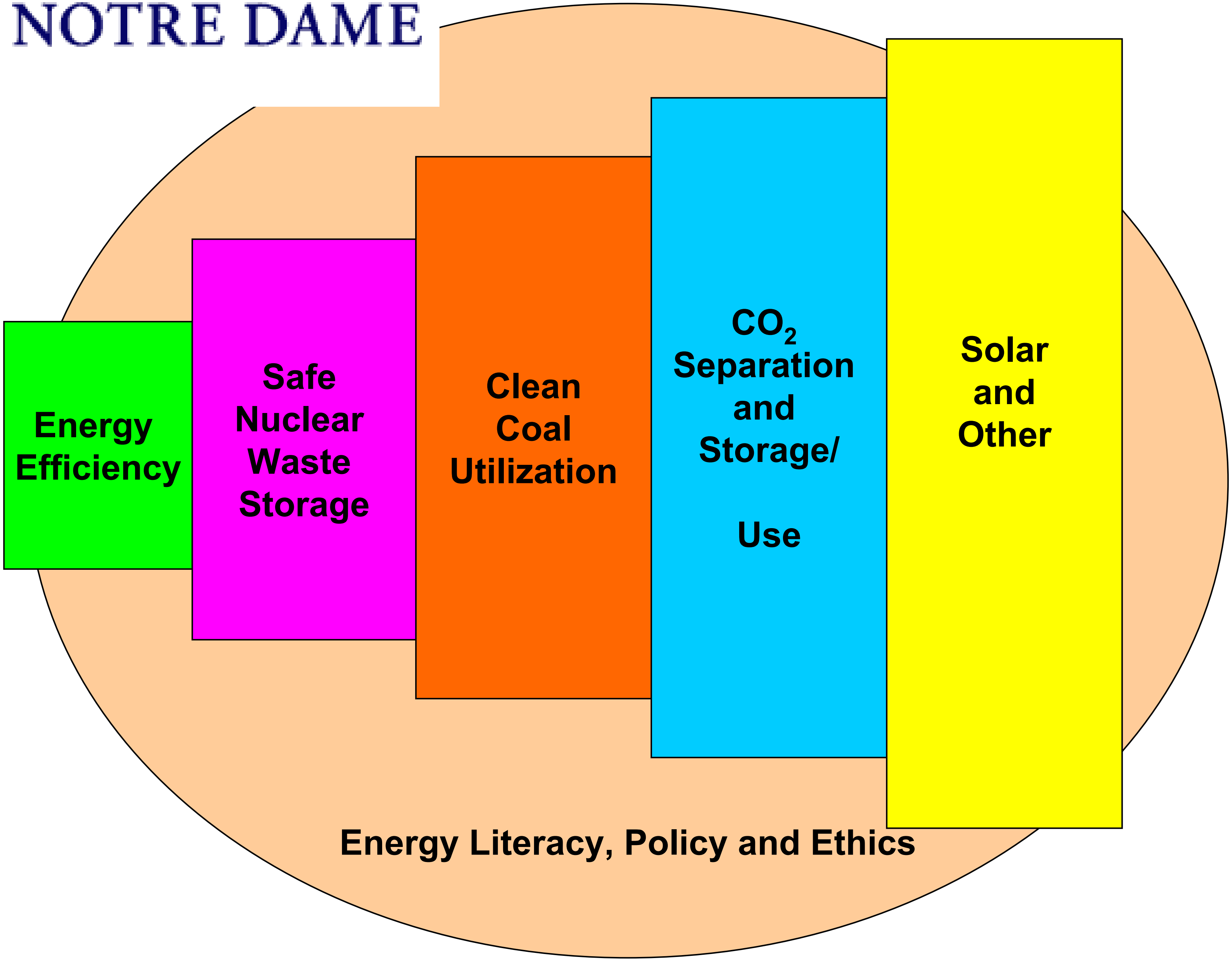
Joan F. Brennecke
Dept. of Chemical and Biomolecular Engineering
Director, Notre Dame Energy Center

Alternative Energy Research Conference
Sept. 28, 2005

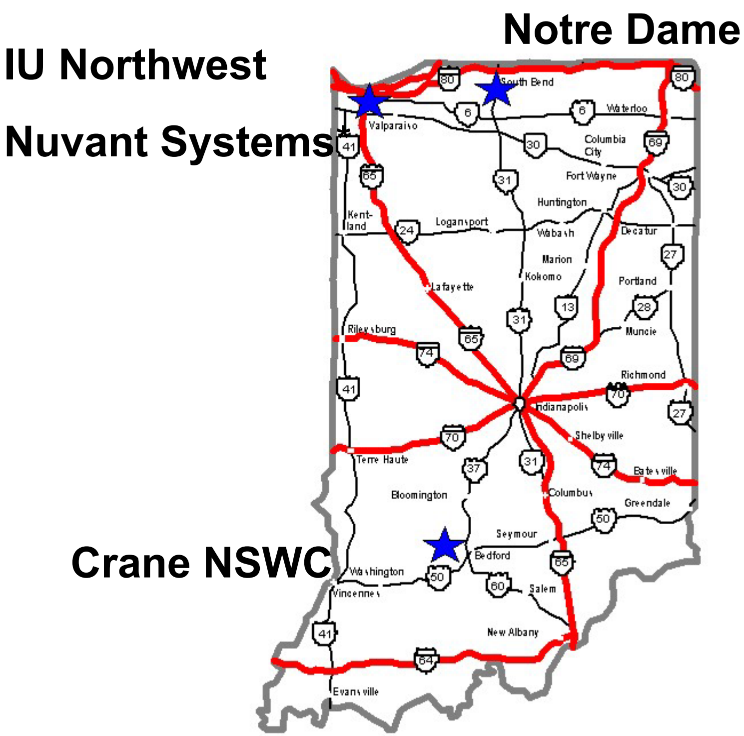


UNIVERSITY OF NOTRE DAME

ENERGY CENTER


Energy Efficiency
Safe Nuclear Waste Storage
Clean Coal Utilization
CO_2 Separation and Storage/ Use
Solar and Other
Energy Literacy, Policy and Ethics

Center for Advanced Fuel Cell Technology

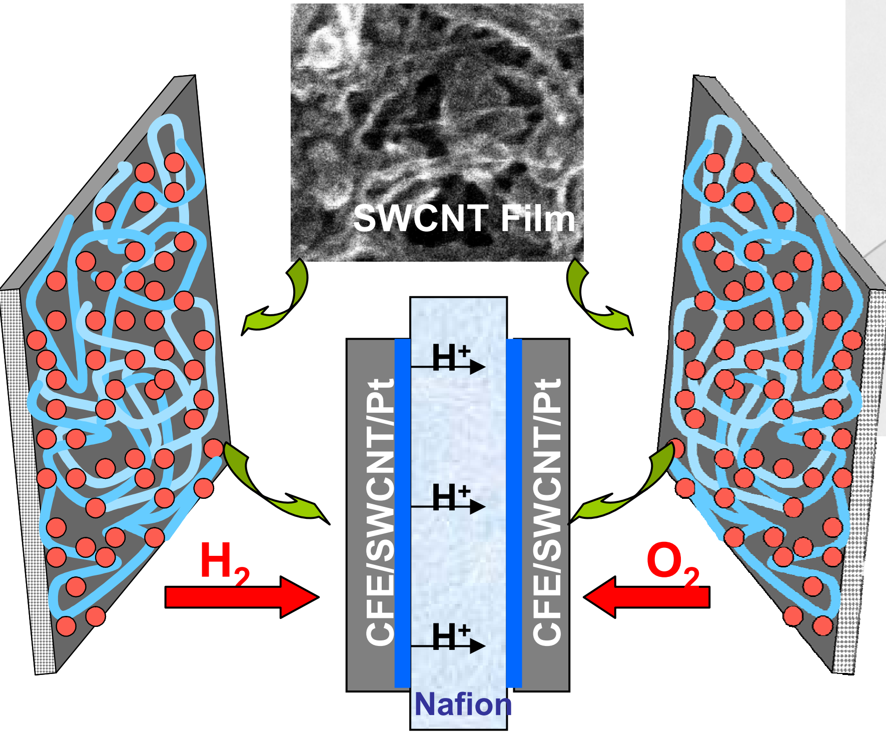


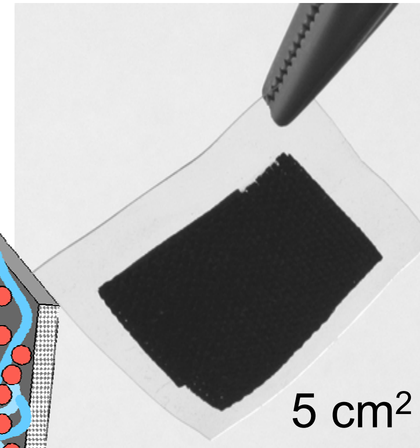
A collaboration of researchers from 4 Indiana institutions, built on Federal and State support

$4M – Federal, $1.8M State
Focus on portable fuel cells for military & consumer applications (DMFC and PEM)

- **Microfluidics**
- **Novel electrodes (nanotubes)**
- **Non-noble catalysts (combinatorial)**
- **Non-noble reforming catalysts**
- **Modeling**

* Nuvant attracted from IL, now in PTC in Merrillville





Nanotube electrode structure with improved power properties

•Now testing novel nanotube paper

Combinatorial catalyst testing with Nuvant array fuel cell

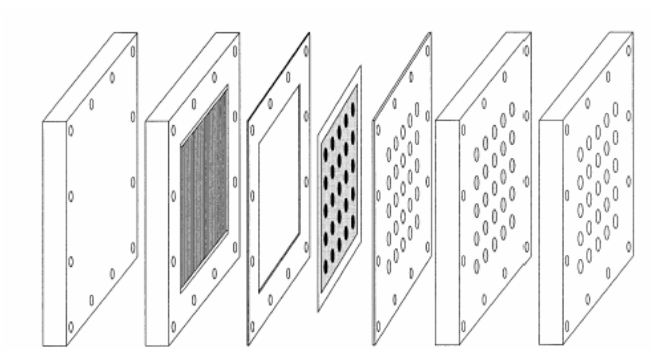


Fig. 5. Schematic of exploded high throughput device.

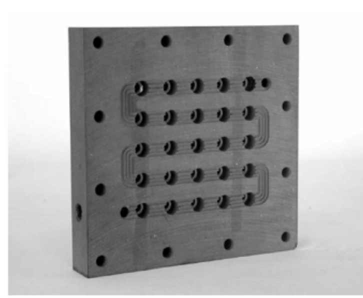
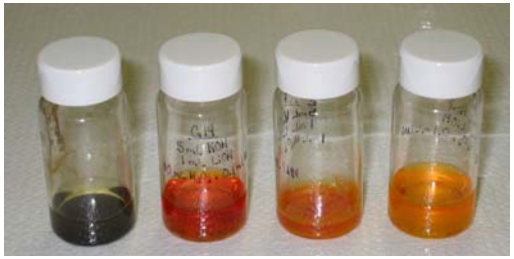
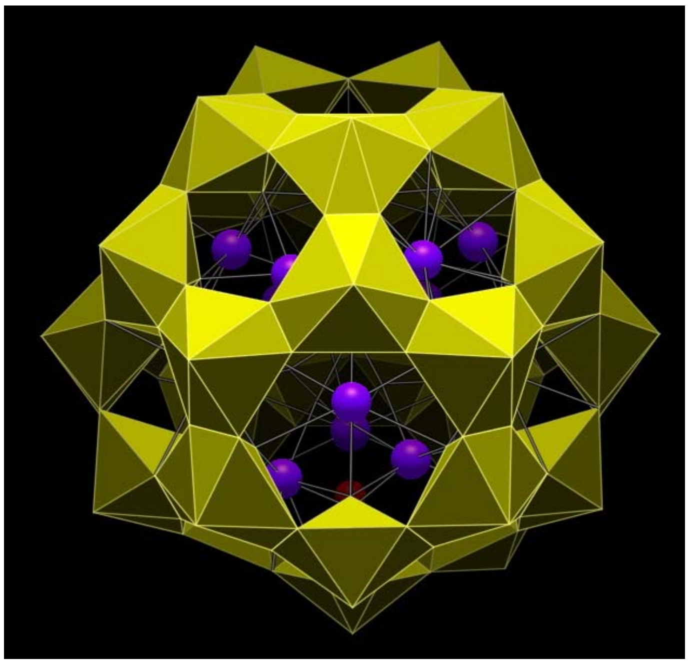


Fig. 3. Ceramic sensor electrode array flow fields.

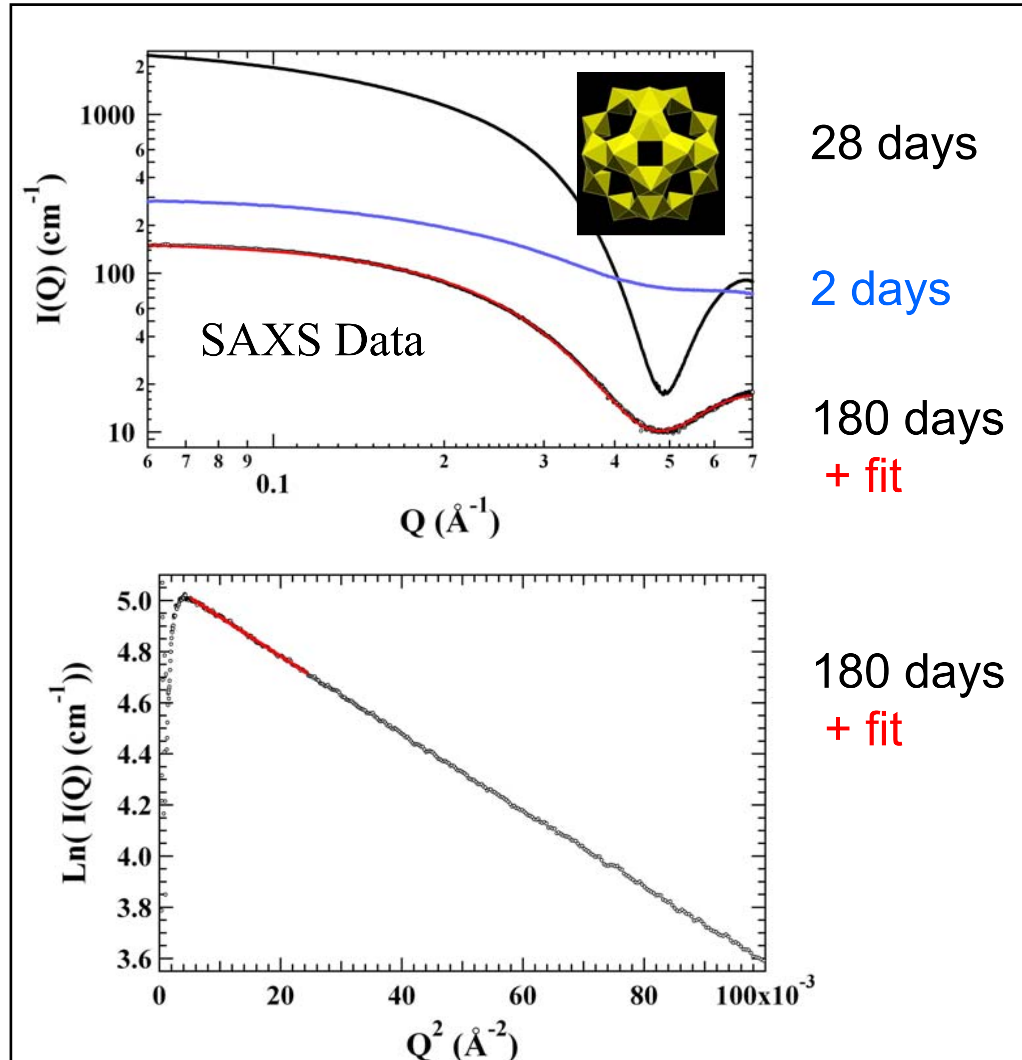
- Profs. McGinn, Moukasian, Kamat, Chang, McCready
- Also microbial fuel cells (Nerenberg)

Nano-aggregates Impact Actinide Transport





$K_{16}(H_2O)_2(UO_2)(O_2)_2(H_2O)_2[(UO_2)(O_2)_{1.5}]_{28}^{-14}$



Mother solutions of U-24 nanospheres

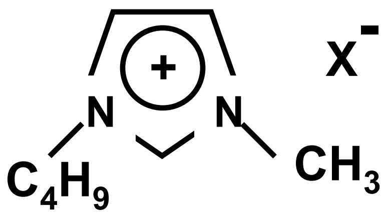
Funding: **~$7MM** DOE, NSF EMSI, PNNL, NATO

Burns et al. (2005) Angew. Chem. Int. Ed. 44: 2135-2139.

Ionic Liquids for Flue Gas and Coal Gasification Separations

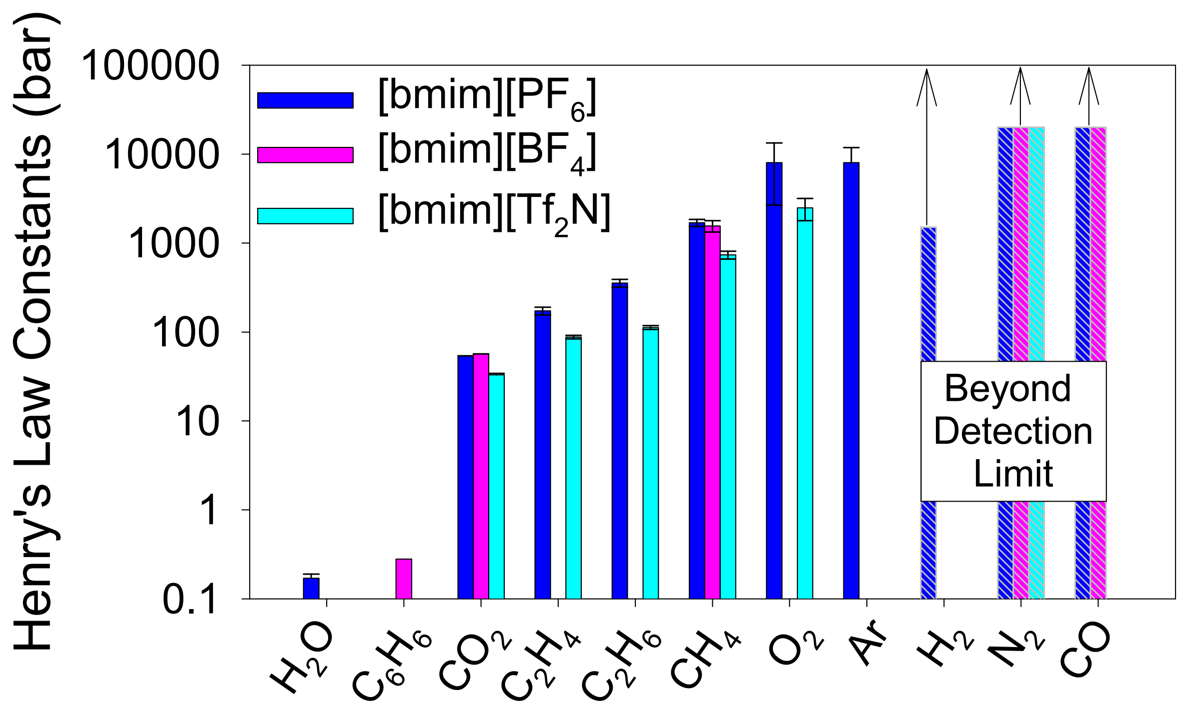
- Organic salts that are liquid at temperatures around ambient
- Liquid over a wide range of temperatures; hence, can be used as solvents
- Demonstrated successes as reaction solvents (olefin dimerization, metathesis, isomerizations, Diels-Alder, Friedel-Crafts alkylations and acylations, hydrogenations, C-C coupling)
- Ionic liquids have vanishingly low vapor pressures
  - fugitive emissions not a problem
  - worker exposure less likely
  - flammability danger decreased
- Developing for use in gas separations (Brennecke and Maginn, US-6579343)

Ionic Liquids for Flue Gas and Coal Gasification Separations



[bmim][X]

X = PF_6
BF_4
$[(CF_3SO_2)_2N]$



- -Separation of CO_2 from flue gas
- -Clean up of syngas from coal gasification
- -Olefin/paraffin separations, air separation
- -More energy efficient processes

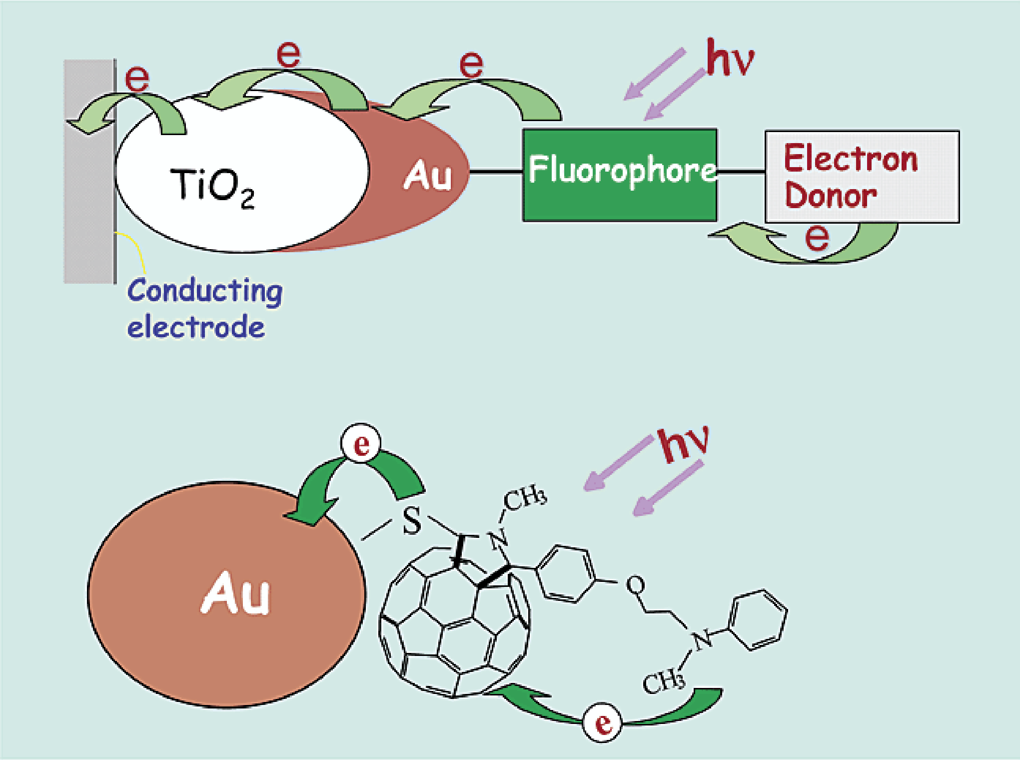
Funding: **~$3.6MM** federal, DOE, NOAA, DoEd
$1.4 MM state

Profs. Brennecke, Maginn, Stadtherr, Sen, Paolucci, Lamberti, Kulpa

Light Energy Conversion

Goal:
-To design heterogeneous assemblies for harvesting light energy
- To improve photoinduced charge separation by binding to metal nanostructures/composites for improved efficiency

Results:
-Elucidated interfacial charge transfer processes
-Introduced composite semiconductor systems for improved performance of dye sensitized solar cells
- Shifted the apparent Fermi level (important to improving energetics) by depositing 2-3 nm Au nanoparticles on TiO_2 nanostructures.
- Achieved a photoconversion efficiency (IPCE) of 60% (power conversion effeciency of 2%) using Au-Porphyrin_C60 based molecular clusters.



Kamat et al., 2004; Funding: DOE

Examples of Current Energy Research at Notre Dame

- Energy Efficiency
  - Methanol and hydrogen fuel cells
- Nuclear Energy
  - Safe nuclear waste storage
- Coal Utilization
  - Gas separations for coal gasification using Ionic Liquids
- CO_2 Capture and Sequestration
  - ILs for CO_2 capture from flue gas
- Solar Photochemistry
  - Composition light harvesting assemblies

Contact Information:

Joan F. Brennecke
Keating-Crawford Professor
Department of Chemical and Biomolecular Engineering
Director, Notre Dame Energy Center
University of Notre Dame
Notre Dame, IN 46556
(574) 631-5847
FAX (574) 631-8366
Email: jfb@nd.edu