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# Catalysis Club of Philadelphia

Thursday November 18<sup>th</sup>, 2010

Holiday Inn Select Hotel  
Naamans Road and I-95, Claymont, DE

## Self-Moving Catalytic Nanomotors

Prof. Ayusman Sen

Pennsylvania State University

&

## Structure Property Relationships of Supported

## Pt/3d Bimetallic Catalysts

William W. Lonergan

University of Delaware  
(Student Talk, 15 minutes)

**Social Hour: 5:30 PM**

**Dinner: 6:30 PM**

**Meeting: 7:30 PM**

**Members: \$35**

**Walk Ins & Non-members: \$40**

**Student & Retired Members: \$20**

### **Menu**

**Chicken Forrestiere**- Wild  
Mushroom Cognac Sauce

**Grilled London Broil**- Served with  
Sauce Robert

**Vegan**- Pasta Primavera

**Meal reservations** - Please notify  
your company representative or  
Kevin Bakhtmutsky  
(kbakh@seas.upenn.edu, phone:  
215.898.0056, fax: 215.573.2093)  
by **Thursday November 11<sup>th</sup>**.

Company Representatives – We  
would like to encourage you to  
make meal/meeting reservations  
to your company representative.

**Membership** - Dues for the 2009-  
10 season will be \$10.00 (\$5.00  
for the local chapter and \$5.00  
for the national club). Dues for  
students and post-docs will be  
\$6.00 (\$5.00 for local club and  
\$1.00 for national club). Please  
send your payment to Steve  
Harris, LyondellBasell Industries  
3801 West Chester Pike,  
Newtown Square, PA 19073.

# Catalysis Club of Philadelphia

Thursday November 18<sup>th</sup>, 2010

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## Self-Moving Catalytic Nanomotors

Prof. Ayusman Sen

Department of Chemistry, Pennsylvania State University

### Abstract

Self-powered nano and microscale moving systems are currently the subject of intense interest due in part to their potential applications in nanomachinery, nanoscale assembly, robotics, tribology, fluidics, and chemical/biochemical sensing. We will demonstrate that one can build nanomotors “from scratch” that mimic biological motors by using catalytic reactions to create forces based on chemical gradients. These motors are autonomous in that they do not require external electric, magnetic, or optical fields as energy sources. Instead, the input energy is supplied locally and chemically. By appropriate design, the chemical gradients can be translated into anisotropic body and/or surface forces. Depending on the shape of the object and the placement of the catalyst, different kinds of motion can be achieved. The resulting nanomotors can be tethered or coupled to other objects to act as the “engines” of nanoscale assemblies. It is also possible to control the movement of nanomotors by: (a) chemotaxis, (b) phototaxis, and (c) magnetic steering. Finally, an object that moves by generating a continuous surface force in a fluid can, in principle, be used to pump the fluid by the same catalytic mechanism. Thus, by immobilizing these nanomotors, we have developed micro/nanofluidic pumps that transduce energy catalytically.

### Speakers Bio:



**Ayusman Sen** was born in Calcutta, India and holds a Ph. D. from the University of Chicago where he was first introduced to catalysis. Following a year of postdoctoral work at the California Institute of Technology, he joined the Chemistry Department of the Pennsylvania State University where is currently Distinguished Professor. He is a Fellow of the American Association for the Advancement of Science. His research interests encompass catalysis, organometallic and polymer chemistry, and nanotechnology. He is the author of approximately 290 scientific publications and holds 23 patents. His pastime centers on gastronomical explorations.

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## Structure Property Relationships of Supported Pt/3d Bimetallic Catalysts

William. W. Lonergan, Dionisios. G. Vlachos, Jingguang. G. Chen

Department of Chemical Engineering, University of Delaware

(Student Talk, 15 minutes)

### Abstract:

Bimetallic catalysts are of great interest because they often display properties that differ from either of their parent metals. Previous studies on the Ni/Pt(111) bimetallic system have shown that the location of Ni atoms in the Pt(111) surface has a strong influence on the electronic and chemical properties of the surface [1]. The bimetallic surface consisting of a monolayer of Ni on top of bulk Pt(111), designated Ni–Pt–Pt(111), binds hydrogen and alkenes much more strongly than either parent metal, resulting in decreased hydrogenation activity. In contrast the surface consisting of a monolayer of Ni atoms in the subsurface region designated as Pt–Ni–Pt(111), has been shown to weaken metal-hydrogen bonds in comparison to Ni–Pt–Pt(111) or either parent metal surface. The resulting abundance of weakly bound hydrogen and alkenes on the Pt–Ni–Pt(111) surface increases its activity for novel low temperature hydrogenation pathways [2, 3].

The objective of current study is to extend previous investigations of Pt/Ni on single crystal surfaces to supported catalysts in an attempt to bridge the materials gap. Both monometallic and bimetallic catalysts were synthesized on  $\gamma$ -Al<sub>2</sub>O<sub>3</sub> via incipient wetness. Two series of bimetallic catalysts were synthesized in order to study the effects of Pt:Ni metal atomic ratio and impregnation sequence. Benzene and 1,3-butadiene hydrogenations were used as probe reactions and it was found that for both hydrogenations the bimetallic catalysts were more active than either monometallic catalyst. Fourier transform infrared (FTIR) spectroscopy was used to characterize CO chemisorption, which showed that the bimetallic catalysts bound CO in a different manner than either monometallic catalyst. The results of both the hydrogenation and chemisorption experiments suggested that there was a bimetallic effect, which justified further physical characterization using extended X-ray absorption fine structure (EXAFS) and transmission electron microscopy (TEM). EXAFS of the Pt L<sub>III</sub> edge confirmed the presence of bimetallic Pt-Ni interactions, and the magnitude of these interactions was found to correlate with the observed trends in hydrogenation activities for the two series of bimetallic

catalysts. TEM imaging was performed in high angle annular dark field (HAADF) mode, and the resulting images showed a majority of particles with diameters on the order of 1 to 2 nm. In addition, several Pt/3d bimetallic catalysts (Pt/Co, Pt/Ni, and Pt/Cu) were synthesized, characterized, and tested for hydrogenation activity. The hydrogenation activity was observed to correlate well with hydrogen and 1,3-butadiene binding energies calculated from theory.

- [1] Kitchin, J.R., Khan, N.A., Barteau, M.A., Chen, J.G., Yakshinskiy, B., and Madey, T.E., *Surf. Sci.* 544, 295 (2003).
- [2] Hwu, H.H., Eng, J., and Chen, J.G., *J. Am. Chem. Soc.* 124, 702 (2002).
- [3] Chen, J.G., Menning, C.A., and Zellner, M.B., *Surf. Sci. Rep.* (2008).

**Speaker Bio:**

William received his B.S. in Chemical Engineering from the University of Virginia in 2006, and joined the Department of Chemical Engineering at UD the following fall. He is co-advised by Dr. Dion Vlachos and Dr. Jingguang Chen, and his research focuses on the synthesis and characterization of supported bimetallic catalysts. William is currently a 5<sup>th</sup> year student and after graduating he plans on pursuing an industrial position in the fields of catalysis and reaction engineering.

