Workshop on

Passive Photocatalytic Oxidation of Air Pollution

Friday, June 29, 2007
9 am - 5 pm

Perseverance Hall
Lawrence Berkeley National Laboratory
Berkeley, California · USA

Abstract

This workshop is intended to provide a roadmap for the development of a program using titanium dioxide nanoparticles to reduce air pollution in California cities. We focus on *passive* Photo-Catalytic Oxidation (PCO) strategies in which the catalytic particles are supported by building materials and irradiated by sunlight. We will review current technical knowledge and identify problems that must be solved with applied research in order to enable eventual deployment of the technology.

Background

Small particles of titanium dioxide act to catalyze oxidation of adsorbed molecules in the presence of above-bandgap ultraviolet (UV) light. Research is underway to characterize the rates and reaction pathways for various volatile organic compounds (VOCs, such as benzene, toluene, terpenes, etc.) that can produce toxic ozone when irradiated in the presence of NO_x. Oxides of nitrogen and sulfur can also be removed. Research is also identifying improved catalysts, mostly variants of anatase TiO_2 particles. The size of the ongoing research effort is indicated by a literature search, using the terms photocatalysis and TiO_2, which identifies 3,000 publications in the past ten years.

The Heat Island Group (of the Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory) has been investigating and assisting with the commercialization of novel infrared-reflecting cool roofing materials for the past decade. We have recently contracted with the California Energy Commission to examine the feasibility of novel roofing and other construction materials that may clean the ambient air.

At the workshop, speakers will summarize the current state of the art. Then, discussion will focus on the identification of the most important problems that need to be addressed before the technology can be deployed. Below is a preliminary list of key issues identified so far.

Who should attend?

- Scientists with information on the efficacy of passive PCO
- Representatives of companies manufacturing or deploying catalysts
- Representatives of public agencies with an interest in abating air pollution such as the California Energy Commission, USEPA, USDOE, California Air Resources Board, Air Pollution Control Districts, etc.

If you wish to speak at the workshop, please make advance arrangements with Paul Berdahl or Hashem Akbari. Additionally, Maya Minamihara can accept registrations and arrange for site access.

Workshop Contacts:

Paul Berdahl, +1-510-486-5278, PHBerdahl@LBL.gov
Hashem Akbari, +1-510-486-4287, H_Akbari@LBL.gov
Administrative contact Maya Minamihara, +1-510-486-6845, +1-510-486-6996 (fax), MMinamihara@LBL.gov

Further workshop details will be posted to http://coolcolors.LBL.gov/pco-workshop .

Questions for future applied research on passive PCO

We take as given that continuing basic research will seek improved catalytic materials such as doped TiO_2 and mixtures of catalytic oxides with metals. Nanoparticle anatase TiO_2, however, provides a baseline material for applications. So the most pressing issue is: Can passive PCO deployment provide significantly cleaner air at an acceptable cost?

(1) *Material Options*. What are the most attractive options for deployment? These may include cement concrete walls, roads, polymeric coatings, window coatings, etc.

(2) *Material design*. As an additive to cement at the 1 – 10 % level, anatase works as a photocatalyst. However, can the catalytic particles be integrated into a porous surface layer and thereby improve performance? How should the nanoparticles be supported? A related issue is optimizing the use of the available UV flux.

(3) *NO_x reaction rates*. Removal of NO_x may be the most important asset of passive PCO. Its reaction produces reactive nitric acid, and in the presence of calcium ions, water soluble calcium nitrate. What are the reaction rates currently achievable, and what are the theoretical limits of performance? [One estimate (C. M. Yu) is that a 1 m^2 area can remove 0.1 g of NO_x during a 12-hour day.]

(4) *Overall effects of passive PCO deployment*. What are the current pollutant levels in cities and how can widespread PCO alter the concentrations and species? Reaction rates

depend on UV flux, reactant levels, temperature, and humidity. The recent European PICADA program demonstrated a favorable impact on NO_x and some VOCs in outdoor experiments. Also, the relationship between laboratory experiments and corresponding outdoor experiments was investigated, with some limited success. However, other work shows that partial oxidation of some VOCs leads to toxic products such as formaldehyde. Is this a show-stopper?

(5) *Durability*. The practical utility of passive PCO requires demonstrations that catalyst deactivation is a minor issue or one that can be managed.

(6) *Cost.* Technology for source control of NO_x costs roughly $2,000 to $10,000 per metric ton. How cost effective is passive PCO?

(7) *Other items as suggested by Workshop participants*.