SINGAPORE GOING FOR GREEN PRODUCTS USING PHOTO-CATALYTIC TECHNOLOGIES

-Highlights of the SIMTech/SPRING Joint Seminar-

Executive Summary:

A half-day SIMTech/SPRING joint seminar is held on 08 January 2010 to discuss about the latest development of nano-TiO2 based photo-catalytic technology. 6 invited speakers as well as panel members came to this seminar to share their insights on the new discoveries, commercialization activities, and international standardization developments. Dr Loh Wah Sing, Convenor of this joint seminar gave an introduction to the photo-catalytic technology and educated the participants with the existing international & national standards for photo-catalysis as well as Singapore's involvement in the ISO activities for TiO2 based photo-catalytic products.

Another Singapore A*STAR research institute Singapore Institute of Manufacturing Technology (SIMTech) kicked off the new year by promoting photo-catalytic technology and commercialization and organized in partnership with the Singapore national standards and accreditation body, SPRING, a seminar on Jan.08, 2010 on Green Products from Photocatalytic Technology: Applications and Standardization. The event attracted over 100 participants from industry and academia and government bodies. Six invited speakers as well as panel members include Dr Loh Wah Sing, Convenor of this joint seminar, from Singapore Standards Council, Prof Darren Sun from Nanyang Technological University (NTU), Mr Junji Kameshima from TOTO Ltd, Dr Gregory Goh from Institute of Materials Research and Engineering (IMRE, A*STAR), Dr Chris Cai from SIMTech and Ms Irene Chen from SPRING Singapore. Their topics focused on unique features of photo-catalytic reactivity on self-cleaning of surface, anti-microbial property, air purification and waste water treatment as well as international standardization development for photo-catalytic products.

In 1972, Fujishima and Honda discovered the phenomenon of photo-catalytic splitting of water on a TiO_2 electrode under ultraviolet (UV) light and since then, enormous efforts have been devoted to the research of TiO_2 material, which has led to many promising applications in areas ranging from photo-catalysis to photovoltaics. Japan is the pioneer in photo-catalytic TiO_2 nano-materials R&D and commercialization supported by Japanese government and industry (led by TOTO). According to the 5-year Japan national project (NEDO Project) of photo-catalysis towards sustainable society mentioned

during Dr Loh Wah Sing's presentation, there are 50 researchers from 5 universities and one national institute plus 10 companies are involved in the project. The sale of photo-catalytic products in Japan is 650 million USD in 2008. TOTO Ltd has been collaborating with Professor Fujishima to develop the photo-catalytic products since the 80s. They launched their TiO_2 based photo-catalyst paints in 2000. Mr Junji Kameshima came to this seminar to introduce the development of their photo-catalytic exterior paints. Because of the strong oxidizing power and photo-induced hydrophilicity of TiO_2 photo-catalysts when exposed to UV or visible light, TOTO's exterior paints is self-cleaning, anti-fogging, anti-bacterial as well as anti-algae, and can effectively remove the NO_x and SO_x for air purification. TOTO's exterior building materials have occupied almost 60% share of the photo-catalyst products market in Japan, although the price of their products is higher than the conventional painting materials. "We should think about the life-cycle-cost when we try to compare these nano-TiO_2 based photo-catalytic paints with the conventional painting materials." Dr Loh Wah Sing pointed out during the panel discussion. In Japan, TOTO provides 10 years warranty to their exterior painting products. The self-cleaned buildings coated with HYDROTECT paints are also able to purify air simultaneously.

In Singapore, there are a few research groups working on TiO_2 nanomaterials and their applications including TiO_2 coating films for self-cleaning applications, TiO_2 nanofiber membrane and its applications on flexible dye sensitized solar cells (DSSCs) and water treatment systems, TiO_2 nanofibers and porous TiO_2 thin films for DSSCs and organic photovoltaic (OPV) solar cells. Prof Darren Sun presented their proprietary robust free standing TiO_2 nano fiber/tube/wire membrane technology which is being used to build a cost and energy efficient wastewater treatment system. Membrane fouling is a major obstacle to the widespread use of this technology for the wastewater treatment solutions and the severe membrane fouling may require intense chemical cleaning or membrane replacement. The concurrent oxidization and filtration properties make the multifunctional TiO_2 nanofiber membrane a promising candidate for the next generation of membrane-based wastewater treatment systems. The photo-catalytic activity and anti-fouling ability of the TiO_2 nanofiber membrane were investigated using humic acid (HA) solution, 57% of HA can be removed using the TiO_2 nanofiber membrane alone, but with UV irradiation on the membrane, the HA removal rate reached almost 100%. Not only full surface exposure to UV or solar for self-regeneration effectively eliminates the membrane fouling problem and greatly elongate the membrane life span, the high surface area of this TiO_2 nanofiber membrane also allows higher absorption rate of various trace organics and bacteria for improving water quality. Considering both photo-catalytic and photovoltaic properties of TiO_2 nano materials under UV radiation, Prof Sun's group successfully developed the TiO_2 nano membrane based flexible solar cells and integrated it into the wastewater treatment systems. They have filed a patent of concurrent clean water and energy production under solar conditions using TiO_2 nanotube membrane, which opens exciting opportunities to produce energy and purify water at the same time.

Prof Sun believes that nanotechnology will bring a revolution to our life. In terms of TiO_2-based photo-catalytic technology, nano means much larger surface area and consequently improved photo-catalytic properties. "TiO_2 nano-dispersion is also very important for making smooth and transparent coating films" Dr Chris Cai said. However, DNA strand breakdown and genetic instability in vivo in mice induced by TiO_2 nanoparticles with the mean size of 160±5 nm have been reported by Benedicte Trouiller et.al.[1] With the increasing applications of nano TiO_2-based photo-catalysts in our daily life, international standardization is needed to evaluate their performance, reliability and safety. WG37 published by ISO (International Organization for Standardization) TC206[2] has described a series of test methods for photo-catalytic materials including those for removal of nitric oxide, removal of acetaldehyde, antibacterial activity, water purification performance, hydrophilicity and others. In addition, Japan, Korea, Taiwan and China have drafted their national standards for photocatalysis. Methods to monitor health hazards in handling of nano-scale photo-catalytic materials are being deliberated in ISO TC229 where Singapore is a P-member[2].

With ongoing rapid industrialization, the environmental pollution and energy crisis have motivated researchers worldwide to work on the eco-friendly TiO_2 nanomaterials for developing more efficient UV / visible light photocatalysts, increasing the photocatalytic efficiency for indoor use, developing new photocatalytic applications such as large scale VOC treatment, wastewater cleaning and waste nutrient treatment for soil-less planting as well as developing new generation of solar cells based on TiO_2 nanostructures.

Reference:

1. "Titanium Dioxide Nanoparticles Induce DNA Damage and Genetic Instability In vivo in Mice", B. Trouiller, R. Reliene, A. Westbrook, P. Solaimani, and R. H. Schiestl, Cancer Res., vol. 69 (22), p. 8784 (2009).
2. ISO TC 206 Fine Ceramics is established in 1992. Chairman is S. Korea and Secretariat is Japan. There are 18 P(articipating) - members and 14 O(bserver) - members. Singapore is O-members from March 2009.

Dr Loh Wah Sing, convenor of this joint seminar is giving an introduction to photocatalytic technology