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MEDIA RELEASE

IBN Researchers First to Transform Carbon Dioxide into Methanol - 'Very Important' Paper in Top Chemistry Journal Describes Green Method for Sequestration and Conversion of Green House Gas

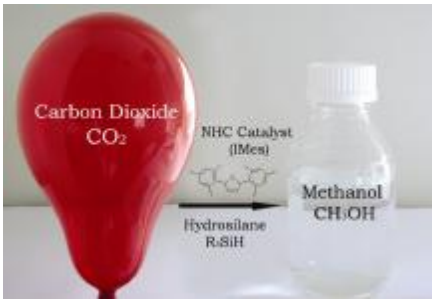

Fig. 1 IBN Scientists Convert Carbon Dioxide into Methanol.

SINGAPORE, APRIL 16, 2009 - Scientists at the Institute of Bioengineering and Nanotechnology (IBN) have succeeded in unlocking the potential of **carbon dioxide** – a common greenhouse gas – by converting it into a more useful product. Using **organocatalysts**, the IBN researchers activated carbon dioxide in a mild and non-toxic process to produce methanol, a widely used industrial feedstock and clean-burning biofuel.

Published recently in leading international chemistry journal *Angewandte Chemie,*[1] IBN's report has been designated a 'Hot Paper.' In addition, the Institute's findings have been determined by reviewers to be "very important" – a recognition provided to less than 10% of the journal's manuscripts.

Carbon Dioxide and Global Warming – Combustion of fossil fuels release huge amounts of carbon dioxide into the earth's atmosphere. Excess carbon dioxide emissions have been implicated as the cause of global warming. Developing new ways of sequestering carbon dioxide is important for curbing global warming, which may otherwise lead to rises in sea levels and other disastrous climate changes. Scientists have been trying to find ways of using carbon dioxide to obtain more useful products.

IBN scientists have made carbon dioxide react by using **N-heterocyclic carbenes (NHCs)**, a novel organocatalyst. In contrast to heavy metal catalysts that contain toxic and unstable components, NHCs are stable, even in the presence of oxygen. Hence, the reaction with NHCs and carbon dioxide can take place under mild conditions in dry air. IBN's research shows that only a small amount of NHC is required to induce carbon dioxide activity in a reaction. "NHCs have shown tremendous potential for activating and fixing carbon dioxide. Our work can contribute towards transforming excess carbon dioxide in the environment into useful products such as methanol," shared Ms Siti Nurhanna Riduan, IBN Senior Lab Officer, who is also pursuing her Ph.D. at IBN under the Scientific Staff Development Award.

Organocatalysts and N-Heterocyclic Carbenes (NHC) – Organocatalysts are catalysts that are comprised of non-metallic elements found in organic compounds. NHCs such as IMes (1,3-bis-(2,4,6-trimethylphenyl)imidazolylidene) are a form of organocatalysts that are stable and easily stored. They do not contain toxic heavy metals and can be produced easily without high costs.

Hydrosilane, a combination of silica and hydrogen, is added to the NHC-activated carbon dioxide, and the product of this reaction is transformed into methanol by adding water through hydrolysis. Dr Yugen Zhang, IBN Team Leader and Principal Research Scientist, explains, "Hydrosilane provides hydrogen, which

[1] Angewandte Chemie International Edition, DOI: 10.1002/anie.200806058

bonds with carbon dioxide in a reduction reaction. This carbon dioxide reduction is efficiently catalyzed by NHCs even at room temperature. Methanol can be easily obtained from the product of the carbon dioxide reaction. Our previous research on NHCs has demonstrated their multiple applications as powerful antioxidants to fight degenerative diseases,[2] and as effective catalysts to transform sugars into an alternative energy source.[3] We have now shown that NHCs can also be applied successfully to the conversion of carbon dioxide into methanol, helping to unleash the potential of this highly abundant gas."

Green Chemistry – Green or sustainable chemistry aims to eliminate the use and generation of hazardous substances to prevent environmental pollution.

Previous attempts to reduce carbon dioxide to more useful products have required more energy input and a much longer reaction time. They also require transition metal catalysts, which are both unstable in oxygen and expensive. Ongoing research at IBN aims to find cheap alternatives for the hydrosilane reagent so that the production of methanol can be even more cost-effective for mass industrial production.

"At IBN, we are innovating effective methods of generating clean energy using **green chemistry** and nanotechnology. In the face of environmental pollution, global warming and increasing demands on diminishing fossil fuel resources, we hope to provide a viable alternative energy option for industry, and effective sequestration and conversion of carbon dioxide." said Professor Jackie Y. Ying, IBN Executive Director.

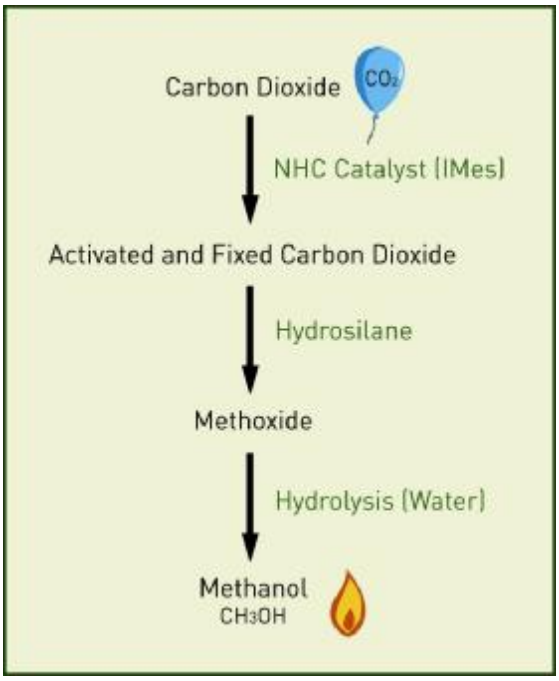

Fig. 2 Carbon Dioxide is Activated and Transformed into Methanol

[2] L. Zhao, C. Zhang, L. Zhuo, Y. Zhang and J. Y. Ying, "Imidazolium Salts: A Mild Reducing and Antioxidative Reagent," Journal of the American Chemical Society, 130 (2008) 12586-12587.

[3] G. Yong, Y. Zhang and J. Y. Ying, "Efficient Catalytic System for the Selective Production of 5-Hydroxymethylfurfural from Glucose and Fructose," Angewandte Chemie International Edition, 47 (2008) 9345-9348.

About the Institute of Bioengineering and Nanotechnology

The Institute of Bioengineering and Nanotechnology (IBN) was established in 2003 and is spearheaded by its Executive Director, Professor Jackie Yi Ru Ying, who has been on the Massachusetts Institute of Technology's Chemical Engineering faculty since 1992, and was among the youngest to be promoted to Professor in 2001. In 2008, Professor Ying was recognized as one of "One Hundred Engineers of the Modern Era" by the American Institute of Chemical Engineers for her groundbreaking work on nanostructured systems, nanoporous materials and host matrices for quantum dots and wires. Under her direction, IBN conducts research at the cutting-edge of bioengineering and nanotechnology. Its programs are geared towards linking multiple disciplines across all fields in engineering, science and medicine to produce research breakthroughs that will improve healthcare and our quality of life.

IBN's research activities are focused in the following areas:

- **Drug and Gene Delivery,** where the controlled release of therapeutics involve the use of functionalized polymers, hydrogels and biologics for targeting diseased cells and organs, and for responding to specific biological stimuli.

- **Cell and Tissue Engineering,** where biomimicking materials, stem cell technology, microfluidic systems and bioimaging tools are combined to develop novel approaches to regenerative medicine and artificial organs.

- **Biosensors and Biodevices,** which involve nanotechnology and microfabricated platforms for high-throughput biomarkers screening, automated biologics synthesis, and rapid disease diagnosis.

- **Pharmaceuticals Synthesis and Nanobiotechnology,** which encompasses the efficient catalytic synthesis of chiral pharmaceuticals, and new nanocomposite materials for sustainable technology and alternative energy generation.

IBN's innovative research is aimed at creating new knowledge and intellectual properties in the emerging fields of bioengineering and nanotechnology to attract top-notch researchers and business partners to Singapore. Since 2003, IBN researchers have produced a total of 490 papers published/in press, of which 223 were published in journals with impact factor greater than 3. IBN also plays an active role in technology transfer and spinning off companies, linking the research institute and industrial partners to other global institutions. As of March 2009, IBN has filed 692 patent applications on its inventions and the Institute is currently looking for partners for collaboration and commercialization of its portfolio of technologies. IBN's current staff strength stands at around 170 scientists, engineers and doctors. With its multinational and multidisciplinary research staff, the institute is geared towards generating new biomaterials, devices, systems, equipment and processes to boost Singapore's economy in the fast-growing biomedical sector.

IBN is also committed to nurturing young minds, and the institute acts as a training ground for PhD students and undergraduates. In October 2003, IBN initiated a Youth Research Program to open its doors to university students, as well as students and teachers from various secondary schools and junior colleges. It has since reached out to more than 28,900 students and teachers from 201 local and overseas schools and institutions.

For more information, please log on to www.ibn.a-star.edu.sg

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