For Immediate Release
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MEDIA RELEASE

IBN Team Discovers New Uses for Imidazolium Salts in Medicine and Alternative Energy

Compound has powerful antioxidant properties to fight diseases and proves to be an efficient catalyst for converting biofuels

SINGAPORE, DECEMBER 1, 2008 — Scientists at the Institute of Bioengineering and Nanotechnology (IBN) have uncovered new properties of imidazolium salts (IMSs), which suggest that they could play a vital role in disease prevention and treatment. IBN researchers also reported the first use of these salts to convert carbohydrates into versatile chemical compounds for biofuel production.

In the first reported study of the redox properties of IMSs published in the *Journal of the American Chemical Society*[1], IBN researchers successfully synthesized uniform gold nanoparticles within seconds at room temperature using IMSs. The ultrafine (1-2 nm) nanoparticles remained stable for up to 6 months at 4°C. Unlike conventional synthesis techniques using borane or borohydride reduction processes, IBN's method does not require any strong reducing reagent yet is able to produce gold nanoparticles under very mild reaction condition with remarkable efficiency. IBN's new synthesis protocol could easily be scaled up for industrial applications.

> Commonly used as solvents for various organic reactions, **imidazolium salts** are room-temperature ionic liquids that are chemically stable and have low vapor pressure. While the physical properties of IMS have been widely studied, their **biochemical** properties and **medical applications** have seldom been mentioned in literature.

According to IBN Principal Research Scientist Dr Yugen Zhang, "Our successful use of IMSs as a reducing agent led us to believe that we might also be able to use this compound as a radical scavenger antioxidant to counter the damage caused by reactive oxygen species in the body."

Environmental stress triggered by an unhealthy lifestyle, such as excessive alcohol consumption, exposure to toxins and drugs, smoking and lack of sleep, may lead the body to produce superoxide radicals known as reactive oxygen species (ROS) that could cause cell damage through oxidation. Oxidative stress from ROS is implicated in most diseases including cancer, heart disease, liver fibrosis, neurodegenerative diseases, autoimmune disorders and aging. Radical scavenger antioxidants help to trap free radicals in the body's cellular system, thus attenuating the effects of ROS.

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[1] 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.

IMS is a precursor for N-heterocyclic carbenes (NHC). A naturally occurring form of NHC is thiamine or Vitamin B, which plays a very important biological role. Vitamin B deficiency has been linked to oxidative stress. While natural antioxidants such as epigallocatechin gallate (EGCG), a green tea extract, have been known to slow down or prevent the oxidative process, they also exhibit low potencies and a rapid turnover in the body's metabolism.

IBN Principal Research Scientist Dr Lang Zhuo shared, "Our investigations with hepatic stellate cells show that IMSs have more powerful antioxidant properties than EGCG, yet are remarkably less cytotoxic. They significantly decreased ROS levels in liver cells by 11% more than EGCG. In addition, IMSs are simple and inexpensive to produce. Therefore, they show great promise as a new type of antioxidant with potential biomedical applications."

In a separate study published in *Angewandte Chemie International Edition*[2], IBN researchers successfully used IMS to develop a new catalyst system for converting sugars into 5-hydroxymethylfurfural (HMF), a key compound used in biofuel chemistry and the petroleum industry.

Diminishing fossil fuel reserves and global warming effects have made the search for sustainable, renewable alternative energy sources a critical global concern. Biofuels are currently the only sustainable source of liquid fuels available, but the lack of highly efficient methods to convert carbohydrates into chemical compounds for biofuel production has impeded the replacement of petroleum feedstock by biomass.

HMF and its 2,5-disubstituted furan derivatives can replace key petroleum-based building blocks, and there are several known catalysts that are active in the dehydration of sugars to form HMF. However, most of them also produce side reactions that form undesired byproducts, and rehydrate HMF to form acid. Therefore, the use of these catalysts has often been constrained to simple sugar feedstock such as fructose. They have not been able to efficiently convert glucose, a more abundant and stable sugar source.

With IMSs as the starting point, IBN researchers developed NHC-metal complexes as catalysts to transform sugars into HMF. These offer a great deal of flexibility as the catalytic activity may be modified by changing specific properties of the NHC. The researchers were able to extract HMF easily as the sole product. IBN's new catalyst achieved the highest reported yields of HMF so far, for both fructose and glucose feedstocks.

[2] 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.

Dr Zhang elaborated, "Our HMF yields were as high as 96% for fructose and 81% for glucose. As both the catalyst and the ionic liquid can be recycled, our technology is more environmentally friendly and would potentially lead to cost savings in the biofuel manufacturing process."

IBN Executive Director Professor Jackie Y. Ying added, "We are excited by the tremendous potential of these novel compounds to make an impact on medicine and alternative energy. Our discovery paves the way for more effective treatment of various degenerative diseases, as well as the conversion of biofuels, helping to alleviate some of the pressing concerns facing our global community."

About the Institute of Bioengineering and Nanotechnology

The Institute of Bioengineering and Nanotechnology (IBN) is a member of the Agency for Science, Technology and Research (A*STAR), Singapore. It was established in 2003.

Massachusetts Institute of Technology (MIT) Professor Jackie Yi Ru Ying, 42, was hand-picked by former A*STAR Chairman Philip Yeo to lead the institute as its Executive Director in March 2003. She has been on MIT's Chemical Engineering faculty since 1992, and was promoted to Professor in 2001. She is among the youngest to be promoted to this rank at MIT. 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 various therapeutics involve the use of functionalized polymers and hydrogels for targeting diseased cells and organs, or for responding to specific biological stimuli.
- **Cell and Tissue Engineering,** where biomimicking materials, stem cell technology and bioimaging are combined to develop novel approaches to regenerative medicine and artificial organs.
- **Pharmaceuticals Synthesis and Nanobiotechnology,** which encompass the efficient catalytic synthesis of chiral pharmaceuticals, and new materials for sustainable technology and alternative energy generation.
- **Biosensors and Biodevices,** which involve nanotechnology and microfabricated platforms for the detection and treatment of diseases, and the synthesis and screening of biologics.

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 445 papers published/in press, of which 184 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 October 2008, IBN has filed 637 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 23,000 students and teachers from over 190 local and overseas schools and institutions.

In 2008, IBN celebrates 5 years of innovative research. For more information, please log on to www.ibn.a-star.edu.sg.

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