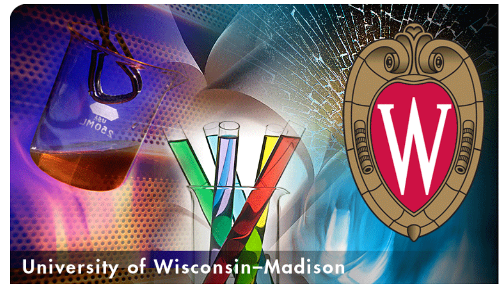
Boron- and Nitride-Containing Catalysts for Oxidative Dehydrogenation of Small Alkanes and Oxidative Coupling of



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The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in the industrial-scale production of propene and other valuable olefins with negligible CO/CO_2 byproduct.

OVERVIEW

C_3 and C_4 olefins such as propene are key starting materials in the plastics and chemical industry. The main method for producing these critical building blocks is a petrochemical process called steam cracking. Over the past decade demand has outstripped supply. As an example: the current world demand for propene is ~ 100 million metric tons per year and expected to increase by 20 percent in the next five years.

As conventional steam cracking has not kept pace with rising demand, several alternative olefin production technologies have been developed (e.g., CATOFIN®, OLEFLEX™, STAR®). However, these methods are both capitally and operationally expensive due to the energy intensive reaction and requirements for catalyst regeneration, resulting in process inefficiencies.

A lower cost, more sustainable process called oxidative dehydrogenation (ODH) has many advantages over current technologies. The process has been studied for decades but hindered by unselective catalysts producing too much unwanted byproducts – until now.

THE INVENTION

UW–Madison researchers have developed improved ODH catalysts for converting short chain alkanes to desired olefins (e.g., propane to propene and ethene) with unprecedented selectivity (>90 percent).

The new catalysts contain boron and/or nitride and minimize unwanted byproducts including CO and CO_2. They contain no precious metals, reduce the required temperature of the reaction and remain active for extended periods of time with no need for costly regenerative treatment.

In addition to driving ODH reactions, the new catalysts can be used to produce ethane or ethene via oxidative coupling of methane (OCM).

BUSINESS OPPORTUNITY

The exothermic reaction of alkanes with oxygen to generate olefins and water has the potential to be a game changing technology in the chemical industry. Until now the selectivity to olefins remained too low to make the reaction economically attractive.

APPLICATIONS

- Oxidative dehydrogenation of alkanes; oxidative coupling of methane
  - Industrial-scale production of propene, isobutene, 1-butene, 2-butene, butadiene, styrene, ethane, ethene and other chemical building blocks

KEY BENEFITS

- Outperform conventional catalysts
- Substantially higher olefin selectivity and alkane conversion rates
- Improved byproduct mix
- Cost efficient
- Ready for industrial-scale implementation
- Stable over the long term

STAGE OF DEVELOPMENT

The new boron nitride (BN) catalysts when used for ODH of propane have demonstrated significantly higher propene selectivity and propane conversion (77 and 17 percent, respectively) compared to traditional vanadium-based catalysts (48 and 13 percent, respectively). The main byproduct of the reaction is ethene, itself an important building block molecule. In some embodiments that method exhibits 90 percent or greater selectivity for propene and ethene together.

Similar results are observed when using BN for ODH of n-butane and isobutane. Using BN for ODH of n-butane results in high selectivity to 1- and 2-butene at high n-butane conversion (70 and 13 percent, respectively), with the majority of byproducts being propene and ethane, creating a total olefin selectivity of 92 percent at this conversion. Using BN for ODH of isobutane results in high selectivity to isobutene at high isobutane conversion (65 and 14 percent, respectively), with the majority of byproducts being propene, creating a total olefin selectivity of 86 percent at this conversion.

BN is also established as an active and selective catalyst for ODH of ethylbenzene to produce styrene, and for oxidative coupling of methane to produce ethane and ethene.

The development of this technology was supported by WARF Accelerator. WARF Accelerator selects WARF's most commercially promising technologies and provides expert assistance and funding to enable achievement of commercially significant milestones. WARF believes that these technologies are especially attractive opportunities for licensing.

ADDITIONAL INFORMATION

Related Portfolios
WARF Accelerator Program Technologies

Publications
Read a news story about this technology.

Grant J.T., Carrero C.A., Goelt F., Venegas J., Mueller P., Burt S.P., Specht S.E., McDermott W.P., Chieregatol A. and Hermans I. 2016. Selective Oxidative Dehydrogenation of Propane to Propene Using Boron Nitride Catalysts. Science. DOI: 10.1126/science

Hermans I., Venegas J., Grant J.T., McDermott W.P., Burt S.P., Micka J. and Carrerol C.A. 2017. Selective Oxidation of n-Butane and Isobutane Catalyzed by Boron Nitride. ChemCatChem. DOI: 10.1002/cctc.201601686

Grant J.T. and Hermans I. 2017. Boron Nitride: A New Selective Catalyst for the Oxidative Dehydrogenation of Propane. Green Chemistry: The Nexus Blog.

Jacoby M. 2016. Boron Nitride Unexpectedly Converts Propane to Propene. C&EN. 94, 5.

Tech Fields

Materials & Chemicals - Synthesis

Clean Technology - Energy & resource efficiencies

CONTACT INFORMATION

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