Green Chemistry for Ketones and Aldehydes Production

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Overview

Our technology provides a new type of oxidative cleavage reaction of organic compounds with highly selective product formation.

Polyoxometalate (POM) catalysts have become well-known for their utility and diversity in specific reactions. Through the elucidation of POM catalytic pathways, greater versatility has been achieved. This technology is one such application of a novel POM catalyst and is exploited to cleave carbon-carbon double bonds in alkenes (olefins) through an aerobic oxidation reaction. Oxidation reactions are of particular interest because they are difficult to achieve on an industrial scale while maintaining "green"Â chemistry practices.

The Need

The realization that many processes practiced on a large scale were detrimental to the environment led to a movement of reshaping the science of organic chemistry. Many of the reactions most problematic to the environment are in the area of oxidation chemistry. Obtaining viable â€œgreenâ€ synthetic procedures requires new catalysts capable of activation of oxidants that will lead to new selective transformations. As such, much of the research in selective oxidation is in the development of new catalysts, for example those that use inorganic POMs as their reactive core.

The use of POM catalysts has presented many new opportunities not typical of oxidative chemical reactions. More specifically, the use of POMs with environmentally benign oxygen donors, like molecular oxygen (O2) or nitrous oxide (N2O), has produced methods for efficient and selective reactions that fulfill the requirements of green chemistry.

An enticing application utilizing these methods is with renewable resources such as unsaturated fatty acid derivatives as feedstock for oxidation reactions. This application of green chemistry could attack two areas, environmentally friendly catalysts and renewable feedstock, and could be a revolutionary push in industrial organic chemistry towards safe, sustainable, and ecologically conscious processing.

The Solution

Novel POM catalyst which achieves aerobic carbon-carbon bond cleavage of alkenes:

- Use renewable resources as feedstock
- Highly selectable products

Technology Essence

Our approach is motivated by societal considerations that demand environmentally benign and sustainable solutions for oxidative reactions. As such, we have developed a scheme to react NO2 with a transition-metal-substituted POM which yields a metal-nitro intermediate that is competent for forming the precursors for oxidation with molecular oxygen, O2, to have a final product of ketones and/or aldehydes, and regenerate the POM catalysts.

This method has preference towards di/tri-substituted alkenes. High yields of ketones or aldehydes have been produced and the POM catalyst is regenerated without further oxidation to carboxylic acids, as is typical with other oxidative catalysts.

The selective cleavage of carbon-carbon double or triple bonds with metal-nitro or metal-nitrito compound has not been reported. This exciting new discovery could lead to a wide variety of organic reactions not previously possible, along with revolutionary green oxidative chemistry techniques.

Applications and Advantages

Advantages

- Environmentally friendly oxidation reaction
- Easy catalyst regeneration

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Applications

- As a novel catalyst in industrial organic chemistry processes
- Sold as a stand-alone catalyst for laboratory or individual use

Development Status

Further research will provide additional product selectivity and will focus on the oxidation of terminal alkenes and more control of reaction selectivity, for example, epoxidation versus carbon-carbon bond cleavage. This will provide further versatility of an already flexible catalyst.

Market Opportunity

The market potential for this technology is largely driven by government regulations and the societal desire for greener processes in industry.

According to the first market research report on POM catalysts by QYResearch, â€œGlobal POM Industry Report,â€ POM catalysts have the potential lead the next generation of industrial organic chemistry techniques. A market closely aligned with implementing POMs for green organic chemistry solutions is the flavors and fragrances industry, and according to the report â€œGlobal Flavors and Fragrances Market 2014-2018,â€ by ReportBuyer, the industry is expected to grow at a CAGR of 5.63% during this period.

Patent Status

USA Granted: 9,815,757