Aerobic Electrochemical Oxidation of Hydrocarbons

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Overview

Aerobic oxidation is a chemical reaction in which hydrocarbons such as alkanes or alkenes are oxidized using oxygen as the oxidizing agent. This reaction is an important industrial process that is used to synthesize chemicals from alkenes and alkanes that are commonly found in petroleum and natural gas. Currently, there are no adequate solutions. Here we provide a new method for the electrochemical oxidation and aerobic oxygenation of hydrocarbons catalyzed by inorganic copper-tungsten oxides that enables the oxidation of ethane to Ethanol and to acetic acid, requires less compound for catalysis, and is easier to prepare in higher yields.

Background and Unmet Need

Saturated and unsaturated hydrocarbons, alkanes and alkenes, respectively, are primary chemicals found in natural gas and formed in petroleum refining. Mostly alkanes are used as fuel, while alkenes are typically used in basic petrochemical industries such as polyethylene and polypropylene production. The valorization of alkanes (especially low molecular weight gaseous alkanes) and alkenes by oxygenation, that is the insertion of oxygen atoms into hydrocarbons using molecular oxygen from air, are potentially very important transformations and is a major challenge in oxidation catalysis. One of the "holy grails"Â of oxidation chemistry is to find viable methods to carry out such aerobic oxygenations of alkanes and alkenes.

The Solution

Prof. Ronny Neumann and his team invented a novel method of hydrocarbons oxygenation using copper-tungsten oxides as catalysts.

Technology Essence

Currently, copper-based compounds and materials do not activate O_2 under reducing conditions but rather by application of high temperatures. Thus, dioxygen activation at ambient conditions towards the formation of reactive intermediates, followed by actual catalytic transformations, especially of light hydrocarbons and alkanes using intrinsically stable inorganic copper-based catalysts, has not been attained. Furthermore, Polyoxometalates have been used in very high temperature oxygenation of alkanes, although selectivity and yields are low with a significant formation of combustion products1. The team invented the use of copper-tungsten oxides as catalysts for the aerobic electrochemical oxidation of hydrocarbons. They oxygenate hydrocarbons with molecular oxygen, O_2, as oxidant under electrochemical reducing conditions.

Applications and Advantages

- Catalyzing the aerobic electrochemical oxidation of alkanes and alkenes.
- Oxidation of ethane to acetic acid.

Development Status

Prof. Neumann and his team invented new inorganic copper-tungsten oxides catalysts for aerobic electrochemical oxidation of hydrocarbons. They demonstrated the preparation of oxygenated hydrocarbon products from a hydrocarbon.

Market Opportunity

Light alkanes are often emitted and/or burnt off at natural gas and petroleum wells. In either case, this adds to global warming through the emission of methane or carbon dioxide. In addition, it is obviously a waste of valuable resources. The use of relatively small electrochemical units at the well site presents an opportunity to utilize the light alkanes through their liquefication and valorization. One particular example is the conversion of ethane, which is found in natural gas in many cases at significant levels, to Ethanol and to acetic acid. Ethanol and Acetic acid are very important petrochemicals that have robust growth rates.

References

1. Sun, M.; Zhang, J.; Putaj, P.; Caps, V.; Lefebvre, F.; Pelletier, J.; Basset, J. M. Catalytic oxidation of light alkanes (C1âˆ’C4) by heteropoly compounds. Chem. Rev. 2014, 114, 2, 981âˆ’1019. https://doi.org/10.1021/cr300302b [1]

Patent Status

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