A New Sustainable Process for Hydrocarbons Oxidation (Yeda)

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Ronny Neumann, Chemistry, Organic Chemistry

Summary

Phenol is an important industrial commodity used as a precursor to many useful compounds. It is being utilized in huge amounts in a wide range of industry sectors including the pharmaceuticals, plastic-related-products production, paints & coatings, electrical equipment, foams and fuel additives. The global phenol market is predicted to witness a robust CAGR of 6.8% during the period of 2018-2022 reaching a volume of 14 Million Tons by the end of the forecasted period, which will account for $17 bn in value. The current most prevalent method for phenol production is the three-step cumene hydroperoxide process that while established, has serious drawbacks related to safety, low selectivity in the formation of cumene hydroperoxide, low per pass yield and the formation of acetone as a byproduct. A new phenol production method, developed at the Weizmann Institute of Science based on electrocatalytic oxidation of benzene, allows for a simple, efficient, cost-effective and selective production of phenol. This new method can result in a drastic cost reduction that will further be emphasized in the future with the ongoing reduced need of the current process' byproduct - acetone (CAGR of approximately 3.6% during the period of 2018-2023, a significantly lower growth rate in comparison to phenol). The method suggested here can also be applied in the future in other processes for conversion of arenes to the corresponding phenols.

Applications

Main process:

- Production of phenol from benzene
- The technology can potentially be applied for additional chemical processes:
- Production of acetaldehyde from ethylene
- Production of malonic and/or pyruvic acids from acrylic acid
- Production of various alcohols from aliphatic and aromatic hydrocarbons.

Advantages

- A simple, fast and cost-effective process
- Direct and Highly selective (no acetone as a co-product)
- Low temperature process
- Safe Process, no hazardous by-products.

Technology's Essence

An electrocatalytic transformation using formic acid to oxidize benzene and its halogenated derivatives to selectively yield aryl formates that are easily hydrolyzed by water yielding the corresponding phenols. The formylation reaction occurs on a Pt anode in the presence of [Co(III)W12O40]5- and similar anions as catalyst and Li formate as electrolyte via formation of a formyloxyl radical as the reactive species, which was trapped by a BMPO spin trap and identified by EPR. Hydrogen was formed at the Pt cathode. The sum transformation is ArH + H2O ArOH + H2. Non-optimized reaction conditions showed a Faradaic efficiency of 75-80 % and selective formation of the mono-oxidized phenol product in a 35 % yield. Decomposition of formic acid to CO2 and H2 is the side-reaction. Published in: Angew. Chem. Int. Ed.2018, 57, No. 19, 5403-5407

Contact for more information:

Maya Gofer ✉, Licensing Officer, +972-8-9344546

Yeda Research and Development Co. Ltd. - Technology Transfer from the Weizmann Institute. P.O. Box 95, Rehovot,76100, Israel. Tel: +972-8-947-0617