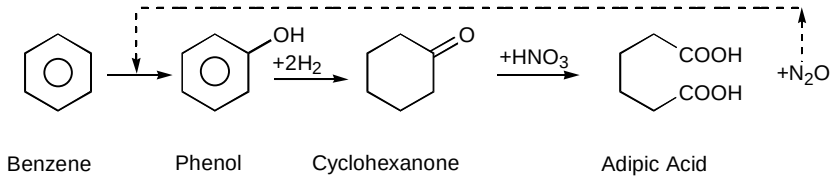
PERP Program
February 2000

On-Purpose N_2O Production for Phenol Manufacture (98/99S14)

Solutia Corp. (formerly Monsanto) in conjunction with the Boreskov Institute of Catalysis (BIC), has developed a new benzene oxidation route to phenol production using nitrous oxide as the oxidizing agent, in the presence of a zeolite catalyst. Solutia has an economic advantage for the use of this technology (AlphOx™), with virtually free nitrous oxide available as a waste product from their adipic acid process. Adipic acid production at Solutia's Pensacola, FL facility is over 600 million pounds per year which equates to almost 200 million pounds of nitrous oxide. The chemistry of such an integrated approach in shown below. It is recognized that the volume of N_2O produced will not be enough to feed a world scale adipic acid plant and will likely need to be supplemented with KA oil from conventional sources.

INTEGRATED PHENOL/ADIPIC ACID ROUTE



G:99Q2\4000\4406\RP\4406-1.CDX

The economic viability of this phenol process for other producers not in the adipic acid manufacturing business depends on the ability to produce or purchase so-called "on-purpose" nitrous oxide at a favorable price.

The classical approach to manufacturing nitrous oxide is via ammonium nitrate decomposition. This method enables nitrous oxide of high purity to be produced for medical anaesthetic applications.

$$NH_4NO_3 \longrightarrow N_2O + 2\,H_2O$$

G:99Q2\4000\4406\RP\4406-1.CDX

However, this approach would be much too expensive for use in a phenol project. In 1994 Mitsui started up a 450 metric ton per year nitrous oxide plant in Osaka, Japan. This plant uses a new technology to produce nitrous oxide via catalytic oxidation of ammonia with oxygen. The N_2O from this plant is also for medical application.

$$2\ NH_3 + 2\ O_2 \longrightarrow N_2O + 3\ H_2O$$

G:\99Q2\4000\4406\RP\4406-1.CDX

In June of 1998 Solutia was awarded a patent for a catalyst to be used for on-purpose production of nitrous oxide via the oxidation of ammonia using air or oxygen enriched air.

In the Mitsui technology, oxygen is used as the oxidant instead of air in order to minimize the difficulties in separating the nitrous oxide from nitrogen. A nitrogen free product is very important for anaesthetic use. However, for the purpose of oxidizing benzene to phenol, the use of air presents no problem, from a chemical perspective, since nitrogen is already present as a byproduct from the benzene oxidation.

Using both the Mitsui and Solutia patent data, several designs were evaluated for this report, each with its own advantages. The base case employs air as the source of oxygen. The product nitrous oxide is not separated from the nitrogen, but instead sent to the benzene to phenol production facility (AlphOx) as a low purity nitrous oxide stream. Although the extra nitrogen will require a larger investment in the AlphOx plant due to the volume of the extra nitrogen, the separation of the phenol and excess benzene from the nitrogen at the back end is relatively easy and nitrogen is an inherent byproduct of benzene oxidation via N_2O requiring separation in every case.

A second option for the on-purpose nitrous oxide plant is to purify the product via a cryogenic recovery system. The separation of the nitrogen from the nitrous oxide requires a low temperature operation and adds significantly to the investment of the nitrous oxide plant. However, the AlphOx plant requires no additional investment in this case.

Finally enriched air can be used if purchased oxygen can be obtained at a reasonable price from a nearby oxygen plant. This produces a product stream with a nitrous oxide content somewhere between the previous two cases. The investment in the nitrous oxide plant is reduced, although the AlphOx plant investment increases moderately and the operating costs are higher.

This report reviews the Mitsui and Solutia inventions and develops costs for on-purpose production of nitrous oxide, as well as assessing its affect on phenol production economics via the BIC route.