

Cyclohexanone Oxime “Ammoximation” Technology



Overview

The Versalis/Lummus technology for cyclohexanone oxime production is via the ammoximation process developed by Versalis and demonstrated at commercial scale since 2001. Cyclohexanone and ammonia react in the presence of hydrogen peroxide using Versalis' high-performance titanium silicalite catalyst (TS-1). The ammoximation technology is a direct, single-step reaction to oxime, where no upstream hydroxylamine formation step is required and no ammonium sulfate is co-produced, offering advantages in capital investment, operating costs

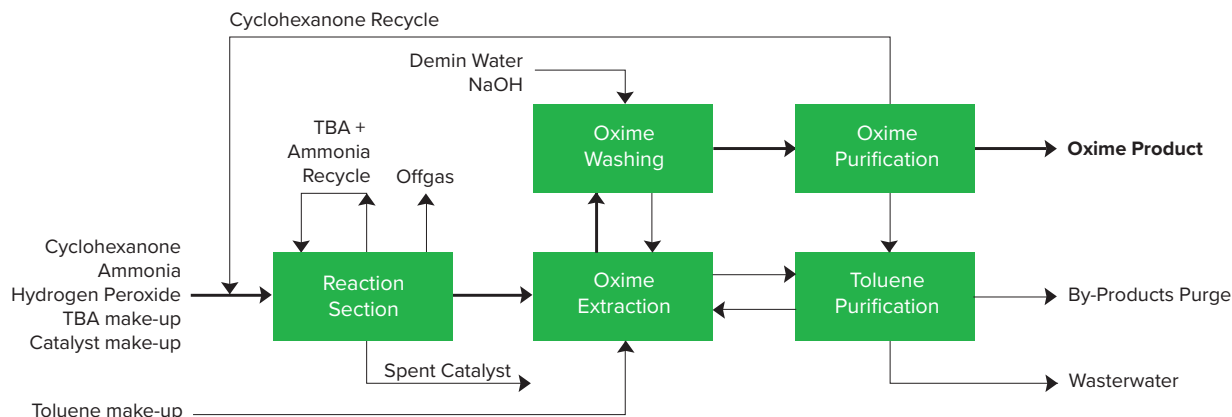
and environmental footprint over conventional technology. In commercial operations, the oxime produced with this technology is used directly in the production of caprolactam, and subsequently, Nylon 6.

The process is provided with dedicated vent gas treatment to minimize emissions. An advanced system of analyzers and safety interlocks, together with specialized design of the reactor, provide an unrivalled level of plant safety and reliability.

Advantages

Process Features	Process Benefits
Direct, single-step oxidation reaction; no hydroxylamine synthesis step required	Affords low capital investment
High selectivity to oxime product; no co-production of low-value sulfates; low catalyst replacement costs	Conveys low operating costs
Advanced reactor safety system and mild reaction conditions with innovative reactor design	Delivers world-class plant safety
No ammonia burning step required and dedicated vent gas treatment	Offers low environmental impact
Technology used in commercial operation since 2001; oxime produced is suitable for all major Caprolactam technologies	A proven technology for nylon production

Process Flow Diagram



Process Description

Reaction Section

Cyclohexanone, ammonia and hydrogen peroxide are fed to the reactor where the ammoxidation reaction takes place in the presence of titanium silicalite (TS-1) proprietary catalyst and tertiarybutanol (TBA) as solvent.

The reaction occurs in an agitated vessel, with catalyst dispersed within the liquid reaction medium. An intermittent make-up of fresh catalyst is introduced, with corresponding volumes of spent catalyst purged from the bottom of the reactor. Liquid effluent leaves the reactor through internal filters. TBA and ammonia are separated and recycled back to the reactor, while the resulting solution of oxime, water, and unconverted cyclohexanone is sent forward to isolate the oxime product.

Product Purification

A liquid-liquid extraction using toluene solvent recovers anhydrous crude oxime, which is then sent to a water washing unit to remove residual impurities. Toluene is removed in a crude oxime distillation. Cyclohexanone is separated from the final oxime product and recycled back to the ammoxidation reactor.

The aqueous phase from extraction, containing traces of toluene and oxime, is sent to a toluene stripping column where organics are recovered from water. Impurities are removed from wastewater in a specialized acidic-oxidation treatment before being discharged for conventional biological treatment. Recovered toluene from the stripping and crude oxime distillation steps is regenerated by distillation to purge heavy by-products and then recycled back to the extraction section.

Process Chemistry

