PERP Program - Polycarbonate

New Report Alert

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Nexant's *ChemSystems* Process Evaluation/Research Planning program has published a new report, ***Polycarbonate (05/06-7)***. To view the table of contents or order this report, please click on the link below:
http://www.nexant.com/products/CSReports/index.asp?body=http://www.chemsystems.com/reports/show_cat.cfm?catID=2

CONVENTIONAL INTERFACIAL TECHNOLOGY

Polycarbonate has conventionally, until recently, been produced via several variations of interfacial technology. In it, alkali salts of bisphenol A (BPA) in aqueous solution are phosgenated in the presence of an inert solvent. The reaction can be carried out in one or more stages (i.e., phosgenation and polycondensation) and can be produced in batch or continuous mode of operation.

Polycarbonate can also be produced via solution or melt processes, but only the melt transesterification process has found commercial viability in recent years, largely due to its ability to obviate the need for phosgene.

Interfacial technology consists of five main areas:

- Phosgene preparation
- Polycarbonate polymerization
- Polymer washing and separation
- Polymer recovery and drying
- Finishing

Interfacial polymerization can be a continuous or batch, one or two step process, resulting in only minor differences relating to economics. Most major producers use a series of centrifuges with water and acid/alkaline washes for polymer washing and separation. Major technology differences exist in the polymer recovery and drying areas.

The reactor is operated at 77-108°F (25-42°C) and near atmospheric pressure. The reactor product is a heterogeneous mixture consisting of the polymer dissolved in an organic phase, and an aqueous phase containing caustic soda, sodium salt of bisphenol A, and sodium chloride. Suitable solvents for this procedure include aromatic hydrocarbons and chlorinated aliphatic or aromatic hydrocarbons, provided they are stable under the reaction conditions. Methylene chloride is usually the solvent of choice.

One of the advantages of this process is that the reaction can proceed at a low temperature in an aqueous system. Thus, no drying of starting materials is required, and the reaction is insensitive to many impurities. Polymers of high molecular weight are readily obtained. Among the disadvantages of this procedure are the difficulty of removing electrolytes from the polymers and the necessity of isolating polymers from relatively dilute solutions.

NON-PHOSGENE MELT TECHNOLOGY

Phosgene is a toxic chemical that requires rigorous process design standards to protect the health and safety of workers. Investment requirements are increased by the need for close analytical monitoring and control, equipment designs for lethal service, and treatment of vent streams by caustic scrubbing or incineration. Toughening of environmental restrictions worldwide has added impetus to the search for non-phosgene routes to polycarbonate.

In addition to phosgene concerns, the interfacial polymerization process typically uses a chlorinated solvent, methylene chloride, another material with exposure limits. A further incentive to eliminate the use of phosgene is the economic penalty incurred because the chlorine content of the phosgene is wasted and converted to sodium chloride. Caustic soda is consumed in the conversion, and the disposal of waste salt solutions presents ecological problems in itself.

GE Plastics, Bayer, Asahi/Chi Mei, and Mitsubishi Chemical/Mitsubishi Gas Chemical have all independently developed non-phosgene production technologies and are currently using these new processes (although not exclusively) for manufacturing polycarbonate. In addition, Teijin and LG have each developed or are developing their own phosgene-free routes and are either building or planning to build non-phosgene-based polycarbonate production facilities.

All these companies are or will be using the same overall approach for making polycarbonate without the use of phosgene. This polymerization technique relies on the transesterification of diphenyl carbonate with bisphenol A. While there are undoubtedly some engineering design differences among the various producers' transesterification technology, the significant distinguishing characteristics are the various means employed to make diphenyl carbonate and diphenyl carbonate precursors.

Four polycarbonate plants using non-phosgene melt technology are commercial:

- GE produces DPC from dimethyl carbonate (DMC) which is produced from CO, methanol and oxygen using EniChem technology
- Bayer technology reacts NO and methanol oxidatively to give methyl nitrite which undergoes carbonylation to produce DMC
- Mitsubishi Chemical has technology for making DPC from di-n-butyl carbonate, which will be produced from urea and n-butyl alcohol.

- Asahi/Chi Mei produces DPC from DMC which is produced via methanolysis of ethylene carbonate

PHOSGENE/MELT "HYBRID" PROCESS

It is Nexant's understanding that one or two of the polycarbonate producers that have developed melt technology have built phosgene/melt "hybrid" plants on the site of their interfacial plants. Hybrid technology is based upon making diphenyl carbonate from phosgene and phenol. The reasons are several:

- The phosgene was already available (the hybrid plant is small compared to the interfacial capacity, requiring only incremental phosgene), minimizing permit and environmental impact
- The byproduct HCl is used on-site and, therefore, has finite value
- The use of this design enables quicker startup and development of the melt technology
- The plant enabled the producer to test both the technology for DPC to polycarbonate as well as the product characteristics when produced from melt transesterification
- The technology enables earlier market development of melt products

COST OF PRODUCTION ESTIMATES

Cost of production estimates are presented for polycarbonate resin, as characterized by the:

- Interfacial process
- Asahi-Chi Mei melt process
- Bayer melt process
- GE Plastics melt process
- Hybrid phosgene/melt process.

GLOBAL MARKET OVERVIEW

Polycarbonate is one of the larger volume engineering thermoplastics and has enjoyed strong demand growth, reflecting its combination of technical performance characteristics. These include its strength, light weight, thermal stability and excellent optical performance.

Historic polycarbonate demand grew at over 13 percent per year (between 1995 and 2000), and the polymer continues to exhibit good growth. Key application areas are electronics and optical media, and future demand growth is expected to follow these sectors, though optical media has not continued to grow at previous rates.

The global demand for Polycarbonate reached 2.7 million tons in 2005. Average annual growth is expected to be more than seven percent per year to 2010.

Historically, the bulk of consumption was attributable to North America and Western Europe, which together accounted for more than half of global consumption in 2005. This picture is expected to alter dramatically over the next decade. Between 2005 and 2010, Asian demand is expected to grow by over seven percent per annum and by 2010 is projected to make up about half of total global demand.

Asia is expected to continue to dwarf all other regions in terms of polycarbonate imports. Although significant capacity is expected to be added within Asia over the medium to long term, the additions are not expected to be able to meet the rate at which demand is forecast to grow. The annual capacity growth rate in Asia is forecast at around ten percent per year, whereas consumption in the region is growing at just under eight percent per year on average. This implies that Asia will be able to reduce some of its dependence on imports post 2005 as it brings more domestic capacity online. North American producers are expected to focus increasingly on domestic markets, while overall the total European region remains relatively balanced.

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