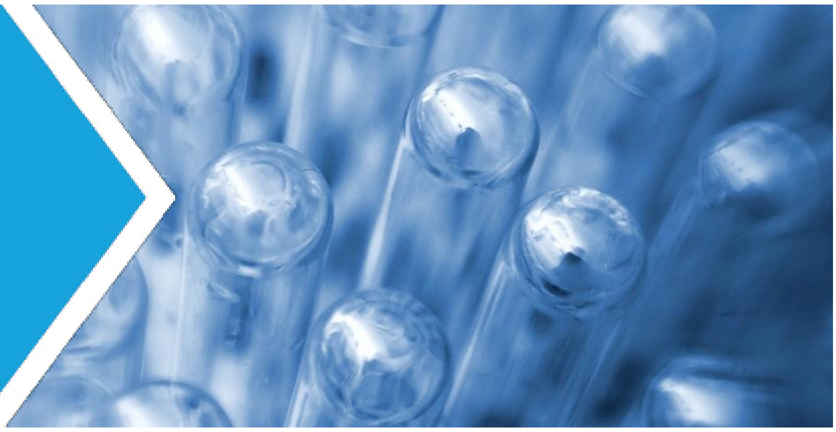
FACT SHEET

Recycling and Recovery of Polyurethanes



CHEMICAL & FEEDSTOCK RECYCLING

Feedstock recycling covers two different technological routes: chemolysis and petro chemical type processes.

The chemical route uses mostly hydrolysis, aminolysis or a glycolyis approach to crack the thermo set resin composition. The cracking is done mostly by chemical means and hence, this technological route is also called chemolysis.

Other cracking technology uses higher temperatures with different types of gaseous composition. Pyrolysis avoids oxygen, gasification operates with low oxygen content and hydrogenation with a hydrogen environment. All three technologies can also be described as typical petro chemical type cracking modes to the PU matrix.

Technology

Chemolysis of PU was developed later, mostly from PU raw material producers: BASF, BAYER, DOW CHEMICAL, ELASTOGRAN and HUNTSMAN, during the time when legislators were forcing raw material suppliers to participate in the recycling hype. Petrochemical cracking of PU foam is done during the > 10 years operating time and in many of the large scale plants for mixed plastics waste. Examples include the large scale operation of gasification (SVZ, Schwarze Pumpe) and hydrogenation (Ruhroel AG, Bottrop) in Germany.

Description

The cracking of the thermo set matrix, mostly flexible or rigid foam mixtures, produces a polyol which can be reintroduced into the PU raw material cycle. These new polyols are not a direct substitute to virgin polyols and recipes for recycled PU foam have to go through a rather diligent formulation change, a demonstration at pilot and full scale foaming lines.

Technology Status

During the years of chemolysis development, all raw materials manufacturers had a medium (1 t/hr) to small size pilot plant, which was used to demonstrate the chemolysis technology on a large enough scale to build a real size plant with 50 kt/year throughput. A plant of that minimum economical size was never built, mostly due to the lack of sufficient homogeneous and good quality EoL PU material, as well as long term contractual feed supply.

PU Specifics

In this type of treatment, the molecules are broken down into smaller building blocks, which may then be reassembled into polymers suitable for use in quality applications, similar to those for which the original components were employed.

Important technologies

Glycolysis means the PU foam is reacted with diols at an elevated temperature (200°C) with a cleavage of covalent bonds. The high molecular weight, cross-linked, solid polyurethanes are broken down to a lower molecular weight, liquid product. Single phase glycolysis is the most widely used technology. Hydrolysis and aminolysis did not pass pilot scale stage. Small scale commercial chemolysis plants exist in; Italy (shoe soles), Austria (elastomeric foam) and Germany (RIM, SS), UK (Flexible slab stock).

The role of petrochemical type feedstock recycling has been diminished to non existence. Cost effective recycling techniques for other feedstocks, such as the use of plastics in iron blast furnaces to substitute coal or heavy fuel is currently practiced in Austria on a very large scale.

Input Characteristics

Most EoL foam from PU has a material composition allowing feedstock recycling to produce polyols or other chemical intermediates. The chemistry of flexible and rigid foam is quite different; consequently, in most cases separated feed streams were used. Compositional decay during lifespan does not limit the feed, but non PU contaminants such as a high content of water, inert or other non PU type polymers will interfere in chemolysis. Other condensation polymers like PET or PA will not.

Market & Cost

Legislative pressure from the end of life vehicle directive and the waste electrical and electronic directive covering refrigerators (WEEE) initiated a strong process development at the major PU raw material suppliers.

Small scale pilot plants still exist to recover post industrial waste for selected production lines of mattresses, shoe soles and RIM. The fact that larger scale chemolysis plants were not built demonstrates the lack of cost effectiveness at that time. Automotive OEMs were in favour of developing this PU specific recycling technology, but the lack of synergies: process flexibility, cost and logistics with other plastics did stop the further realisation of chemolysis.

The petrochemical routes accepting a much broader feed mix offered a better synergy with plastics used in cars. Large scale demonstrating testing was done in different countries such as Germany and Sweden using a refined automotive shredder residue (ASR) stream. The cost of operation did not get paid through the disposal fees that the shredder operators were willing to pay at that time 2000-2005.

Ecology

Many LCA based ecological analyses did show that high efficiency feedstock recycling of a chemolysis or a petrochemical nature were in the class of best technologies, if logistical efforts could be optimised.

Limits

Light and bulky foam does not warrant collection as shown for automotive seating. Synergies with other plastic materials play a decisive role in the economics and less for the technology.

Products

The recycling of PU flexible foam via chemolysis produces a polyol, which is mostly used for rigid PU foam production. A limited or smaller market size of feed and product leads to an imbalance in the market and can result in subsidised unhealthy economics.

Conclusions

Several types of chemolysis processes have been developed for different foam types. Single phase glycolysis is currently applied industrially. In the case of flexible foams, it yields polyols which can replace up to 90% of the virgin polyols in semi-rigid foams, thus bringing the recycled content of “old” foam in the “new” foam to 30%. Technical success does not lead to a commercial reality.

References

See Fact Sheet List of References and suggested reading material.

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