Water White Hydrocarbon Resins – Continuous Hydrogenation in the Buss Loop® Reactor

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Introduction

Hydrocarbon (tackifying) resins are produced by polymerizing what is often considered side -or even waste-streams of petroleum refineries. They are generally characterised as aliphatic, aromatic and/or cycloaliphatic hydrocarbons with unsaturated double bonds. Hydrogenated or 'water white' resins are produced by reacting the resin with hydrogen. The hydrogenation reaction, the subject of this article, improves colour, odour, UV stability as well as heat resistance of the resin by saturating the double bonds and can produce a range of water white resins (fully or partially hydrogenated as circumstances require). These superior resins match specific market demands and are used in a number of applications including adhesives (diapers, sanitary napkins, food packing, automotive), coatings (anticorrosion, steel/aluminium paints), sealants, rubber as well as other applications.

The Buss Loop® Reactor has long been proven as the premier tool to carry out catalysed gas-liquid reactions where gas-liquid interfacial mass transfer frequently limits the overall production rate. The Buss Loop® Reactor also provides high heat removal capacity. Since its development in the late 1940's, this reactor has been used for, among other applications, in hundreds highly exothermal hydrogenation processes. While achieving superior reaction rates, it is also capable of handling solids (powdered catalysts), dissolved and dispersed gas and operating at high pressures and temperatures – making it the ideal choice for hydrogenation of various resin feedstocks.

Photo of water white resin pellets © iStock

Background and Technology Development

The track record of Buss ChemTech's (BCT) involvement in the resin hydrogenation process dates back to the late 90's when it was demonstrated that Buss Loop® Reactor technology suits this particular reaction perfectly, leading to promising reaction rates and excellent product quality. The focus of our in-house development was, in addition to the optimisation of reaction temperature and pressure and identification of a suitable solvent, the selection and validation of a suitable catalyst. A successful catalyst must combine high activity and stability with excellent filterability. These characteristics were found in a supported nickel catalyst developed and supplied by a major catalyst producer. The catalyst is used in powder form in the Buss Loop® Reactor.

Challenges for Process Design and Engineering

The first industrial units were designed as batch plants. While product quality was satisfying from the beginning, the batchwise operation under the harsh reaction conditions (p, T) also brought some drawbacks including the large equipment size as well as high hydrogen and utility consumption (especially for heating raw material). Consequently, the goal was to develop a continuous process to mitigate the drawbacks. A continuous hydrogenation also results in better integration with the continuous upstream and downstream process steps making large buffer vessels obsolete.

Developing the continuous process brought new challenges for designing an industrial scale plant which had to be mastered, e.g.:

- Manage the catalyst inventory at constant product qualities
- Integrate the different sections (upstream, hydrogenation and downstream) where operating conditions need to be controlled and kept constant
- Select equipment and control schemes to manage slurry transfer from high and low pressure and temperature
- Develop and implement a safety strategy to handle deviations from standard operating conditions (backflow, loss of cooling, …)

Besides tackling the above mentioned challenges for the continuous process, an additional key equipment – a cross flow filter – had to be introduced as an integral part of the Loop Reactor. The filter is retaining the solid catalyst particles in the reaction system while the liquid product stream is continuously withdrawn. Sizing and selection of the filter medium for this severe duty process conditions was done based on in-house pilot plant testing. The equipment was designed according to the needs of the continuous process: for long durability without maintenance and maximum retention rates. The solid-free product from the cross flow filter is depressurized and, in downstream processes, the solvent is removed and the resin is typically pastilised and packaged. The solvent is then recycled with minimal make-up requirements. With regard to operating costs, low catalyst consumption and the optimised yet flexible catalyst handling system are key advantages of Buss ChemTech’s continuous resin hydrogenation technology.

The continuous process is self-sustaining i.e. no raw material heating energy is required, It is characterised by only minor utility consumption and high space-time-yield. Due to the high temperature level for the reaction, efficient heat recovery possibilities can be implemented into the process and therefore make use of the evolved reaction heat. Emissions from the plant are in compliance with the highest of standards. Our engineering addresses all aspects of process safety and risk mitigation. These safety considerations also include solutions for a safe catalyst handling (fresh and used) meaning no exposure of personnel or environment to the powder in the industrial plants.

Industrial Scale Units in Operation

Over the last few years, the continuous process was not only developed and designed, but successfully implemented: Six large scale plants have been started up successfully or are under construction around the world. The typical nominal capacity is 20’000 MTPY up to 50’000 MTPY hydrogenated hydrocarbon resin per train.

Photo of Buss Loop® Reactor installation © Buss ChemTech

Outlook

Today, Buss ChemTech is the leading technology provider for continuous hydrogenation of hydrocarbon resin and typically supplies extended basic engineering packages, together with the proprietary key equipment, field services such as commissioning support, training and start-up of the plant as well as process guarantees to customers. Further services are detail engineering support, construction supervision and commissioning support as well as participation in PHA studies (e.g. HAZOP). With our pilot and laboratory facilities, we can respond to special customer requirements, conducting experiments and provide analytical support. With this advantage, BCT can adapt its designs quickly and effectively to the feedstock and site specific circumstances of a client.

BCT is currently expanding its offering to include proprietary technology for the upstream and downstream process steps (polymerisation and evaporation). Furthermore, expected market growth and demand for ever increasing product quality reaffirms the leadership of Buss Loop® Reactor technology.