Saying goodbye to solvents

Dry Processing — a paradigm shift in chemical synthesis

Are you looking for a solvent-free, safe, eco-friendly and energy-efficient way of producing new types of products with new levels of quality? New technology is available to help you do exactly that.

Photos: LIST

With KneaderReactor technology, producers can replace solvent, emulsion and suspension polymerization with bulk polymerization to simplify the process, cut raw materials costs and save energy. The technology is suitable for solvent-free living and radical polymerization.

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As rising demand for energy continues to drive up costs, producers are looking for ways of increasing efficiency. In most cases, it takes a radical change in approach to make a real difference. Rather than continuing to concentrate on individual stages in the process, engineers will have to take a holistic look at the process in order to achieve process and cost optimization.

List's Dry Processing, which eliminates the use of process solvents, is a good example of a paradigm shift in chemical synthesis. Large volumes of solvents and auxiliaries, for example dispersants, have traditionally been used in production. In recent years, however, innovative process technology for direct solvent-free synthesis has emerged. The elimination of solvents significantly reduces energy consumption, investment costs and CO_2 emissions per tonne of material produced. Because the costs associated with emissions will continue to rise in the future, this technology offers a crucial competitive advantage.

In solvent-based synthesis, the reaction mixture has a consistently low viscosity. A conventional stirred tank reactor works well because of the rheological behavior and the certainty that no state or phase changes will take place during the process. When synthesis is complete, the product is mechanically separated from the solvent and dried.

This however presupposes that the product is a solid, which makes it suitable for mechanical solid-liquid separation. This is often not the case, making it necessary to remove the solvent using a thermal process. The solvent is then distilled and recycled.

Managing viscoplastic phases

In contrast to solvent-based synthesis, Dry Processing was developed for direct solvent-free synthesis and downstream processing. A viscous phase is generated during the reaction. Upon completion of the reaction the viscous phase is normally converted into a solid end product. The industrial implementation of Dry Processing requires technologies that can handle viscoplastic phases.

At the same time it must be ensured that large amounts of heat per unit weight of reactant mass are removed to maintain the proper reaction mass temperature. List's KneaderReactor technology has demonstrated the ability to meet these requirements in industrial applications. The milestones are:

- replacement of suspension polymerization in SAP (superabsorbent polymer) pro-

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duction with continuous solvent-free polymerization;
- production of coating resins using bulk polymerization rather than solvent polymerization.

The KneaderReactor technology offers the following outstanding advantages in Dry Processing applications:
- excellent mixing and kneading of pasty and high viscosity phases (>1000 Pa s);
- large working volume reactors efficiently handle large production volumes;
- large heat exchange surface areas maximize productivity;
- excellent self-cleaning;
- narrow residence time distribution;
- high flexibility in terms of production capacity;
- enclosed eco-friendly design;
- robust design, suitable for handling high-viscosity materials;
- compact design maximizes time-space yield.

Applications such as polymerization must meet stringent product quality requirements. In order to comply with the specified product properties, it is decisive to precisely control the temperature of the product during the synthesis. In the KneaderReactors the high surface renewal and the evaporative cooling keep the temperature well under control. The process parameters and product properties are systematically investigated in pilot production units. Industrial production systems can then be tailored to meet the exact product requirements. The new levels of product qualities and the elimination of the solvents, achievable through this innovative technology, open up new fields of applications.

Rigorous testing

The List new process development methodology has a proven track record. The first step is to work with the customer to carry out a feasibility study. A suitable test facility is made available for the study. The purpose-equipped test center ensures the collection of reliable results that build the basis for further evaluations. Once the chemical reaction and the process have been defined, the next step is to validate the process in a pilot system which is designed for semi-industrial throughput and which can be scaled up. Sampling amounts are produced on this system, and the data is collected for subsequent scale up. The process is developed systematically to ensure market acceptance when the product is introduced. Powerful simulation programs are indispensable for development of solvent-free polymerization. The programs are used to create dynamic models of reaction kinetics and thermal energy balances. Using this methodology, the development roadmap can be laid out prior to the first practical trials.

Conclusion: The elimination of solvents increases production efficiency. Higher time-space yields, a reduction in CO_2 emissions, elimination of the distillation process for solvent recycling and a less labor-intensive process can significantly reduce production costs. ■