Flow Chemistry – the future?

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Flow Chemistry – the future?

We live in exciting times.
Never before has the chemicals industry had a similar opportunity to examine itself and make choices in the adoption of innovation. It is singularly fascinating to observe the increasing presence of important players from chemicals and pharmaceuticals manufacturing, academia and innovation-based organisations and enterprises at conferences, symposia and fairs engaged in promoting, debating or simply selling new technologies. Whether one assigns this realism to a sudden realisation of how unsustainable some processes are, or how unsustainable certain feed-stocks might be, the issue remains the same. Innovation is being sought for. In any case, we can safely discount simple cost-cutting as the main driver, when compared with the whole portfolio of challenges facing chemicals producers today. The opportunity lies before us: doing chemistry under more non-traditional extreme conditions is becoming easier.
In recent years, and consistently promoted by Chimica Oggi - Chemistry Today, attention has been given to flow-chemistry as a way to help overcome production pitfalls, perform advanced chemistry more elegantly and safely, and to reduce waste through overall efficiency improvements. It is vital that we see this wave of interest as being sustainable too. And why not? Industry is starting to benefit from the presence of imaginative enterprises, such as Chemtrix, AM Technologies, ESK, Ehrfeld, Vapourtek, Syrris, FutureChemistry, Flowid and many others, as well as large companies making use of their strong expertise in materials, such as Corning. We also need to acknowledge those chemical companies that have invested in their own flow-chemistry developments, such as Lonza, Sigma-Aldrich, Novartis and La Mesta, as well as many yet to be reported corporate achievements. This movement is gaining momentum.
Today, many successes in this field can be assigned to taking a new view on the science of making chemical reactions work. The classic divisions between scientific fields are fading; the spirit of multi-disciplinary collaboration is infectious and is leading to new creativity in industrial processing. We only need to highlight the input of engineering principles into a hitherto organic chemistry-dominated domain to see the kinds of innovations being tried out in fine chemicals and pharmaceuticals manufacturing. Modular manufacturing is also on the horizon, led in fact by some commodity producers who already see the need to be environmentally conscious, as well as being compliant with increasingly tighter rules and regulations. Companies like Akzo Nobel have adjusted their business models to fit with this new reality, in the production, for example, of Chlorine. A similar approach in pharmaceutical, fine and speciality chemical production will bring benefits.

It does require innovation organisations and companies to take a more integrated approach to the design of equipment. Having developed clever reactor systems, an integrated approach to the whole flow-chemistry production process will need to address the dosing of solid, liquid and gaseous reactants.
The development of rapid real-time analytics offers the chance for tighter process control. This is the way to achieve the much

sought-for efficiency improvements. We have seen, especially during the 6th Symposium on Continuous Flow Reactor Technology for Industrial Applications in Budapest, that hazardous reactions and intensified processes (higher temperatures and pressures) become accessible in flow, where in the past they were discarded because of batch-processing limitations.

It leaves us to imagine further developments in innovation for chemicals. Having scrutinised how we make molecules interact more efficiently, what happens to the product stream emerging from our newly-found continuous reactors? Continuous flow-chemistry demands continuous processing and continuous downstream separations. Otherwise we are back to the situation of batch-orientated work-ups.

Steps are being taken to implement techniques borrowed from, say, water treatment, isotopes separation and ink-jet printing, in order to develop efficient, low energy, chemicals separation technologies. The challenges needing to be overcome include, for example, providing a realistic alternative to the versatile multi-purpose configuration of batch processing equipment. It is easy to forget the hurdles to adopting new processing technologies. Often one comes across hesitation based upon the perceived costs of investment. But once the true picture emerges of how the production costs of fine and speciality chemicals are assigned, it becomes clear that the costs of raw materials are dominant, indicating that improved process efficiencies can lead to significant production cost savings. The speed of production in flow chemistry, a parameter now closer related to the reaction kinetics, can indicate a more frequent re-use of process equipment. Each run being more tailored to actual market demand, rather than to minimum batch size, means that the assignable capital charge to unit production costs can move downwards. Inventory control is easier too.

It is only to be expected that no single organisation will deliver all the answers. Rather, collaborations between chemicals companies, innovation organisations and equipment manufacturers will be the key to the development and supply of practical solutions to questions being posed by industry. Such constructions are already the modus operandi of organisations like TNO. The reduction of waste, minimisation of environmental impact, reduction of carbon footprint, a move to smaller factories and better use of renewable energy are all challenges facing chemicals production today. Added to this is the drive to make higher added value speciality and fine chemicals. The intended result, after all, is that the chemicals business should become more sustainable and competitive.

In short, this conjunction of industry drivers and the power to innovate means that the excitement will continue!

REFERENCES AND NOTES

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