CASE STUDY

Microwave Chemistry – From Lab to Plant

Quick Facts...

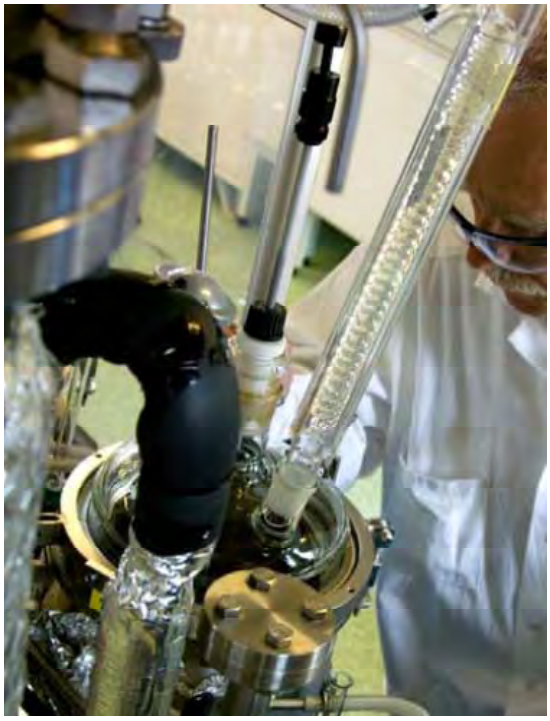
Company
Carbon Trust funded project

Industry
Chemical

Challenges
- Scale-up of microwave chemistry
- Material choice for equipment build
- Increased measurement and control complexities

Solution
- Continuous flow reactor

Outcomes
- Reactor capable of processing 1 tonne per day
- ≤50% increase in yields
- Reaction times reduced by ≤ 99%
- Energy usage reduced by ≤ 90%



Background

C-Tech Innovation undertook a Carbon Trust funded project to quantify the potential energy savings available if microwave chemistry could be scaled up to plant scale. Previously moving directly from laboratory-scale work, where small quantities of compounds are produced for compound libraries, and scaling up to pre-production quantities, has proved difficult to achieve using microwave technology.

Challenges

As scale increases, the advantages using of microwaves compared to conventional methods can be lost. This is because the power generated from microwaves can dissipate rapidly as the distance the microwaves have to travel into the reaction mixture increases. Consequently this can result in overheating at the surfaces, just as is the case with conventional heating. Furthermore materials that are used to build small scale reactors are often not suitable to fabricate larger reactors, and problems of measurement and control can be more acute as the scale of operation is increased.

Approach

We decided to use a continuous flow approach as this would overcome the problem of penetration depth. A thick walled quartz glass tube was chosen as the reactor material as it is chemically resistant, microwave transparent and could withstand the high temperatures and pressures required. A customized seal was then designed to close the reactor tube and contain the microwave field. A fibre optic temperature probe was used to measure the reactor temperature.

Outcome

C-Tech Innovation developed a continuous flow microwave reactor, capable of processing up to 1 tonne of material per day. A range of reactions was used to test the reactor's performance with the following results:

- significant reductions in reaction time (8 h to 3 min) compared to conventional processes
- significant increases in yields (35% to 70%)
- reduction in energy consumption (up to 90% in some cases)
- reduction in CO_2 emissions

The sizable increases in yield observed also had the further benefit of a downstream energy saving as it reduced the degree of purification required and also decreased the volume of starting materials necessary for the reaction. Using a continuous microwave flow approach is also much safer than the batch approach as there is a much lower inventory of hazardous materials.

C-Tech Innovation has demonstrated that large scale microwave chemistry is no longer the future, it is here today.

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