Green Chemistry Centre of Excellence

Microwave Chemistry
MICROWAVE CHEMISTRY

The Green Chemistry Centre of Excellence (GCCE) has been involved for a number of years in research on the effects of microwave radiation on chemical compounds. This has provided new insight and understanding on how microwaves can accelerate chemical reactions.

We have discovered that microwaves may be used to selectively activate components of biomass (trees, grasses, crops, agricultural and food waste, macro and micro-algae, etc.) leading to a much more controlled decomposition process than can normally be achieved, e.g., by using acid treatment. In this way, we are able to make a range of valuable products including liquid and solid fuels, and chemicals from sustainable sources using green chemical technology. We have proven this at scales from grams to tens of kilograms.

MICROWAVE TREATMENT

Microwave technology for heating has been shown to be more energy efficient than conventional methods in many applications. Microwave irradiation is rapid and volumetric with the whole material heated simultaneously. In contrast, conventional heating is slow and the heat is introduced into the sample from the surface. This feature of microwaves is very important for processing poor thermal conducting materials such as wood.

Microwave heating can be controlled instantly and the power applied can be accurately regulated. This allows safe and precise control, even when applying very rapid heating rates. Microwaves also promote novel reaction pathways and can greatly accelerate reaction rates.

BENEFITS OF MICROWAVES

The use of microwaves for the conversion of biomass to valuable products offers a number of very important advantages:

- Lower temperatures
- Mobile processors that can be located next to large concentrations of biomass (e.g. farms)
- Flexible processing enabling the production of liquid fuels, solid fuels and chemical products
- Reduced CO₂ burden and low product carbon footprints
- Rapid, continuous processing and high energy efficiency

Microwave Commercialisation Club

The Microwave Commercialisation Club (MCC) is a multidisciplinary team including experts in chemical engineering, microwave technology, biomass chemistry and process management. The MCC is funded by the EPSRC Impact Acceleration Account – with the overall aim of supporting the transition of microwave technology into industry.
OUR MICROWAVE FACILITIES

We have created a dedicated laboratory scale microwave facility where we can take reactions from 1mL to 1000mL scale under hydrolysis or pyrolysis conditions using our suite of eight microwaves. These include the Milestone SynthWAVE capable of carrying out extraction at high (300°C) temperatures and high pressures (199bar); the Sairem Miniflow configured to run reactions in continuous flow or batch mode and a Milestone RotoSynth fitted with a 2L reactor and specifically designed distillation apparatus to enable biomass pyrolysis to be carried out followed by bio-oil fractionation.

We also have access to scale-up facilities at the Biorenewables Development Centre which is equipped with a microwave pyrolysis unit capable of processing 30 kg/hour of feedstock and a bespoke designed, semi-continuous microwave hydrolysis reactor with a 30L capacity.

Our laboratory and pilot-scale facilities enable us to:

- Conduct our world leading research on the controlled microwave decomposition of biomass
- Optimize process conditions for the preparation of liquid fuel (intermediate), solid fuel and chemical products
- Design associated microwave processing equipment
- Prove processes in continuous mode and in production of multi Kgs quantities of products
- Produce samples and products to allow for commercial decisions to be made

Case Study: Direct Microwave-Assisted Hydrothermal Depolymerisation of Cellulose

The liquid and solid products obtained following microwave irradiation of microcrystalline cellulose was carried out over a range of temperatures. A mechanism for cellulose interaction with microwaves was proposed with higher temperatures (250°C) and higher microwave density resulting in high glucose yields (>20%).
CURRENT PROJECT

InnovateUK, BBSRC, EPSRC IB Cat: Round 3 Early stage translation

Integrated energy efficient microwave and unique fermentation processes for pilot scale production of high value chemicals from lignocellulosic waste (2016-2020, £3.2 M). In collaboration with University of Bath and C-Tech Innovation Ltd, Croda, AB Agri.

Recently, we reported an innovative one-step microwave (MW) process for the depolymerisation of bio-wastes. This key enabling technology achieves high sugar yields despite low energy inputs. Though a range of inhibitors are also formed in the process which limit the growth of most yeasts, we have shown that the robust yeast Metschnikowia pulcherrima (Mp) thrives on this feedstock to produce valuable 2-phenylethanol, arabinitol and a microbial oil akin to palm oil. Therefore this project aims to develop a pilot scale multi-product process by coupling these breakthroughs in low energy waste treatment and unique fermentation to produce high value chemicals.

SELECTED PUBLICATIONS


