Department of Chemistry

Microwave Chemistry
The Green Chemistry Centre of Excellence has been involved for a number of years in research on the effects of microwave radiation on chemical compounds. This has given us 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., 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.

THE MICROWAVE EFFECT

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
We have established a new Biorefinery Microwave Demonstrator

The facility has been established at the Biorenewables Development Centre (BDC), a new scale-up facility at the University of York, which is equipped with batch and continuous microwave processors as well as other cutting edge equipment. Work in the facility is supported by excellent analytical and product characterisation facilities, including Mass and NMR Spectrometry.

Our open-access microwave pyrolysis scale-up equipment is capable of continuous flow up to 30 kg/hour at variable power (6 kW) and has been custom built by SAIREM. This facility is supported by the European Regional Development Fund (ERDF).

We use this facility to:

- Conduct our world leading research on the controlled microwave decomposition of biomass
- Optimise process conditions for the preparation of liquid fuel (intermediate), solid fuel and other 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
Extracting Value from Orange Peel

After extracting the juice of an orange, almost half the fruit is thrown away – despite the peel being a rich source of valuable compounds useful for the production of flavours, fragrances, foods and medicines. We have developed a low temperature hydrothermal microwave process separating pectin from cellulose in the cell wall, without any acid or other additive. The process releases pectin, D-limonene, flavonoids, sugars, furans and cellulose.

Fig. 2. The Microwave Group’s current projects and funding
Selected Published Work on Microwave Pyrolysis


Gronnow, M.J. et al. (2013). Torrefaction/biochar production by microwave and conventional slow pyrolysis – comparison of energy properties. GCB Bioenergy, 5, 144-152.

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