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The role of pyrolysis in the decarbonisation of waste treatment

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Foreword

When high organic-content wastes such as food waste, wood or other forms of biomass material are disposed of in landfill or sent for incineration they generate large volumes of greenhouse gases (methane and carbon dioxide), as well as numerous other atmospheric pollutants such as nitrous and sulphur oxides. In addition, transport off-site from the point of waste generation to a disposal facility can also entail a significant carbon impact depending on the distances involved.

As we look to find solutions that reduce the environmental impact of these facilities and treatments, moving toward a circular economy supports emissions reductions as well as providing cost savings in the process.

Anaerobic digestion (AD) is a process that has been utilised for many years to treat organic wastes and capture the methane produced from the digestion process. However, there are some materials, particularly those with low biodegradability, that are challenging feedstocks for AD and therefore other low-carbon solutions should be considered for these.

What Is Pyrolysis?

One technology that has strong potential as a solution to this is pyrolysis. Pyrolysis is probably best known as the process that converts wood into charcoal but has also been used extensively in the chemical manufacturing industry for producing different types of organic substances such as carbon, ethylene and petroleum-derived chemicals[1]. This thermal degradation process involves heating the feedstock material to a high temperature in the absence of oxygen so that combustion (as happens in incineration) does not occur, or only partially occurs.

Waste feedstocks that are particularly suitable for pyrolysis include materials such as waste wood and off-specification compost (i.e. compost that does not meet a recognised quality standard such as PAS100)[2],[3]. This latter material is particularly significant from an environmental perspective, as off-specification compost is regarded as a waste and needs to be disposed of as such, and with 6.8 million tonnes of biodegradable waste from households ending up in landfill in 2021[4], it is clear that finding an alternative solution for this material is key. The utilisation of pyrolysis to treat this waste-stream into usable materials coupled with avoiding the high cost of landfill disposal can make this an attractive solution, both economically and from a sustainability perspective. Pyrolysis can also be used to process wastes such as rubber tyres that are challenging to recycle, and can augment AD processes through using digestate as a feedstock, thereby recovering even more value[5],[6].

How Can Pyrolysis Decarbonise Waste Treatment?

When the pyrolysis process is carried out at different temperatures or with a variety of residence times within the reactor chamber, different resultant materials are produced[1].

All forms of pyrolysis produce char, a carbon-rich residue[7]. Depending on the feedstock material, char can be utilised in a number of applications including in construction materials or in agriculture[8],[9]. In addition, as high quality biochar such as that produced from compost oversize represents a permanent sequestration of carbon when utilised, it is capable of qualifying under carbon removal certification schemes such as that proposed by the European Commission[10]. Certificates generated by biochar producers will be able to be sold on carbon trading markets and will provide an additional source of revenue. Char from tyre pyrolysis can be used as a carbon-black material in the production of new tyres[5].

Another key offtake from some pyrolysis processes is synthesis gas (or "syngas"). Syngas is a mixture of hydrogen and other gases (including methane, depending on the pyrolysis process feedstock) and can be used on-site in a combined heat & power (CHP) plant to generate low-carbon electricity. This electricity can be used to power the pyrolysis process itself, and when combined with heat from the CHP can make the process self-sustaining[11],[12]. Power from the CHP can also be harnessed in an electrolysis plant to produce green hydrogen, or hydrogen from the syngas can be isolated through first of all increasing yield through the addition of steam and then passing it through a separation process[13].

Pyrolysis also breaks down long-chain hydrocarbons into simpler molecules, including oils. These oils can be used as biofuel alternatives to petroleum that produce significantly lower carbon emissions when burned in a combustion engine[14].

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What Are The Challenges?

The challenges associated with deployment of pyrolysis primarily centre around matching pyrolysis type to feedstock and in the presentation of feedstock to the pyrolysis system. Most pyrolysis systems have restrictive parameters in terms of characteristics such as particle size and shape, moisture content, calorific value, etc. which makes pre-processing of feedstock a key step in the success of any project. It is also important to clearly define the required outputs/offtakes - whether these are to be solely focused on char generation or whether syngas and/or oil production is also required will dictate plant sizing, configuration and thermal requirements. Finally, whether syngas is to be used directly as a fuel source in a CHP or whether hydrogen production is desirable will inform what back-end processes need to be designed into the system. As a result, proper project feasibility needs to be conducted as early as possible in development to ensure that the full potential of this exciting and innovative low-carbon technology is realised.

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