SUPERCRITICAL WATER GASIFICATION OF MICROALGAE

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This chapter reviews recent advancements and major findings in microalgae's supercritical water gasification (SCWG). The reported literature presented here covers a wide range of microalgae species that are compared and discussed for their performance (gasification efficiency and gas yield) in relation to reaction parameters. Despite the number of research works, there are still gaps in understanding the dominant reaction mechanisms, roles of catalysts and practical continuous reactions set up in SCWG of microalgae toward commercialisation of the technology.

MICROALGAE: FUTURE PROMISING BIOMASS

Biomass energy or bioenergy is produced from a wide range of biological feedstocks through different processes in the form of heat, electricity or biofuels. Bioethanol, biodiesel, and bio-jet fuel are common examples of biofuels utilised in transportation. Biomass feedstock includes primary (agricultural), secondary (processed from primary sources such as manure) and tertiary (wastes from human activities) sources. Primary biomass feedstock, especially energy crops like corn, soybean, canola and palm oil, are the most conventional feedstocks because they can be planted and harvested with a continuous supply.

The challenges to transitioning energy dependency from fossil fuels to biofuels are generally from an economic, social and environmental standpoint. Today, approximately 55% of biomass is used for feed and food products, 27% for bioenergy, 8% for biomaterials and 10% for others [1]. The plantation of energy crops typically utilises a similar amount of agricultural land, water and manpower to food plantation, creating competition between agriculture for biofuel and food. Concerns about food security, commodities pricing fluctuations, ecosystem disturbance and biofuels growth limitation are raised surrounding the commercialisation of biofuels.

Microalgae are emerging as sustainable biomass candidates. The tension from supply and demand of biomass feedstock requires alternative sources, such as microalgae which do not conflict with food production. Microalgae are unicellular plant organisms normally found in freshwater or marine systems. They are photosynthetic plants utilising sunlight, carbon dioxide and certain essential nutrients for growth. Microalgae are believed to be promising feedstocks for biofuel production as an alternative to conventional energy crops such as palm, canola, corn and soybean for a few reasons summarised below.

Firstly, microalgae have fast growth rates due to their high photosynthesis efficiency. Their doubling time is less than 24 h and even shorter (~3.5 h) during the exponential growth phase [2]. The exceptional growth rate of microalgae compared to other terrestrial plants makes them be harvested continuously throughout the year to cater to the increasing demand for biofuels.

Secondly, microalgae are rich in oil and lipids. Their oil contents range from 15 to 80% of the dry weight of microalgae biomass, as shown in Table 9.1 [2]. In fact, microalgae have the highest oil yields among the plant oils used for biofuel production. According to Chisti [2], the annual oil yield produced by microalgae (70% oil by weight) is significantly higher than that of other crops such as oil palm, coconut, jatropha, and canola. Mata et al. [3] give a comprehensive list of lipids content and productivities of different microalgae species.

Thirdly, microalgae cultivation does not compete with conventional food crops for arable land. The cultivation land space required to plant the microalgae