Chapter 5
Recent Advances in Fluidized Bed Gasification of Oil Palm Empty Fruit Bunches

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ABSTRACT

The chapter presents recent developments in the gasification of oil palm empty fruit bunches (EFB) through fluidized bed gasifiers. The bioenergy potential of oil palm EFB as an environmentally friendly biomass is presented. Furthermore, the chapter highlights the prospects of utilising biomass gasification technology as a practical method for valorising EFB. The successful development and deployment of gasification for oil palm EFB depends on a critical understanding of the fundamental theories of the chemical reactions, classification, and operational parameters of biomass gasifiers. Hence, the potential use of fluidized bed gasifiers for oil palm empty fruit bunches (EFB) is highlighted in detail. Next, the analysis of the fundamental theories, assumptions, and equations of fluidization critical to fluidized bed gasification of EFB is presented. The chapter concludes by highlighting the potential of oil palm EFB as a low-cost, abundant, lignocellulosic feedstock for valorisation through fluidized bed gasification.

INTRODUCTION

The cultivation of oil palm (*E. guinnensis*) and the production of crude palm oil (CPO) generate large quantities of lignocellulosic wastes in Malaysia. Over the years, the inefficient disposal and management of oil palm wastes (OPW) have presented significant challenges to the oil palm industry. Besides, the rising costs of disposal, stricter environmental regulations, and low-efficiency conversion technologies have increased calls to address the problems associated with OPW in the country. Given this, the government of Malaysia (GoM) enacted the National Biomass Strategy (NBS-2020) to explore the potential

DOI: 10.4018/978-1-7998-0369-0.ch005

of valorising OPW into green chemicals, fuels, materials and energy in Malaysia. The policy also seeks to establish a bio-based energy economy (BEE), reduce greenhouse gas emissions (GHG) emissions, and create 66,000 jobs (AIM, 2013). However, this requires a comprehensive assessment of the biomass supply chain and bioenergy potentials of OPWs. In order to achieve the objectives of the NBS-2020, it is critical to identify and estimate the accessibility, acceptability, and abundance of OPW biomass. Secondly, it is crucial to analyse and select the most cost-effective, efficient, and environmentally friendly technologies for valorising OPW.

According to the Malaysian Palm Oil Board (MPOB), about 99.85 million tonnes of Oil Palm Fresh Fruit Bunches (OPFFB) are annually processed into CPO at over 400 oil palm mills (OPM) in Malaysia (Kamyab *et al.*, 2018; MPOB, 2016). The process results in a significant generation of lignocellulosic solid wastes. It is estimated that for energy 1 kg of CPO produced, approximately 4 kg of wastes are generated during the process. The composition of lignocellulosic wastes generated typically comprises; 23% oil palm empty fruit bunches (OPEFB, 15% oil palm fibres (OPF), and 7% palm kernel shells (PKS) (Basiron, 2007; Umikalsom *et al.*, 1997). Based on the findings, the most abundant OPWs generated in Malaysian OPM are oil palm empty fruit bunches (OPEFB). The OPEFB is the brown, spikey, and fibrous residue generated from stripping the oil palm fruits from OPFFB during CPO production. Due to its high moisture content, OPEFB is bulky and hence considered a low-value OPW that requires significant pre-treatment and processing before it can be utilised for further applications.

The current strategies for disposing and managing OPEFB involve open-air combustion, burying or landfilling, along with utilization as boiler fuel, organic manure, and mulching materials in plantations. However, large stockpiles of OPWs remain unutilized (De Souza *et al.*, 2010; Hamzah *et al.*, 2016). As a result, the wastes present significant waste disposal and management problems for the oil palm industry in Malaysia. Also, the long-term accumulation and poor management of OPW can potentially result in land degradation, GHG emissions, and loss of biodiversity (Mukherjee *et al.*, 2014). However, the potentially damaging effects of OPW wastes could be addressed through the design and development of novel, renewable, and sustainable technologies. It is envisaged that the deployment of these technologies could address the current challenges of OPW and effective valorise the wastes into useful products.

Consequently, numerous studies have examined the potential of valorising OPW through various biomass conversion technologies. Examples of conversion technologies typically employed include; gasification, pyrolysis, liquefaction, torrefaction and combustion (Hosseini *et al.*, 2014; Nizamuddin *et al.*, 2016; Samiran *et al.*, 2016; Sukiran *et al.*, 2017). Based on literature review, gasification is considered one of the most efficient, timely, and cost-effective technologies for the valorising oil palm EFB in literature. In addition, fluidized bed gasification of OPWs is regarded as one of the most promising technology for the valorisation of oil palm wastes, particularly OPEFB which is the most problematic yet abundant OPW from OPM in Malaysia (Lahijani *et al.*, 2011; Lahijani, P. *et al.*, 2014; Mohammed, M. A. A. *et al.*, 2011).

Therefore, this book chapter seeks to identify and highlight recent advances in fluidized bed gasification of oil palm empty fruit bunches (OPEFB). It will also present the fundamentals of gasification chemistry, operating parameters and types of biomass gasifiers. Lastly, an overview of the recent developments in biomass gasification and the fluidized bed gasification of OPEFB will be presented.