CHAPTER 10

Ozonolysis Pretreatment of Empty Fruit Bunch for Total Reducing Sugar Recovery and Lignin Degradation using Response Surface Methodology and Artificial Neural Network

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10.1 OVERVIEW

Empty Fruit Bunch (EFB) are converted into value-added products as it is abundant and low-cost. However, a pretreatment process is required to maximize the Total Reducing Sugar recovery (TRS). The ozonolysis pretreatment has appeared as an effective biomass pretreatment method. This study performed an optimization study of TRS recovery and lignin degradation by ozonolysis pretreatment using Response Surface Methodology (RSM) and coupling Artificial Neural Network (ANN) - Genetic Algorithm (GA). The significant parameters of ozonolysis pretreatment including moisture content, particle size, reaction time and ozone concentration were studied and designed according to the Box-Behnken Design (BBD). The STATISTICA ver. 13.0 and MATLAB 2014b™ software were employed for RSM and ANN models, respectively. The ANN model applies a feed-forward backpropagation neural network and Levenberg-Marquardt (LM) as the training algorithm. Both approaches optimized 95.7% and 96.1% of lignin degradation and 84.9% and 93.2% of TRS recovery under the optimum conditions by RSM and ANN-GA, respectively. The RSM results inferred that the interaction between particle size and reaction time substantially influences TRS recovery. The ANN-GA model demonstrated the superiority of its model in evaluating the non-linear behaviour compared to the RSM model based on statistical analysis.

10.2 EMPTY FRUIT BUNCH

A feasible economics can be guaranteed by replacing the utilization of conventional and non-renewable fossil fuels. Biomass (lignocellulosic) is considered one of the major precursors for the production of renewable bioproducts and biofuels. Currently, palm oil is vital wealth-generating product of some southeast Asian countries including Malaysia, Indonesia, and Thailand. More than 90 percent of world's palm oil supply is covered by these countries. The production of palm oil is accompanied by the EFB as residues and Malaysia alone generated 103 million tons of EFB annually (Salleh et al., 2020). Therefore, there are tremendous opportunities for EFB as a feedstock in the processing of high-value-added goods, which not only satisfies the zero-waste strategy but also generates additional income for the palm oil industry (Kahar et al., 2022; Abdullah et al., 2016).

Unfortunately, the EFB residue are disposed of or burned in oil palm plantations is a common practice for fertilizer production beside relied on the natural decomposition process or being used as an organic mulch on the plantation (Anyaoha et al., 2018). The discovery of the beneficial and practical use of EFB as natural fibre and other value-added biochemicals derived from monomer sugar alleviate the environmental concerns on oil palm waste disposal in the industry.

The fibre of EFB is a lignocellulosic biomass consisting of cellulose, hemicellulose, and lignin (Table 10.1). The high content of cellulose and hemicellulose reflect the consistency of EFB as a potential natural fibre resource (Khalil et al., 2012). However, the rigid and compact structure arrangement of lignocellulosic biomass causes the biomass recalcitrance to hydrolysis as post-treatment (Figure 10.1). The presence of lignin and hemicellulose in the cell walls renders the bio-polymeric structure to be highly resistant to solubilization which inhibits the structural polysaccharides from degradation of cellulose and hemicellulose. Due to the lack of accessibility of complex lignocellulosic biomass structure, the hydrolysis process often became a bottleneck in industrial application which reduces yield efficiency of bioconversion processes such as sugar recovery for bioethanol production (Kumar et al., 2020). Therefore, a requirement of pretreatment steps to degrade the lignin before bioconversion processes is compulsory.

Table 10.1 Chemical composition of EFB (Várnai et al., 2010)

Properties	Values
Moisture (%)	2.4 - 14.3
Proximate analysis (wt.%)	
Volatile matter	70.0 - 83.9
Fixed carbon	9.0 - 18.3
Ash	1.3 - 13.7
Ultimate analysis (wt.%)	
Carbon (C)	43.8 - 54.8
Hydrogen (H)	4.4 - 7.4
Oxygen (O)	38.3 - 47.8
Nitrogen (N)	0.3 - 1.2
Sulphur (S)	0.04 - 1.1

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