

Production of High Grade Solid Fuel from Lignocellulosic Biomass by Solvent Extraction

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Biomass as a renewable energy is highly essential to reduce the dependence on fossil fuels as well as to mitigate the emission of greenhouse gasses. Regarded as an abundant carbon source, biomass also potentially substitutes coal in many applications. Among variety of bioresources, lignocellulosic biomass is considered to be an attractive one as it is costless and widely available.

Nowadays, there are a variety of conversion pathways that have been developed to utilize the biomass, such as combustion, pyrolysis, and gasification. However, despite of its tremendous availability, biomass contains high moisture content and low energy density. It also contains minerals that causes problems in its utilization. Minerals, as particulate matter, deposits in boiler during combustion that accelerates corrosion and erosion [1]. The increased ash deposition also can bring into catalyst deactivation during gasification [2]. In addition, it is also known that minerals can cause severe problems for environment.

Many efforts have been made to upgrade the biomass as a solid fuel. Torrefaction is the most common pre-treatment process for biomass with the aim of reducing moisture content and improving calorific value as well as its grindability. Currently, many researches focusing on eliminating minerals from biomass were also carried out. In Yeong Eom did demineralization of biomass by using diverse solvents (HCl, HF, and water) [3]. It was found that the treatment by acid and water can reduce the ash content from 0.70% to 0.11% and 0.50%, respectively. A similar experiment was carried out by Stylianos and

Tansy. They found that demineralization of biomass not only can reduce the ash content but also increase the yield of bio-oil in pyrolysis process [4, 5]. However, involving acid in the process can cause corrosion problem, while water dilution seems not effective in reducing the ash content. Moreover, acid is also toxic and harmful for environment.

In this study, a new approach for biomass demineralization was introduced. Biomass was extracted by an organic solvent to produce ashless biomass with high calorific value. The same approach has been done with coal for the same purpose. The result shows that the process is effective to eliminate almost all of the ashes [6].

A woody biomass sample was used in this study. The composition of the biomass was determined by proximate analysis, while the calorific value was determined by burning the sample in a bomb calorimeter. A non-polar organic solvent (1-methylnaphthalene (1-MN)) was used due to its good selectivity against minerals [6].

Before being extracted, the sample was firstly torrefied at 200–330°C by N₂ to produce durable, well grinded, and hydrophobic sample. The torrefied samples are shown in Table 1.

Table 1 The Torrefied Biomass Samples

Sample	Temperature (°C)	Calorific Value (cal/g)	Proximate Analysis (%-db)		
			FC	VM	A
Raw	100	4517	17.67	81.79	0.54
T1	200	4643	19.26	79.99	0.75
T2	270	5221	27.43	71.62	0.95
T3	300	5743	33.48	65.67	0.85
T4	330	6221	47.09	51.53	1.38

After torrefaction, a 30 gram of the sample was dissolved in 1-MN with the ratio of 1:9. The slurry was then flowed into a 0.5 L batch reactor and heated to 350°C while agitated continuously. After reaching the

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desired temperature, the temperature was maintained for one hour. After extraction, extracted biomass was separated from residue by using filter. The extracted biomass was heated at 245°C to recover the solvent as well as to get a high grade solid fuel.

Table 2 summarizes the yield of extracted biomass. It shows that ET3 gives the highest mass yield and calorific value. The ET4 only gives 25%, almost as small as ET1. ET1 gives the least yield because T1 contains high volatile matter. On the other hand, ET4 gives small yield because there is a big extractable volatile gas loss for T4 during torrefaction. According to Tabel 2, ET1, ET2, and ET3 contain similar composition: 40% fixed carbon and 60% volatile matter. On the other hand, ET4 contains less volatile matter and more fixed carbon. In addition, all of the extracted biomass can be produced with a negligible ash content.

Table 2 The Extracted Biomass

Sample	Mass Yield (%-db)	Calorific Value (cal/g)	Proximate Analysis (%-db)		
			FC	VM	A
ET1	22	8178	41.84	58.11	0.05
ET2	34	8258	40.49	59.43	0.08
ET3	35	8265	38.92	61.01	0.07
ET4	25	8192	44.68	55.22	0.10

In short, the solvent extraction can effectively upgrade biomass into a high grade solid fuel. Besides ashless, the fuel has a high calorific value that contains almost double as its parent biomass'. Future work will focus on optimum extraction condition, such as temperature and extraction time. Further characterization is also required, such as ultimate analysis and FTIR. Moreover, the fuel also needs to be tested in its downstream application to see the performance during the process.

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