The Influence of processing time on coal liquefaction of low rank coal at low temperature

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Submission date: 18-Apr-2019 12:36PM (UTC+0700)
Submission ID: 1114791814
File name: nfluence_of_Processing_of_Liquifaction_low_rank_coal16042019.pdf (2M)
Word count: 1731
Character count: 9036

The Influence of processing time on coal liquefaction of low rank coal at low temperature

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ABSTRACT

The need for fossil fuels in the form of petroleum is always increasing. Coal has potential as a liquid fuel source. Liquefaction is one of the steps to utilizing low rank coal which are abudance available in Indonesia. In the liquefaction of coal into liquid, solvents and catalysts are reacted with coal. The solvent can act as a hydrogen donor by which react with coal to increasing the H/C ratio. It is well known that liquefaction can be carried out at high temperatures so that it requires a lot of energy. This study is attempted to observe the phenomena of liquefaction at a relatively low temperature. It is expected that practically the coal liquefaction can be more economical from view of processing cost. In this study the materials used include coal, glycerol, phenol and cobalt pentahydrate as catalyst. The reactor used is small with volume of 200 mL and temperature 250 °C.

***Keywords**: liquefaction, coal, low temperature, tetralin, phenol*

INTRODUCTION

The need for fossil fuels in the form of petroleum is always increasing. However, the poduction of domestic petroleum are limited therefore it is need additional supplayer. The abundance of low rank coal can be used as a source of liquid fuel.

Efforts to convert coal into oil or what we call liquefaction have been started by Bergius in around 1932. Generally coal has a majority of carbon, hydrogen and oxygen. Therefore coal has potential to be an alternative as fuel source. To obtain oil from coal, the coal must be reacted with hydrogen. The hydrogen will react with coal to produce hydrocarbon materials by which the H/C of coal liquid will be increased. As a comparison, petroleum has the ratio of H/C is around 1.7 while in coal the ratio ranges from 0.46 to 0.8 (Robinson, 2009).

Several aspects related to coal liquefaction processes have been reported (Robinson, 2009), (Hook and Aleklett, 2009). In coal liquefaction the influence factors are temperature, pressure, catalyst, and solvent. In the research carried out by Ali et al., 2014, it is known that the coal melting temperature around 300°C- 450°C with yield reaches 90%.

To meet the hydrogen's reaction with coal, hydrogen needs to be introduced from the outside. It is reported that solvents that can function as hydrogen donors consist of reactive solvents (Singh, 2015), (Thavasi et al., 2009). Many reports reveal that tetralin is a popular solvent used in coal liquefaction. But the use of tetralin can increase the processing costs of liquefaction. Therefore another source of hydrogen should be derived from other sources that are cheaper. Some sources of hydrogen have been used by researchers (Abdullah et al., 2008). A cheaper source of hydrogen can be used as a mixture of tetralin-glycerol (Ali et al., 2014), (Alvarez, 2013). Other sources can also be used, namely formic acid or propanol (Roger and Zheng, 2016).

Gao et al. (2015), (Wolfson et al., 2013), (Isa, 2017) has studied the effect of solvents and pressure on coal liquefaction and concluded that the pressure and amount of solvents are very influential to increase the yield of liquefaction. A number of reactions can take place with glycerol media (Garscia et al., 2010). In this paper it will be discussed the possibility of coal liquefaction at low temperature around 150°C or 200°C, (Wang et al., 2010), (Shoola, 2015). At low temperature, practically the liquefaction process is cheaper.

METHODS

The low rank coal used in this study came from South Kalimantan Warukin formation. The coal has properties as explained elsewere (Ilcham et al., 2017). The experimental were carried out in reactor with volume of 200 mL. The reactor is equiped by heater, temperature controller and condensor. Firstly coal were pulverized until its size 100 mesh. Next, the

coal with catalist and solvent were put in the reactor then heater and temperature controller were switched on. The catalist is cobalt pentahydrate and the solvent is the mixture of glycerol and phenol with certain ratio. The heating was kept during certain time. After heating the reactor was anealed until ambient temperature. After that, the liquid and solid were take out then separated. Finally, the liquid and solid were measured. The characterization of coal was using Scanning Electron Microscopy (SEM) with model Phenom ProX.

RESULT AND DISCUSSION

1. The influence of time process

The first experiment was conducted with variation of process time. The coal of 100 mesh of 2 grams with solvent ratio glycerol/phenol 15:1 were mixed and put into reactor with temperature kept 300°C. Time process were 45, 60, 75, and 90 minutes. The initial time is measured when heater was switch on. The measurement of liquid and solid are displayed on Table 1.

Table 1. Measurement of product of coal liquefaction

Sample Code	Temperature °C	Process Time, minutes	Coal Residu, grams	Liquid Volume, mL	Loss weigth of coal, %
b	250	45	2.74	20	8.67
c	250	60	2.60	17	13.33
d	250	75	2.24	12	25.33
e	250	90	2.05	10	33.33

The results in Table 1 reveal that during process of liquefaction there are some mass of coal convert to liquid. The percentage of coal that liquify are increasing as well as process time. These results accordance with many explanation that quantitatively product of liquefaction is determined by process time. However the maximum results will be obtained at temperature around 400-450 °C (Ali et al., 2014).

The observation on residues reveals that during liquefaction coal undergo physically tansformation. It can be seen on Fig 1 that within 30 minutes (**Fig 1.b**) coal began to break. The breaking of coal completely when heating off at 45 minutes (**Fig 1.c**). Continously heating has resulted changing of coal physically similarly (**Fig 1.d** and **1.e**).

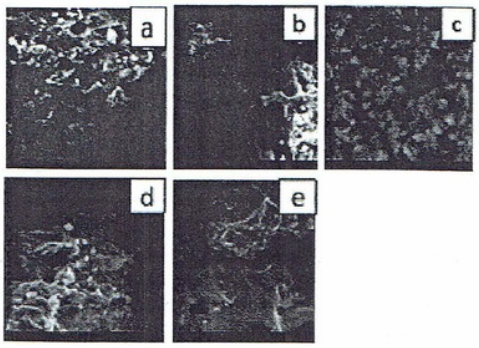

Fig 1. The micrographic on residues of coal liquefaction with different of processing time: a. Coal before liquefaction, b 30 minutes, c 45 minutes, d 60 minutes, e 90 minutes processing time respectively.

CONCLUSION

- The maximum results will be obtained at temperature around 400-450 °C
- The quantitatively product of liquefaction is determined by process time
- The continously heating has resulted changing of coal physically similarly

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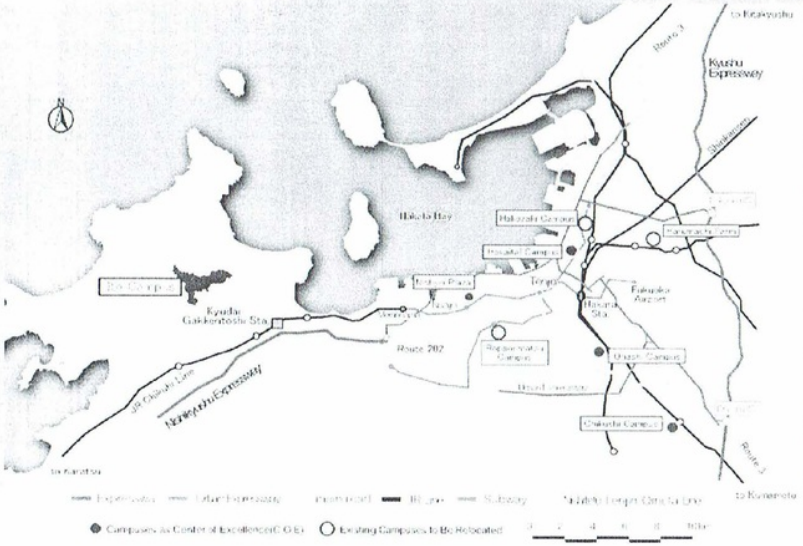

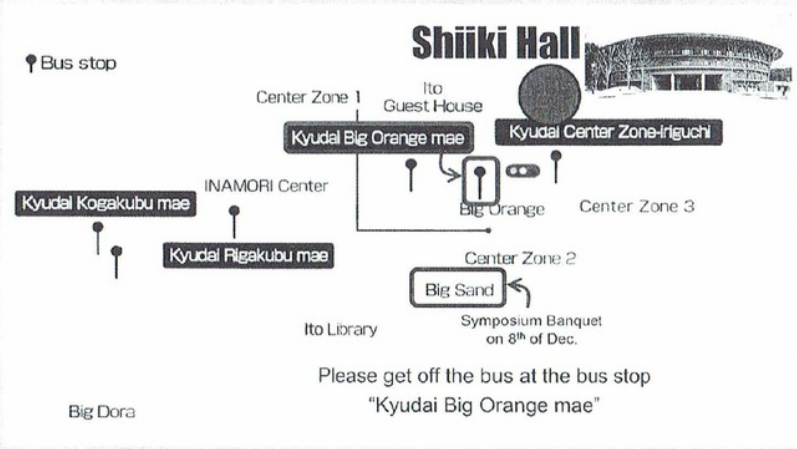

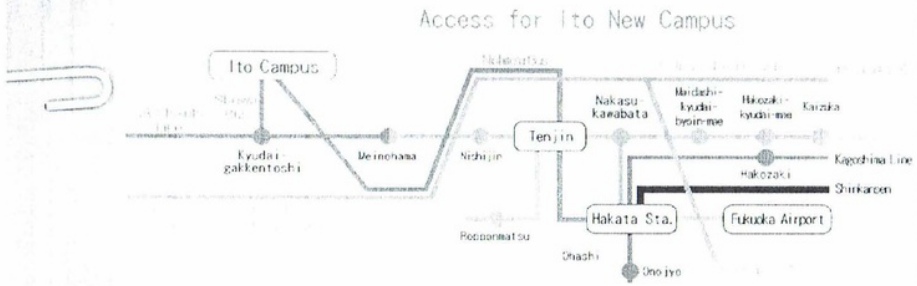

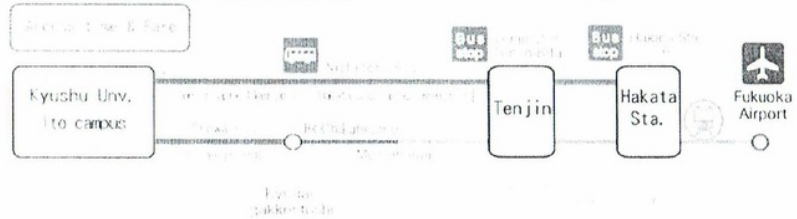

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