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Research Notes

Thermal Drying Methods on Coal Liquefaction Conversion

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Abstract: The sample coal used in this work was lignite containing 25% of moisture and 19% of ash from Canada. Drying of lignite coal had considerable influence on the coal liquefaction conversion. Vacuum dried and nitrogen dried samples provided higher conversion than air dried samples. The air drying showed nearly lower conversion, which probably as a result of oxidation. Air Drying seems to add oxidation to form more oxygen functional groups which increases the cross-linking reactions in the early stages of liquefaction. Among three thermal drying methods, vacuum dry provided highest conversion. It was expressed that coal sample with lower amount of moisture revealed higher conversion. Both temperatures and drying times seem to be key variables which impacted coal liquefaction conversion.

Keywords: Coal Drying, Liquefaction, Coal Conversion, Lignite, Oxidation

Introduction

According to some estimates, nearly fifty percent of the coal resources of the world are low rank coal, such as lignite coal. Lignite coal is plentiful in Canada and plays a significant role in power generation (Heydari *et al*., 2016). Especially for low rank coals such as lignites with high moisture content, treatment of these coals by different drying techniques can improve coal liquefaction conversion. High moisture content of the these coals are the main shortcomings and lead to some inconveniencies such as growing the transportation cost, reducing the thermal efficiency of the plant, enhancing the GHG emission and causes some difficulties during milling and transportation, therefore it is expected an economic essential to dry these coals before coal liquefaction processes (Karthikeyan *et al*., 2009). The storage condition of coal is critical as the coal after dried has a tendency to adsorb moisture too fast nonetheless of being drying under different situations. Elimination of moisture from the coal matrix prior to liquefaction can decrease the cost of both wastewater treatments and separating water from the coal itself (Song *et al*., 1994; Yu *et al*., 20163; Itay *et al*., 1989; Höök and Aleklett, 2009; Miknis *et al*., 1996).

Materials and Methods

The lignite coal in this study contained high moisture received from Poplar River Mine located in Southern Saskatchewan, Canada. The bulk coal samples was crushed by jaw crusher and powdered in a ball mill and mixed to homogenize the coal and reduce the particle size to 60 mesh (-250 µm) to characterize these samples. The sample was dried under air, vacuum and nitrogen atmosphere at various drying times to evaluate the effect of drying on coal conversion. Experiments were accomplished in a stirred autoclave for 1 h, at 12 MPa and 415°C with a coal–derived solvent with hydrogen gas. A 500 mL (Fig. 1)) reactor was loaded with 105g of solvent and 50 g of coal sample. The reactor was purged three times with Nitrogen gas to minimize the amount of Oxygen in the system and hydrogen gas is then introduced to the system. The reactor is cooled down to 100°C and pressurized gases are purged into the fume hood. Subsequently, THF is used to clean the reactor. The mixture of coal liquid and THF is then filtrated via a filter paper using a vacuum pump. The solids collected are called as coal residue. The coal liquid is then placed into the rotary evaporator to collect THF. The proximate Analyses were conducted on Dry Ash Free basis (DAF) and listed in Table 1.

Table 1: Proximate and ultimate analysis of poplar coal

Proximate analysis	wt%	Ultimate analysis	daf, wt%
Volatile matter	30.44	C	41.07
Fixed carbon	24.18	H	5.72
Ash	19.53	O	51.57
Moisture	25.85	N	0.72
		S	0.92

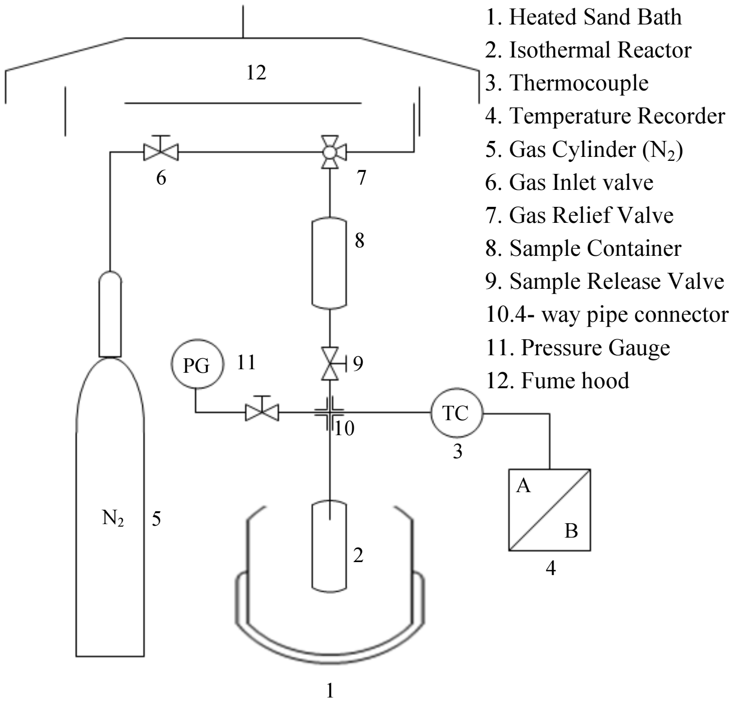

Fig. 1: Schematic diagram of experimental setup

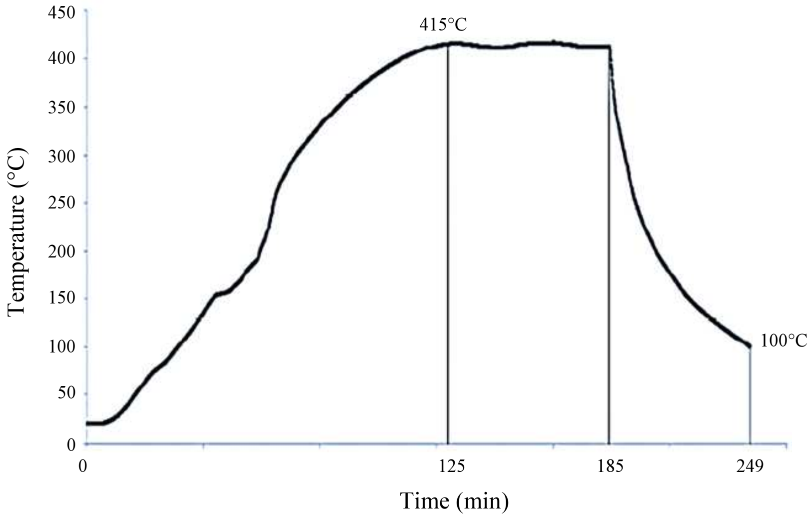

Fig. 2: Typical time-temperature profile for coal liquefaction

Results

Figure 2 explains the time-temperature history of experiment. It took almost 2 h for achieving to the desired temperature and leveled off at the same temperature for 1 hour. The cooling down process proceeds 1 h to 100°C in order to open the reactor and release the pressure. Figure 3 represents effect of different drying methods on Coal liquefaction conversion. Among three drying techniques, vacuum dry displayed highest conversion. In comparison between the air dried and vacuum dried samples, the conversion are similar. This result suggests that the oxidation may not happen to air dried samples when they were dried in short period of time here 1 hour. On the other hand, for the added water coal sample, although the moisture has been added to be the same as the as received coal, drying of coal had synergetic effect on coal conversion in comparison to raw coal without any pretreatment.

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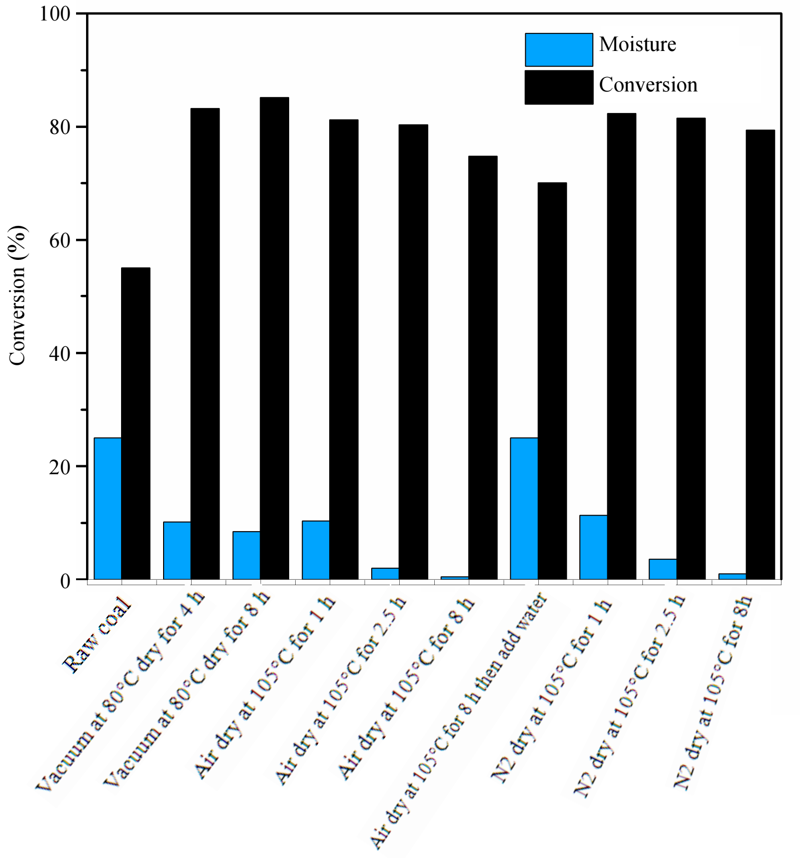

Fig. 3: Coal liquefaction conversion versus different drying methods

Discussion

According to our overall observation, the samples with lower moisture content provided higher conversion. This observation backs up the hypothesis regarding to the relation between the moisture and conversion of coal to liquid. Air Drying seems to add oxidation to form more oxygen functional groups which increases the cross-linking reactions in the early stages of liquefaction.

Conclusion

Drying at air has negative effects on the coal conversion because considerably improve oxygen functionality which increases the cross-linking reactions in the coal liquefaction process. Conversion between air dried and vacuum dried samples are very similar. This is due to the short drying time (less than 3 hours) of air dried samples that minimize the possibility of oxidation. It was stated that the coal sample with the lower moisture content provided higher conversion at around 82%. As coal is dried for long period of time (8 hours), the oxidation will most likely take place. On Industrial scale, it would be more cost effective if coal is dried under air for short period of time less than 1 hour where the cost of energy used for drying is minimal. However, vacuum dried is only applicable in lab scale. It was concluded that both temperatures and drying times would be considered significant variables which modified coal liquefaction conversion.

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Ethics

The manuscript has not been published previously, and is not under consideration and the results of this study are extracted from PhD thesis of the corresponding author.

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