MOISTURE EFFECT ON CO_2 ADSORPTION ON COAL

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Overview

CO_2 mitigation into a coal reservoir is advantageous for CO_2 sequestration and enhanced coalbed methane (ECBM) recovery (Pan et al., 2018; White et al., 2005). Much research has been conducted on the main factors for CO_2 adsorption onto the coal, and it has been discovered that moisture has the most significant impact (Crosdale et al., 2008; Hao et al., 2018). Many scholars have focused their research on dry and wet coal to identify the possibility of increasing the storage of CO_2 in the coal seam (Pan et al., 2010). The change in physical properties, including making a variety of moisture, affected the adsorption capacity of coal (Wang et al., 2021). To study the moisture effect, the measurements of CO_2 adsorption capacity on fresh and dry coal with similar characteristics but different moisture content under average temperature and pressure. The research aims to compare dry and fresh coal to know how significant the presence of water molecules is for CO_2 adsorption.

Methods

Samples were taken from the thickest coal seam on three coalfields in Indonesia's South Sumatra Basin. The samples were crushed to 0.25 mm (60 mesh) for coal characteristics, moisture content, and adsorption analysis. This research does coal characteristics using proximate analysis following ASTM D3172-73 guidelines. The preparation of petrography organic was done following ASTM D2798-72 and analyzed based on ICCP (International Committee for Coal and Organic Petrology (ICCP), 2001; Pickel et al., 2017; Sýkorová et al., 2005). Moisture content was determined by weighing approximately 1 g of coal, heating it to 105 ℃, and then re-weighing the dry sample at room temperature. This method was developed based on ASTM D3173-73. Adsorption analysis was performed with the weight of all coal samples for fresh and dry coal, which was 5 g. For dry coals, coal samples were dried for two hours in a vacuum oven at 105 ℃. The dried coal samples were transferred abruptly to the sample cell to avoid any exposure to oxidation or moisture after the drying process. Isotherm determination used a volumetric method (Figure 1). Adsorption analysis was done with six pressure steps (0.5, 1, 1.5, 2, 2.5, and 3 MPa) at 45 ℃. The free volume of the system was determined by injecting helium into the system and placing a sample on the sample cell. After determination of the free volume, the cells are evacuated. CO_2 is introduced into the reference cell and allowed to equilibrate, waiting until the pressure is constant for 30 min. The reference cell is opened, and the system is allowed to equilibrate until there is no change in the pressure for 24 h. Adsorption was calculated as the Gibbs excess adsorption (n^{ex}) and adsorption isotherm was determined using the Langmuir model.

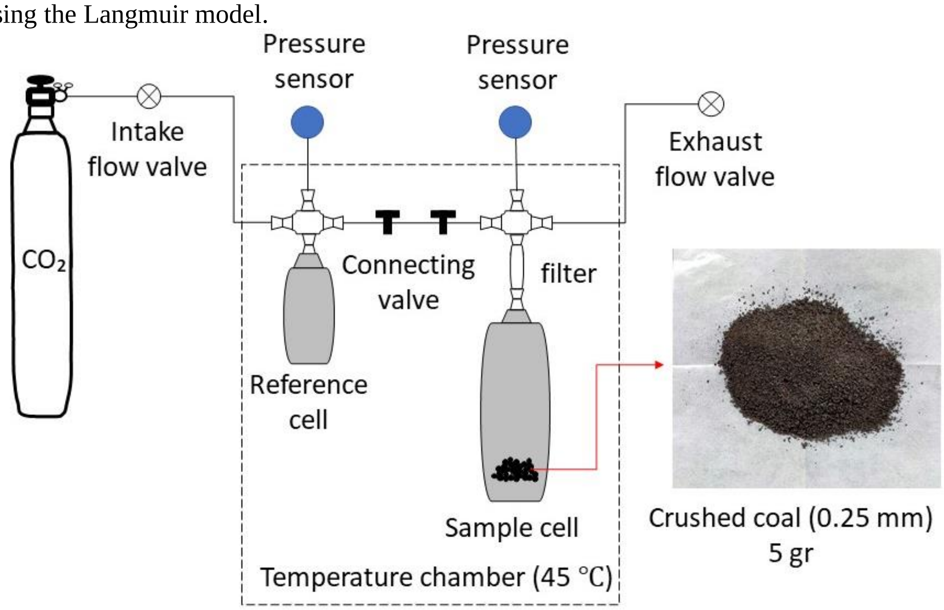

Figure 1. Volumetric method in this study

Results

The samples from three different coalfields show different moisture content but similar characteristics. The proximate characteristic analysis shows three low-rank coal samples with vitrinite reflectance (0.49-0.57%). The coalfield has the similarity to coal rank but is slightly different in coal lithotype where coal samples from West Banko (WB) were banded-dull, coal samples from East Banko (EB) were dull, and coal samples from North Muara Tiga Besar (NMTB) were banded-dull. A sample from West Bangko (WB) shows lower moisture content (16%, a.r) than coal from East Bangko (22%, a.r) and North Muara Tiga Besar (23%, a.r).

CO_2 is injected into fresh and dry coal to know coal adsorption capacity from South Sumatera. The curves of the adsorption isotherms of fresh and dry coal are all similar to the Langmuir adsorption isotherm. Equilibrium pressure in the same pressure show fresh coal has a higher pressure equilibrium than dry coal. Along with higher pressure, the amount of CO_2 absorbed by coal samples with higher moisture content is lower than coal samples with lower moisture content.

In the fresh coal experiment, coal with lower moisture content has a higher n_{ex} than coal with higher moisture content. Low-rank fresh coal has a significant water-holding capacity (Chen et al., 2018), and this condition leads to coal with more moisture having a limited pore surface and making fewer adsorption sites for CO_2 (Cheng et al., 2017). The result shows that CO_2 adsorption on dry coal makes significant differences from fresh coal. Like fresh coal conditions, the drying process makes the adsorption site more available for CO_2. Since the dry coal has abstained from moisture, the effect of moisture between dry coal makes it hard to define. The difference in adsorption on fresh coal has the most considerable effect due to moisture. Meanwhile, adsorption on dry coal is primarily due to other coal characteristic effects like ash yield or coal petrography. This condition proves that water rather than CO_2 molecules dominate coal with higher moisture content and adsorption sites.

Conclusions

The measurement of CO_2 adsorption capacity on fresh and dry coal shows that the presence of water molecules creates significant CO_2 adsorption capacity. Water molecules competed with CO_2 molecules for adsorption sites, reducing coal's ability to absorb CO_2.

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