Evaluation of Carbon dioxide Adsorption and Desorption Isotherm on Malaysian Coals

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Abstract*—Gas adsorption is considered as one of the major storing mechanism during carbon dioxide (CO_2) sequestration in coal bed seam. It is necessary to study the CO_2 adsorption and desorption isotherms on Malaysian coals. The coal samples which have tested in this study are from lower and upper zones, Merit-Pila mine and Area 1 and Area 4 coordinates, Mukah-Balingian mine, Sarawak, Malaysia. BELSORP-miniII instrument have been utilized to measure CO_2 adsorption and desorption isotherm of those coal samples at 298.15 K (25°C) and at up to 101.33 kPa (1 atm). Coal samples from Area 1 and Area 4 coordinates have the highest adsorption capacity by 5.0152×10^{-4} and 4.9725×10^{-4} mol/g respectively. According to IUPAC classification of adsorption isotherms, CO_2 adsorption isotherm of all coal samples follow type I which most probably describe the adsorption limited to a few molecular layers (micropores). The results of adsorption and desorption isotherm demonstrate that there is hysteresis between adsorption and desorption isotherms for all coal samples. The coal samples from lower and upper zones (Merit-Pila coal mine) have the highest hysteresis level compared to samples from Area 1 and Area 4 coordinates (Mukah-Balingian coal mine) which show a positive hysteresis between their adsorption and desorption isotherms. According to hysteresis classifications, the hysteresis during CO_2 adsorption and desorption process for coal samples from Merit-Pila and Mukah-Balingian mines follows type H_4 which describes micropores and mesopores ranges. The evaluation of the equilibrium adsorption data using the adsorption isotherm and kinetic model were tested where Langmuir adsorption isotherm and the linear driving force model (LDF) provided the best fitting of the adsorption experimental data.

Keywords— Coal; CO_2 adsorption; Desorption, Hysteresis.

I. INTRODUCTION

Geological storage of carbon dioxide (CO_2) in deep unmineable coal seams is one of new disposal methods with or without enhanced coal bed methane recovery. Unlike other conventional geologic reservoirs, CO_2 sequestration in coal bed seams is a complex process, mainly due to the extremely complicated and heterogeneous nature of the coal bed seam [1] and extreme coal bed seam conditions. Coal is considered as an organic polymeric material and comprises some inorganic impurities. Hence studying and understanding the interactions of CO_2 with coal under different pressures and temperatures is essential.

According to White et al which reported that 95ï 98% CO_2 stored by adsorption mechanism in the coal matrix depends on the gas in the coal bed seam and there are other trapping mechanisms such as gas trapped within the coal matrix structure, free gas and gas trapped as a solute in the pore water [2]. CO_2 storage in coal bed seams mainly depends on the adsorption properties of the porous coal structures [3].

For the determination of gas adsorption and desorption isotherms of porous materials such as coal, there are three different techniques are commonly used. The techniques differ in terms of the physical parameters used to determine the isotherms. In the manometric, the amount of sorbed gas is measured by reading gas pressure. In volumetric method, the amount of sorbed gas is measured by reading gas pressure or gas volume. The manometric and volumetric method requires a very accurate determination of cell and void volumes. In gravimetric method the amount of sorbed gas is measured by reading sample (sorbent) gravity at constant pressure by means of an accurate balance with the sample either suspended mechanically or by magnetic coupling across the wall of a high-pressure vessel [4].

Normally, deviation occurs between adsorption and desorption isotherm of gases on porous materials. This deviation between adsorption and desorption isotherms is called sorption hysteresis which indicate that coal desorbs less gas than the sorption volume in the adsorption isotherm at the same pressure (positive hysteresis). The hysteresis degree is independent of individual coal physical properties (surface texture, permeability, porosity, surface area, pore volume) and operating condition (pressure and temperature). J. He et al reported that there is a hysteresis between CO_2 adsorption and desorption isotherms in both dry and wet coals at 45°C [5]. CO_2 sorption hysteresis is favourable for the long-term stability of CO_2 sequestration [6] because if there is hysteresis this means coal desorbs less gas than the sorption volume in the adsorption isotherm at the same pressure (positive hysteresis). There are hypotheses have