CO$_2$ sorption properties of the selected lithotypes of lignite from Polish deposits

Barbara BIELOWICZ[1] and Paweł BARAN[2]

[1] AGH University of Science and Technology, Faculty of Geology, Geophysics and Environment Protection. al. Mickiewicza 30, 30-059 Kraków, Poland; bbiel@agh.edu.pl
[2] AGH University of Science and Technology, Faculty of Energy and Fuels, al. Mickiewicza 30, 30-059 Kraków, Poland

Introduction

Sorption studies aimed at determining the CO$_2$ sorption capacity of coal were carried out using four ortho-lignite and one ortho-bituminous coal samples. Determining the CO$_2$ sorption capacity of coal, that is the maximum amount of substance that can be absorbed by the unit weight of the sorbent under certain conditions of pressure and temperature, is based on the gas content of coal.

Samples and methods

The studies have used the lignite samples collected from the currently exploited and perspective deposits. An original instrument was used for measuring sorption isotherms and the desorption of gases (vapors) at elevated pressures (Nodzenski, 1998). The equations determining a number of parameters and indicators used in order to better describe the experimental data and to differentiate the examined samples include: the Langmuir isotherms, Dubinin-Radushkevich equation describing the theory of volume filling of micropores, and the BET equation used to calculate the volume and surface area of the monolayer. The obtained results were compared to the petrographic composition, ultimate, and proximate analysis of lignite. All chemical and technological analyzes were performed in accordance with ISO standards.

Results

The gas content of coal is the total amount of gas contained per unit weight of coal under certain conditions of pressure and temperature. The gas content of coal Vg is the sum of the gas volume absorbed per unit weight of coal and the volume of the so-called "free gas" or unabsorbed gas contained in the pore space. The gas content isotherms are presented in Fig.1. The equations determining a number of parameters and indicators used in order to better describe the experimental data and to differentiate the examined samples include: the Langmuir isotherms (Langmuir, 1918), the Dubinin-Radushkevich equation (Dubinin, Zaverina, & Radushkevich, 1947) describing the theory of volume filling of micropores, and the BET used to calculate the volume and surface area of the monolayer (Gregg & Sing, 1995).

Conclusions

The carbon dioxide sorption capacity of the examined lignites is highly variable despite their similar lithological development. The determined sorption isotherms were described using the Langmuir, BET, and DR equations. The formal description of experimental isotherms allowed determining constant equations of sorption isotherms. It has been confirmed that all the three equations well describe the examined coal-gas system. The analysis of the constants of the DR equation has shown that the analyzed lignite samples practically do not have micropores, hence the mesopore pores are the reason behind a relatively high sorption capacity. The calculated constants were subjected to statistical analysis in relation to the parameters obtained as a result of elemental, technological and petrographic analysis. It has been found that the CO$_2$ sorption capacity is clearly associated with the gelification index. The degree of gelification of macerals from the huminite group is indicated by the gelification index (GI), which differentiates gelified macerals from the ungelified ones. A continuous presence of water is a prerequisite for gelification, while fluctuation in water table affects the GI; this is due to the fact that inertinites are usually formed during dry periods. Therefore, it can be concluded that the sorption properties increase with the increasing content of gelified components. In the case of examined samples, the lowest sorption capacity has been recorded for detritic lignite with high ash content, which, at the same time, was of the lowest rank. The CO$_2$ sorption capacity of coal increases with the degree of coalification and is the highest in mixed detro-xylitic and xylo-detritic lithotypes with low

attrinite content. Based on the obtained results, a preliminary determination of sorption properties of the prospective deposits and the suitability of coal for CO_2 storage can be made.
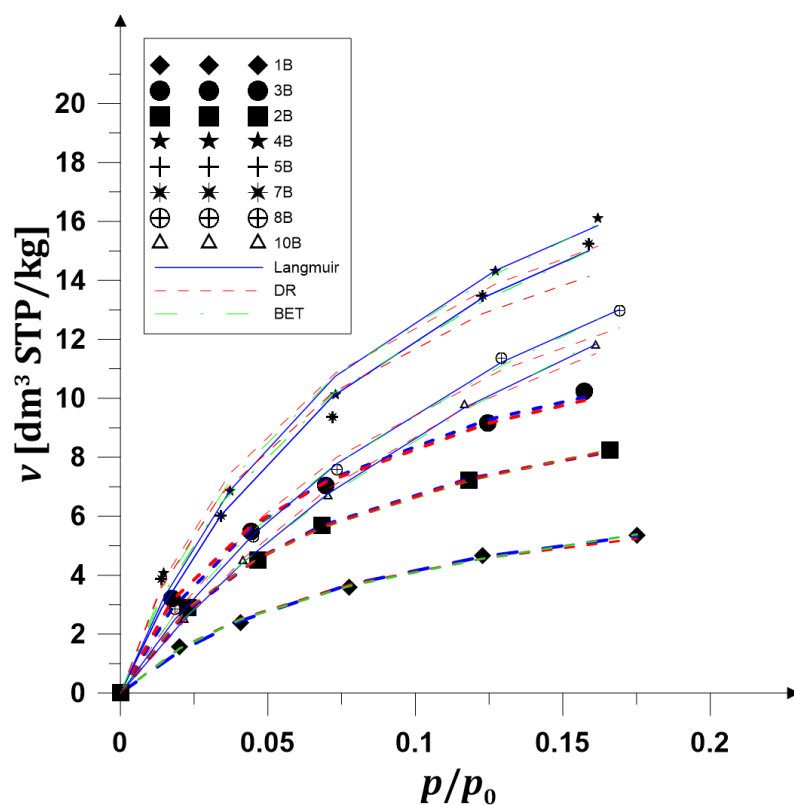

Figure 1. The CO_2 content isotherms at 298 K for low-rank coal samples 1B - Jóźwin detritic lignite; 2B - Jóźwin xylitic lignite; 3B - Jóźwin detro-xylitic lignite; 4B   - Turów xylitic lignite; 5B - Turów xylo-detritic lignite; 7B - Sieniawa xylo-detritic lignite; 8B - Sieniawa xylitic lignite; 10B - Bełchatów xylo-detritic lignite.

Acknowledgements

References

Dubinin, M. M., Zaverina, E. D., Radushkevich, L. V., 1947. Sorption and structure of active carbons. I. Adsorption of organic vapors. Zhurnal FizicheskoiKhimii, *2*, 1351–1362.

Gregg, S. J., Sing, K. S. W. (1995). Adsorption, surface area, and porosity (2nd ed.). London : Academic press.

Langmuir, I. (1918). The adsorption of gases on plane surfaces of glass, mica and platinum. Journal of the American Chemical Society, 40(9), 1361–1403.

Nodzenski, A. (1998). Sorption and desorption of gases (CH_4, CO_2) on hard coal and active carbon at elevated pressures. Fuel, 77(11), 1243–1246.