# Effect of Carbonization-Induced Crystalline Structure on Pore Development and Methane Adsorption of Coconut-Based Activated Carbons

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The generation of organic waste resources, such as livestock manure, sewage sludge, and food waste has been continuously increasing due to population growth and industrial development. These organic wastes are converted into biogas through anaerobic digestion processes in biogasification facilities, and the produced biogas is subsequently upgraded to high-purity methane for use as an energy source. However, biogasification facilities are generally located in suburban areas due to land availability requirements and odor-related issues, whereas the major demand for methane is concentrated in urban regions. Therefore, the development of efficient and safe methane storage and transportation technologies is essential for the effective utilization of biogas-derived methane. Among various methane storage technologies, adsorbed natural gas (ANG) storage has attracted significant attention, as it enables methane storage in porous materials under ambient temperature and relatively low pressure (~3.5 MPa). Compared to conventional compressed natural gas (CNG) and liquefied natural gas (LNG) technologies, ANG offers higher energy efficiency and enhanced storage safety. The performance of porous materials for methane storage is strongly dependent on a high specific surface area and a micropore size distribution in the range of 0.7–1.0 nm. Accordingly, most previous studies have primarily focused on activation processes to increase pore development. Nevertheless, controlling the pore structure of porous materials solely through activation processes has intrinsic limitations. To achieve more precise control of pore architecture and further improve methane adsorption performance, it is necessary to regulate the crystalline structure of the precursor materials prior to activation.

In this study, coconut-derived activated carbons (C-AC) were prepared via carbonization at temperatures ranging from 600-900 ℃, followed by steam activation. The relationship between pore structure and methane adsorption behavior was systematically investigated. In particular, the influence of crystalline structure evolution induced by different carbonization temperatures on subsequent pore development was examined through comprehensive analyses of textural properties and crystal structure. As a result, the degree of crystallinity of the C-AC increased with increasing carbonization temperature, which restricted pore development during steam activation and led to a decrease in specific surface area and total pore volume. As the carbonization temperature increased, the crystalline structure of the C-AC increased, which restricted pore development during steam activation and resulted in a decrease in specific surface area and total pore volume. Consequently, the C-AC carbonized at 900 ℃ (C900) exhibited a lower specific surface area compared to C-AC carbonized at lower temperatures (C600–C800). Despite this, C900 demonstrated the highest methane adsorption capacity among the samples. In particular, the C-AC C900-H950-60 achieved a maximum methane uptake of 9.5 wt.%. These results indicate that controlling the crystalline structure of the carbon precursor enables regulation of pore development during activation, allowing the fabrication of porous carbon materials with enhanced methane adsorption capacity even at comparable specific surface areas.