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Study of pore distribution in activated carbon by low-temperature nitrogen adsorption

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INTRODUCTION

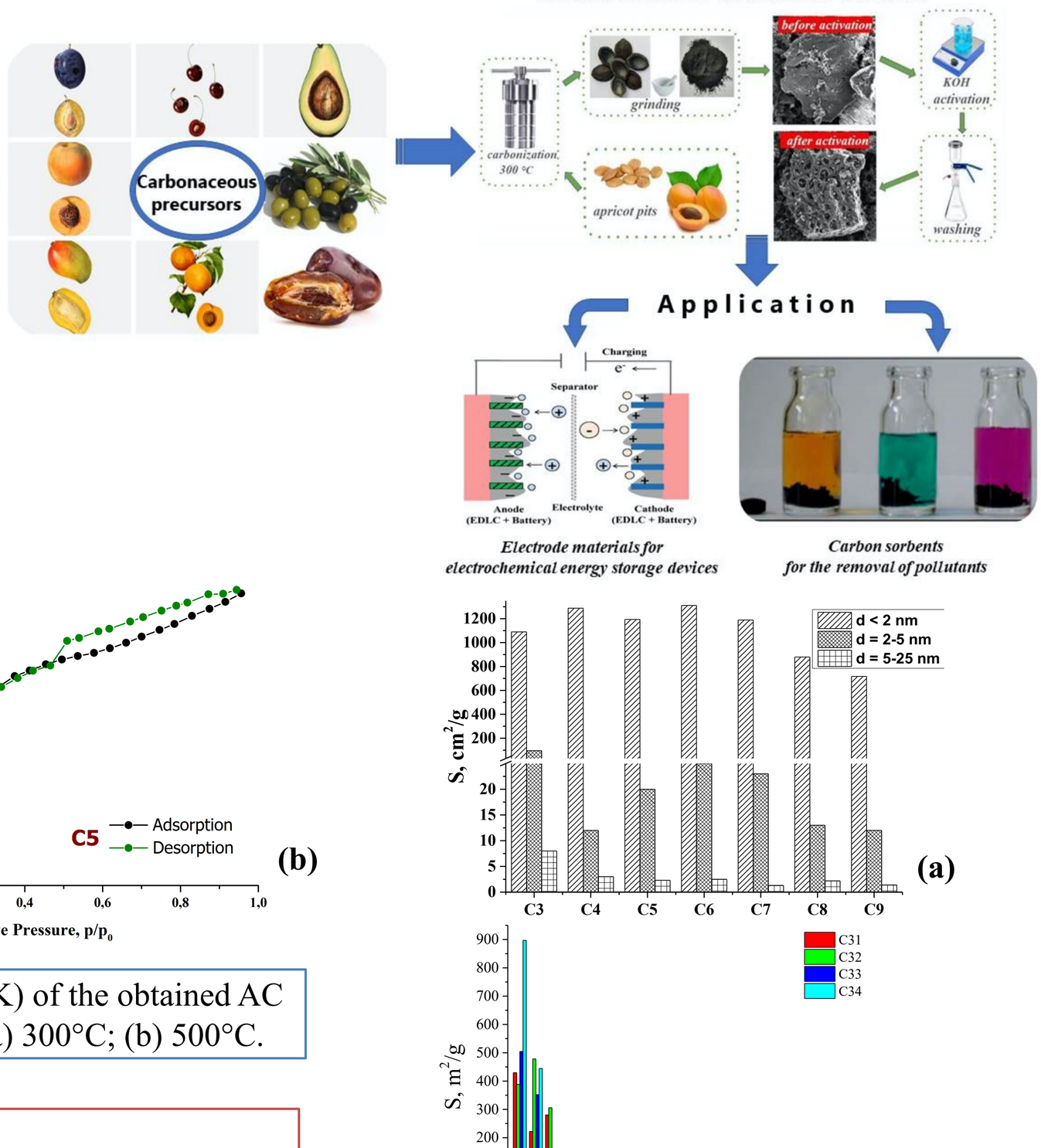
Gas adsorption plays a crucial role in the characterization of a wide range of porous materials. Among the many gases and vapors that are readily available for use as adsorptives, nitrogen remains universally preeminent. The surface area and pore size distribution of solid catalyst materials can be determined through gas adsorption–desorption measurements at 77 K. For pore structure analysis, nitrogen adsorption–desorption isotherms should be measured over the widest possible range of relative pressures while accounting for slow equilibration and other operational challenges, particularly at very low pressures.

Numerous methods exist for calculating surface area, pore size, pore distribution, and pore volume by fitting isotherm data to different models. For example, the Brunauer–Emmett–Teller (BET) method is commonly used to determine surface area, while the Barrett–Joyner–Halenda (BJH) model [1] is applied for pore size distribution analysis. Sing et al. classified pores in the context of physisorption into four categories based on their size: macropores (>50 nm), mesopores (2–50 nm), micropores (<2 nm), and ultramicropores (<0.7 nm) [2].

RESULTS AND DISCUSSION

This study investigates the effect of carbonization temperature on the porosity and surface area of KOH-modified activated carbon (AC) samples. Raw material of plant origin was carbonized in a closed furnace at temperatures ranging from 300 to 900 °C. Therefore, additional processing, such as activation, was required. To determine the effect of the chemical activator on the formation of the porous structure, the obtained carbonized material was mechanically crushed, mixed in different mass ratios of AC/KOH, stirred for 1–2 hours and heated in an Ar atmosphere. to 900 °C, followed by isothermal exposure. Subsequently, mineral impurities and ash were chemically removed from the samples using hydrochloric acid (HCl).

THE LOW-TEMPERATURE NITROGEN ADSORPTION METHOD (LINAM) was used to detect the mesopores of seven apricot-derived carbon materials, and the experimental results are analyzed in this paper. The minimum pore diameter detectable by LINAM is 0.6 nm, facilitating the study of pore distribution in activated carbon. Ultramicropores and micropores with diameters ranging from 0.6 to 1.5 nm contribute the most to the specific surface area across the entire series of samples, compared to pores with diameters of 2 to 25 nm. However, for the sample carbonized at 300 °C, mesopores measuring 2–5 nm accounted for 36% of the total pore volume (see fig. 2a).



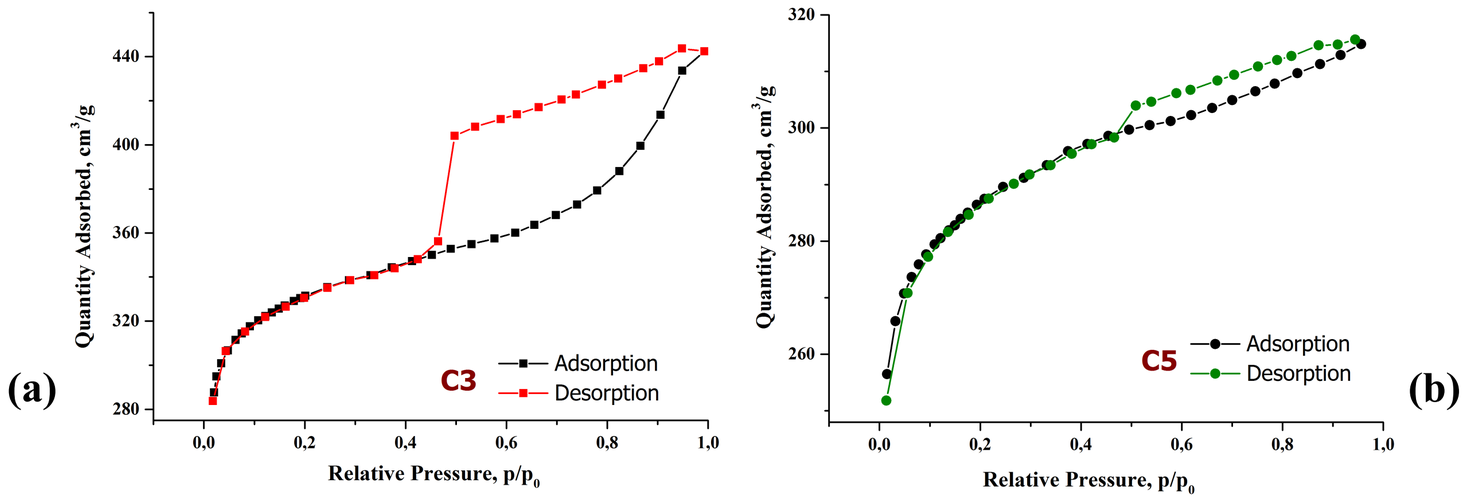


Figure 1. Nitrogen adsorption/desorption isotherms (77 K) of the obtained AC samples with different temperatures of carbonization: (a) 300°C; (b) 500°C.

Figure 2. Dependence of AC specific surface area with different ratios of carbonization temperature (a) and AC/KOH (b)

References

[1] E. P. Barrett, L. G. Joyner, P. P. Halenda, J. Am. Chem. Soc. 73, 373 (1951). http://dx.doi.org/10.1021/ja01145a126.

[2] K. S. W. Sing, D. H. Everett, R. A. W. Haul, L. Moscou, R. A. Pierotti, J. Rouquerol, T. Siemieniewska. Reporting Physisorption Data for Gas/Solid Systems. Handbook of Heterogeneous Catalysis (Wiley-VCH: Weinheim, Germany 2008). http://dx.doi.org/10.1002/9783527610044.hetcat0065.