

Effects of Carbon Porosity on Sorption Applications: CO₂ adsorption, Capacitive Deionization, and Supercapacitor

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Introduction

The increasing demands for portable power source have accelerated the attention for high power energy application such as supercapacitors. In addition, the numerous efforts to fulfill the advanced water purification have been conducted due to the water shortage and distribution issues. Capacitive deionization (CDI) uses the capacitive behavior on the electrochemically charged electrode. Porous carbons are usually chosen as the electrode materials of above electrochemical energy and environmental system. They also have received significant interests for the capture of CO₂ due to their unique pore-structure properties. Understanding the relationship between the porosity of carbons and their sorption performance enables the improvement of the system efficiency. Herein, we synthesized two-types of porous carbons with similar specific surface area, which have a different porosity, from Rice Husk as an abundant carbon precursor. Both of porous carbon were fabricated into the electrodes of supercapacitor and CDI for desalination, and evaluated their porous characteristics including physical sorption of CO₂.

Materials and Methods

Rice husk (RH) was used as a precursor of porous carbons. One method to endow the porous structure to RH-derived carbon matrix is chemical activation with KOH at 600 °C for 1 h, denoted as RH-KOH. RH-HF-AC was used carbonized RH and further treatments, which included 20% hydrofluoric acid immersion for 1 h to completely remove silica component and following steam activation at 900 °C for 30 min. RH-KOH and RH-HF-AC were evaluated the sorption performance as CO₂ sorption, supercapacitor and desalination using CDI.

Results and Discussion

Figure 1. shows the nitrogen sorption isotherms and pore size distributions of RH derived porous carbons. Specific surface area and pore structural properties are summarized in **Table 1.** Comparable specific surface area of RH-KOH and RH-HF-AC were obtained as 1314 and 1296 m²/g, respectively. However, RH-HF-AC has more highly developed pore structure with increased pore volume and meso-size pores.

Table 1. Summary of pore structural properties of RH-derived porous carbons.

	$a_{s,BET}$ (m ² g ⁻¹)	BET-calculation	
		V_p (cm ³ g ⁻¹)	D_{mean} (nm)
RH-KOH	1314	0.915	2.78
RH-HF-AC	1296	1.280	3.95

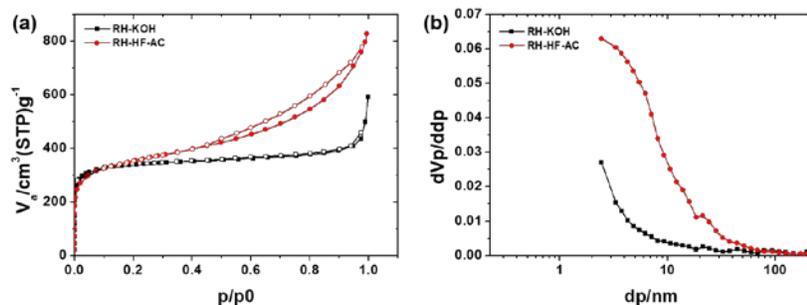


Figure 1 (a) Nitrogen adsorption/desorption isotherm curves and (b) corresponding pore size distributions of RH-derived porous carbons.

As a representative example, both of porous carbons were applied as the electrode of aqueous supercapacitor to compare the sorption performance. **Figure 2 (a)**, indicates the rate capability according to the increased current density and it is obviously confirmed that the developed porosity of RH-HF-AC leads to enhanced specific capacitance. The porosity also affect the cyclic stability. **Figure 2 (b) and (c)**, shows the cyclic stability and corresponding EIS results, suggesting the robust structure of RH-HF-AC during the repeated ion adsorption and desorption.

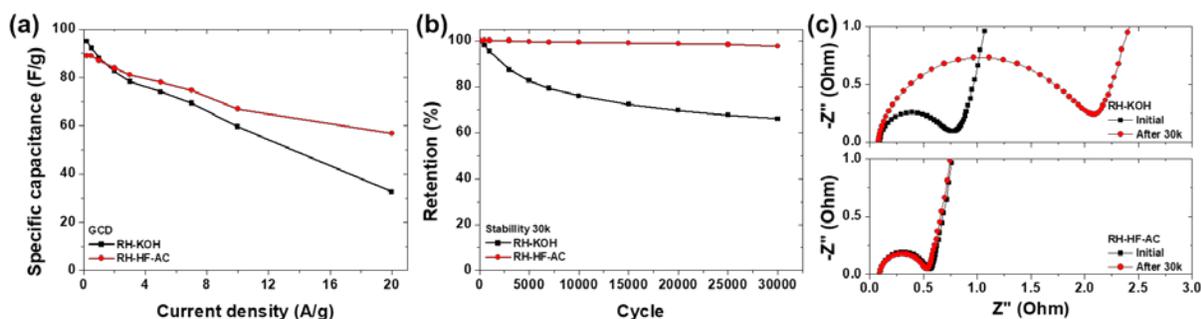


Figure 2 (a) Rate capability of RH-KOH and RH-HF-AC at a different current density from 0.2 A/g to 20 A/g, (b) cyclic stability at a current density of 20 A/g for 30,000 charge/discharge curves, and (c) Nyquist plots applied as an electrode material of supercapacitor.

Conclusions

In this study, porous carbons with different pore structure were prepared from Rice Husks. The mesoporous carbon with higher porosity allowed the improved sorption performance of CO₂ sorption, supercapacitor and CDI for desalination.

Acknowledgment

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (no. 2017R1A6A3A11031355)

References

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