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An effective strategy for fabricating sustainable porous carbon spheres derived from Kraft lignin with controllable structures

Kiet Le Anh Cao, Takashi Ogi*

Chemical Engineering Program, Department of Advanced Science and Engineering,
Graduate School of Advanced Science and Engineering, Hiroshima University, Japan

*E-mail: ogit@hiroshima-u.ac.jp

Spherical carbon particles have attracted tremendous interests in recent years due to their intriguing structure-induced physicochemical properties and great potential for widespread applications. The rational synthesis of carbon-based materials from green, renewable, and cost-effective resources in accordance with sustainable development goals is of high interest and encouraged. In this regard, lignin has been considered as a potential sustainable source for the preparation of advanced porous carbonaceous materials due to its high carbon content (above 60 wt.%), abundant, low feedstock cost, and extensively crosslinked polyphenolic structure. However, their preparation with the precise design and controllable structure using a facile and scalable strategy remains a significant challenge. The motivation for this present study is to synthesize porous carbon spheres in a sustainable manner via a spray drying approach followed by a carbonization process, using Kraft lignin as the carbon precursor and potassium hydroxide (KOH) as the activation agent. As a result, the proposed method successfully controlled the structure of carbon particles from dense to hollow structure, and the surface textural properties can be easily tuned by adjusting the KOH concentration (Fig. 1) [1]. In addition, to obtain an in-depth understanding of the particle formation of carbon particles, a plausible mechanism is also investigated in this research, which provides systematic guidance for further fabrication of spherical carbon materials with appropriate architecture and composition. Furthermore, the high specific surface area (2424.8 m^2 g^{-1}) with micro-mesoporous structure of hollow carbon spheres (HCSs) were obtained at a low KOH-to-lignin mass ratio (below 1.5), which was in accordance with green chemistry principles. These HCSs have applications as electrode materials in supercapacitors for energy storage devices [2]. With the great achievements and continuous efforts in this important field, these results suggest that our approach adopted herein will open up opportunities for the development of advanced carbon materials and high value-added utilization of Kraft lignin as a promising material for potential applications.

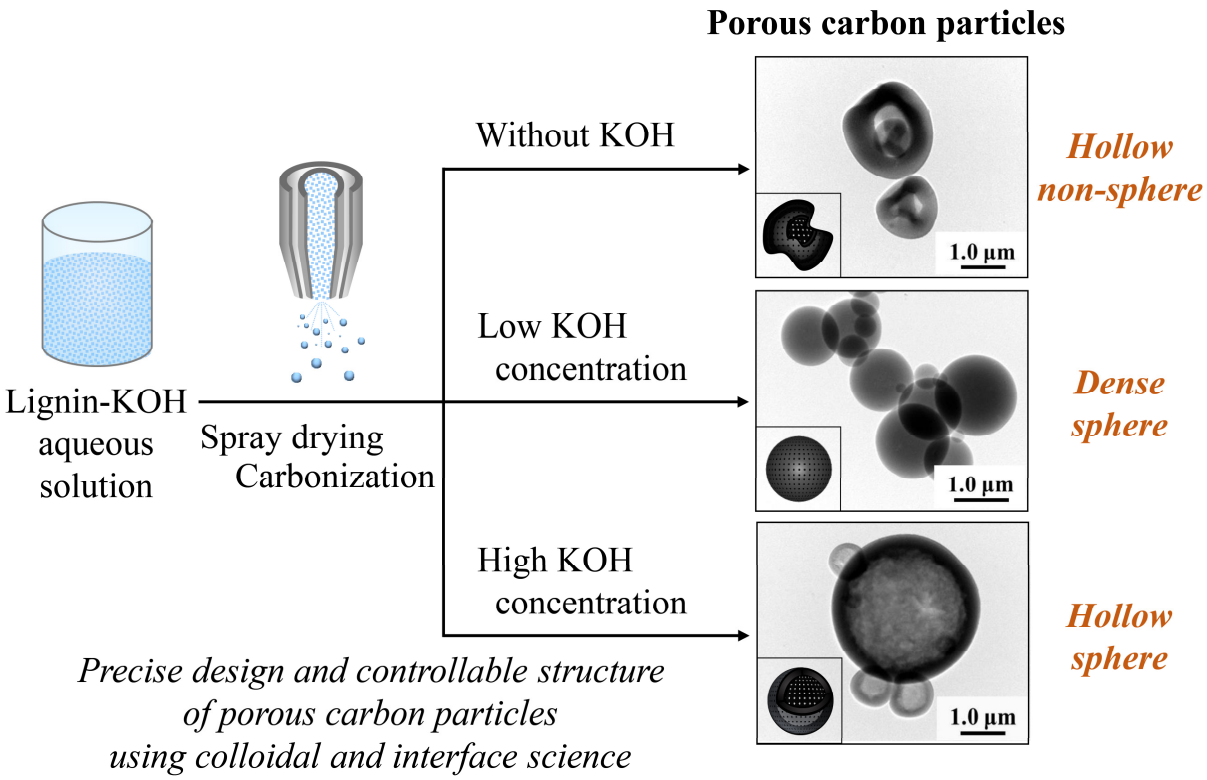

Fig. 1. Schematic illustration for the fabrication of porous carbon particles with controllable morphology and structure.

References:

[1] Cao, K.L.A., Rahmatika, A.M., Kitamoto, Y., Nguyen, M.T.T., Ogi, T., Controllable synthesis of spherical carbon particles transition from dense to hollow structure derived from Kraft lignin, J. Colloid Interface Sci. 589 (2021) 252–263.

[2] Cao, K.L.A., Kitamoto, Y., Iskandar, F., Ogi, T., Sustainable porous hollow carbon spheres with high specific surface area derived from Kraft lignin, Adv. Powder Technol. 32 (2021) 2064–2073.