Utilizing Magnesiothermic CO_2 Reduction to Tailor the Surface Composition of Highly Porous Carbon Nanoparticles

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Abstract

Persistently growing greenhouse gas emissions and the resulting threat to our everyday life conditions have stimulated intensive research for sustainable technologies. Progress has been made in scientific research for CO_2 management, and CO_2 conversion into value-added products has been proposed as a viable and high promising solution.[1] At the same time, carbon nanomaterials exhibit a combination of properties which makes them suitable for a wide range of applications, thus accelerating the demand in industry for this kind of materials. Metallothermic process, utilizing alkaline-earths and CO_2 as feedstock, is an emerging route to produce carbon nanomaterials.[2,3] In this work, Mg metal powder is heating up to 675°C into a quartz tube furnace, under constant CO_2 flow and atmospheric pressure conditions to form a combination of MgO and carbon nanoparticles (Fig.1). Carbon is isolated after washing in HCl solution. Adding organic compounds such as Melamine and Thiourea along with Mg metal powder, highly porous N, S and O tunable doped carbon nanoparticles have been obtained. The resultant materials' physicochemical properties were evaluated by X-Ray diffraction (XRD) analysis, X-ray photoelectron spectroscopy (XPS) elemental analysis and Raman spectroscopy. Scanning electron microscopy (SEM) reveals the presence of both fibral and cubic carbon structures with controllable textures.
The electrochemical performance of those carbons was evaluated in neutral aqueous electrolyte (Na_2SO_4, 0.5M) using a three-electrode configuration consisting of porous carbon, Pt foil and Ag/AgCl as working, counter and reference electrode, respectively. Electrochemical measurements revealed that the activated porous carbon exhibited remarkable electrochemical performance with capacitance of 593.45 F/g at 20 mV/s and 328.05 F/g at 100 mV/s within a large voltage window. This outcome was ascribed to the intrinsic properties of produced nanocarbons, including -N, -S doping and high BET surface area (1996 m^2/g), making them promising candidates for electrochemical applications.

References

[1] T. Giannakopoulou, N. Todorova, N. Plakantonaki, M. Vagenas, I.Papailias, E. Sakellis and C. Trapalis, J. CO2 Util., 65 (2022) 102200.
[2]] H. Zhang, X. Zhang, X. Sun and Y. Ma, Sci Rep, 3 (2013) 3534.
[3] A. Dabrowska, A. Huczko and S. Dyjak, Phys. Status Solidi B, 249 (2012) 2373-2377

Figures

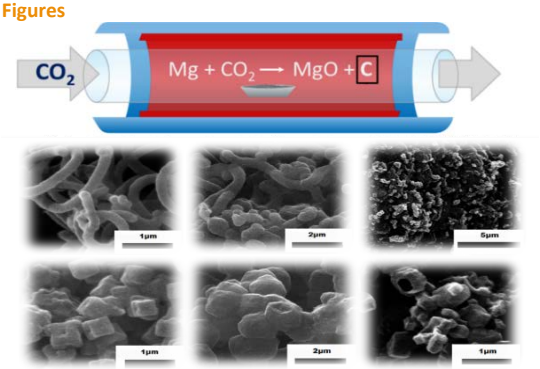

Figure 1: Schematic representation of metallothermic reduction reaction and corresponding SEM micrographs from resulting carbon nanoparticles.