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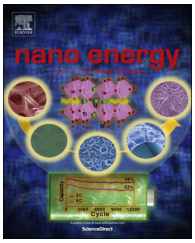

COMMUNICATION

Fluorine-rich nanoporous carbon with enhanced surface affinity in organic electrolyte for high-performance supercapacitors

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Abstract
Fluorine-rich nanoporous carbons with tunable porosity and F content have been successfully synthesized from a silane precursor using a solution-based F doping method. The F-rich carbon surface with higher polarity provides stronger affinity and wettability for the organic electrolyte, which is for the first time demonstrated though Gauss computational calculation between F-carbon surface and organic electrolytes. The optimized F-rich nanoporous carbon manifests a high specific capacitance of 168 F g^{-1} in a symmetric cell with excellent retention at high rates and upon prolonged 10,000 cycles.

Introduction

Supercapacitors are desirable energy-storage devices due to their high power density and long cycling life, yet their low energy density still limit their broad applications [1-3]. Supercapacitors commonly utilize carbon as both (symmetric supercapacitors) or one of the electrodes (asymmetric supercapacitors), of which the device capacitances are generally

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limited by the capacitance of the carbon electrodes. Developing better carbon materials with higher capacitance and working voltage has been emerging as one the most essential challenges in the field [3].

Generally, carbon electrodes store electrochemical energy in the form of electrical double layer capacitance, which requires high surface area [4] and highly effective electron-conducting pathways [5]. Towards this goal, a large variety of carbons have been studied, such as biomass-derived carbons [6], polymer-templated carbons [7], carbide-derived microporous carbons [8], and carbon onions [9]. While most of the research has been focused on engineering the pore structure, recent studies have shown that doping the carbons with heteroatoms could improve the capacitance, possibly owning to the improved charge mobility and wettability with electrolytes [10,11]. Such doping processes are generally achieved by reacting carbons with heteroatom-containing agents or by carbonizing heteroatom-containing precursors [10]. Nitrogen is by far the most intensely studied n-type dopant, which is generally doped into carbons by treating the carbons with ammonia gas or urea, or by carbonizing nitrogen-containing precursors such as melamine, poly(acrylonitrile), poly(vinylpyridine), and quinolone-polymerized pitch [5,12]. Doping with other heteroatoms such as boron, phosphorous and sulfur, was also explored, which was realized by carbonizing boron-containing precursors [13], by carbonizing sulfurated polymers [14], or by activating carbon precursors using phosphoric acid, respectively [15]. However, despite of the improved capacitance, most dopant moieties (e.g., quinoid, quinhydrone, phenolic, carbonxyl, carbonyl and lactone) are electrochemically unstable, often resulting in

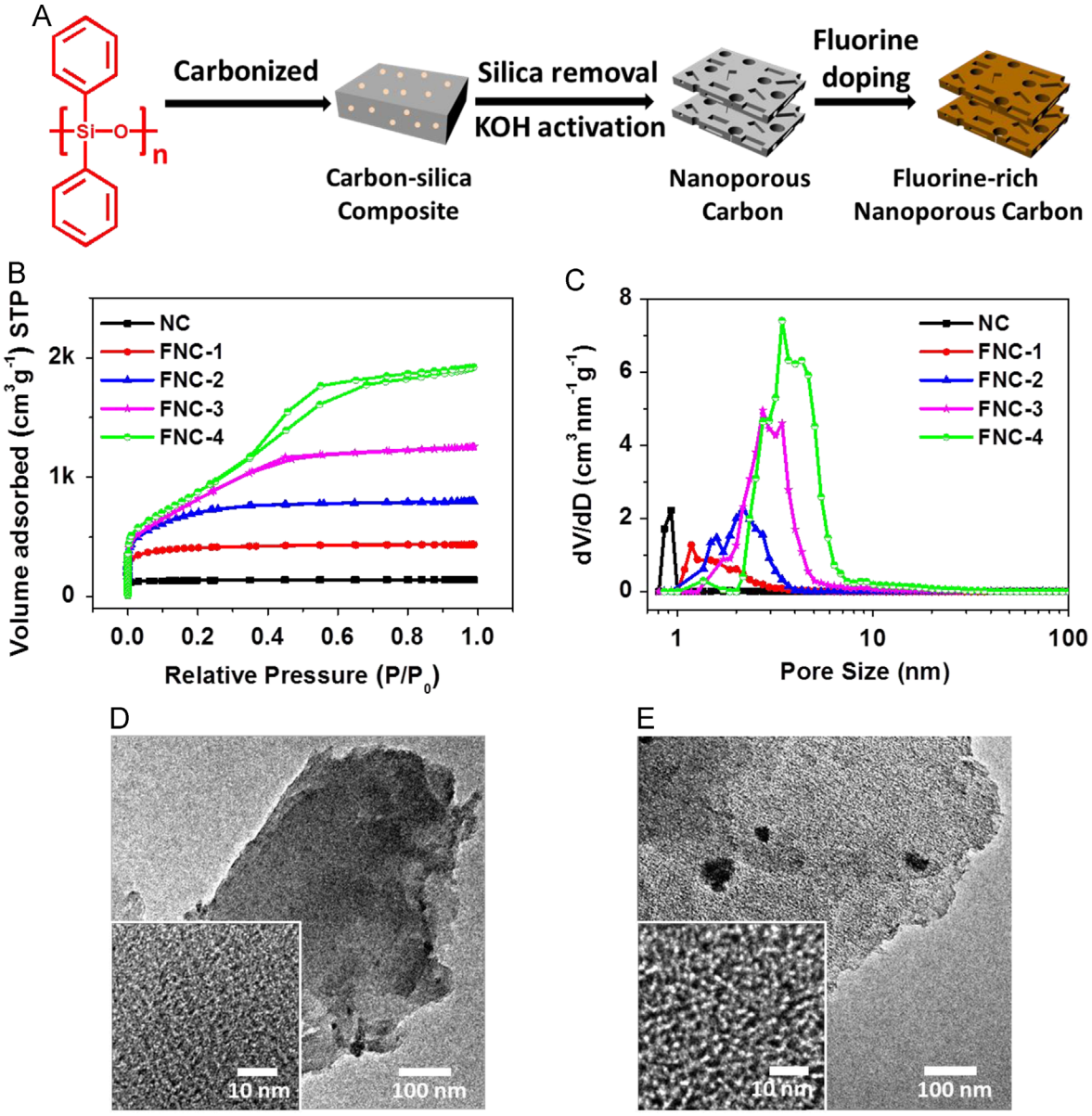

Figure 1 (A) Schematic illustration of the synthesis procedure of fluorine-rich nanoporous carbon. (B) Nitrogen sorption isotherms of NC and FNCs. (C) Pore size distribution of NC and FNCs calculated by a DFT method. TEM images of (D) NC and (E) FNC-4. Insets are the corresponding HRTEM images.