Synthesis and Characterization of Efficient Nitrogen-Doped Carbon Materials for Supercapacitors Application

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INTRODUCTION

N-doped carbons are widely used in the energy storage and conversion field because of their excellent electrical conductivity, high specific surface area, and superb electrochemical stability. Herein, high efficiency carbon material has been derived using the craft pulping residues – black liquor as the carbon source. The carbon material was prepared from black liquor through a two-step process, including chemical activation with NaOH at high temperature and doping with nitrogen using dicyandiamide (DCDA). The synthesized catalyst's morphology, structure, and composition were characterized using TEM, XPS, Raman Spectroscopy, and ICP-OES. The electrochemical performance has been evaluated using cyclic voltammetry (CV) and galvanostatic charge-discharge (GCD) techniques.

TEM ANALYSIS

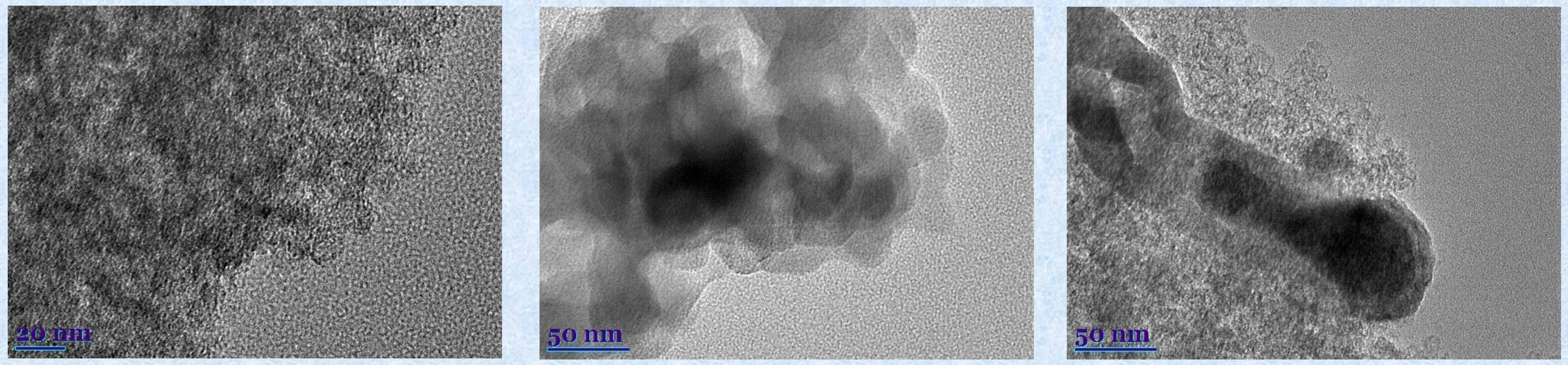


Fig. 1. TEM images of N-doped carbon.

SEM ANALYSIS

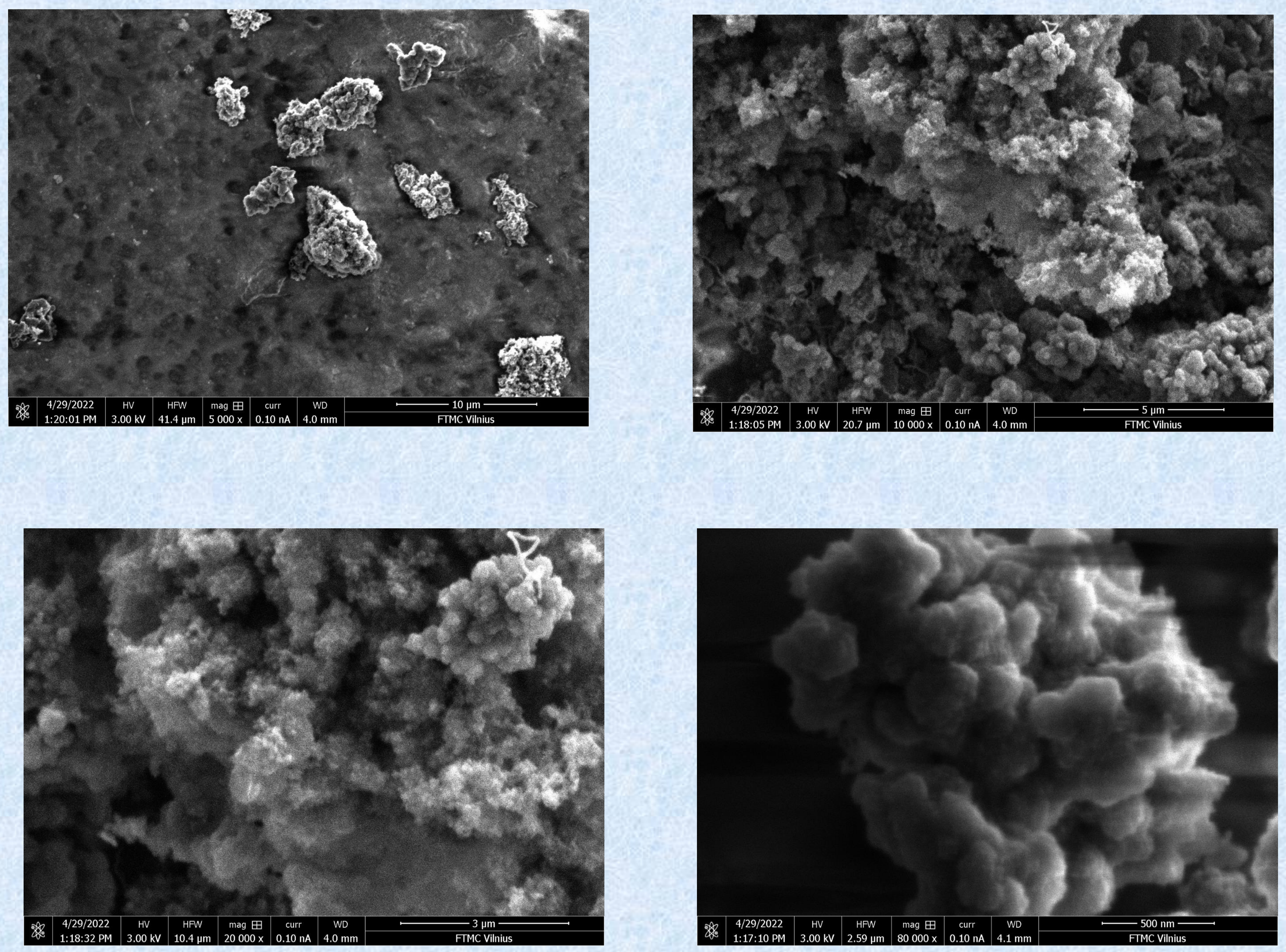
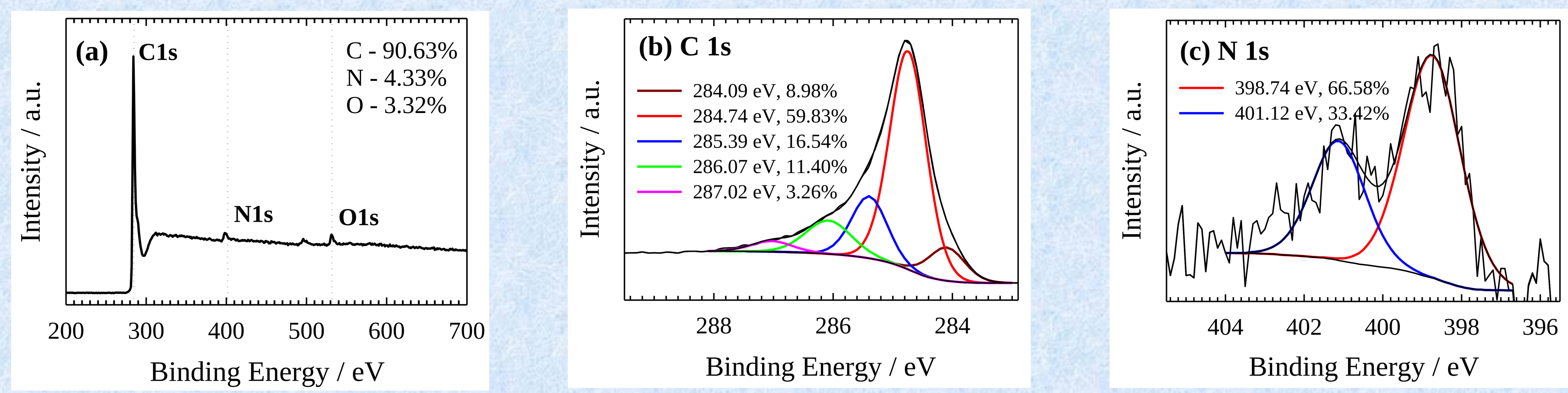
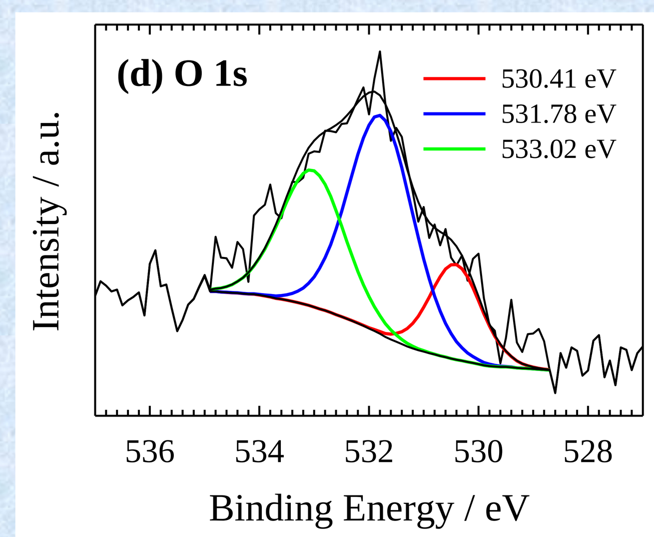


Fig. 2. SEM images of N-doped carbon under different magnification.

XPS ANALYSIS





Name	*Peak BE*	*FWHM eV*	*Area (P) CPS.eV*	*Area (N)*	*Atomic %*	*Q*	*SF*
Si2p	101.54	0.51	78.18	1.20	0.51	1	0.817
C1s	284.77	0.97	15377.65	215.63	90.63	1	1.000
N1s	398.63	2.09	1225.57	10.30	4.33	1	1.800
O1s	531.93	2.26	1383.05	7.89	3.32	1	2.930
Na1s	1071.89	1.60	806.57	2.89	1.21	1	8.520

Fig. 3. Survey spectra of N-doped carbon (a), XPS spectra of C 1s (b), N 1s (c) and O 1s (d).

CV ANALYSIS

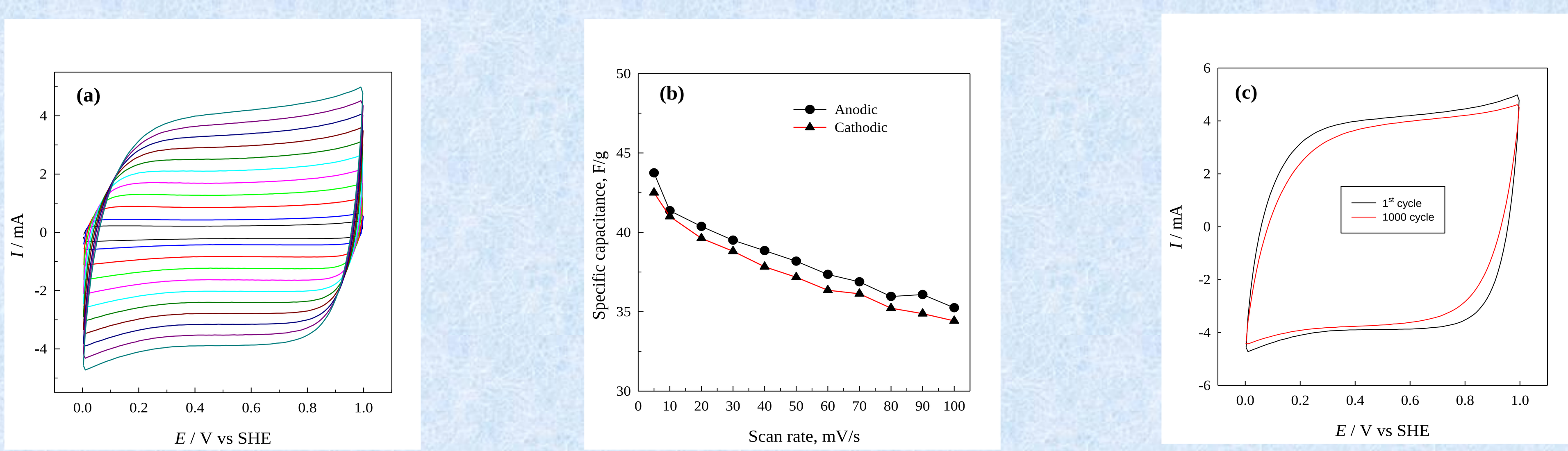


Fig. 4. CV curves of N-doped carbon electrode recorded in 1 M Na_2SO_4 solution at scan rates 5-100 mV s^{-1} (a), anodic and cathodic specific capacitances at different scan rates (b) and CV's at 100 mV s^{-1} scan rate after 1000 cycles (c).

Acknowledgment

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CONCLUSIONS

The synthesized nitrogen-doped carbon material had a high specific surface area of 2481 m^2 g^{-1}. Moreover, this catalyst had a high nitrogen content of 4.33 at%. Most of the nitrogen was in the pyridinic-N (66.58 at%) and graphitic-N forms (33.42 at%).

It was found that the specific capacitance of catalysts depends on the catalyst loading. The specific capacitance of ca. 50 F g^{-1} was achieved in the 1 M Na_2SO_4 aqueous solution at the scan rate of 5 mV s^{-1}. Besides, the specific capacitance retention was 99% after 1000 cycles indicating good electrochemical stability. Our present results demonstrated that craft pulping residue, such as black liquor, can be employed as a promising carbon precursor to synthesize low-cost and efficient catalysts for supercapacitors.