

Supplementary Information

From Marine Plant to Photovoltaic Devices

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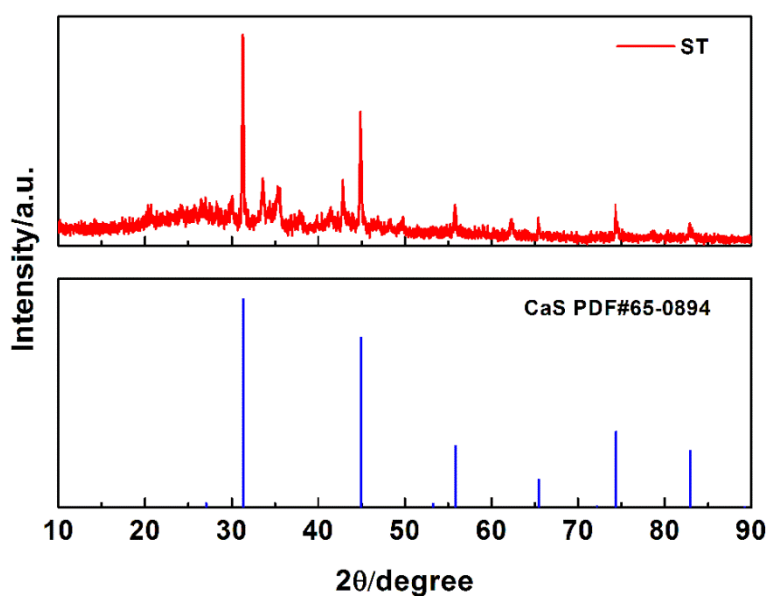


Fig. S1 The XRD patterns of main parts from as-prepared ST-CE by carbonization of ST under N₂ at 800 °C.

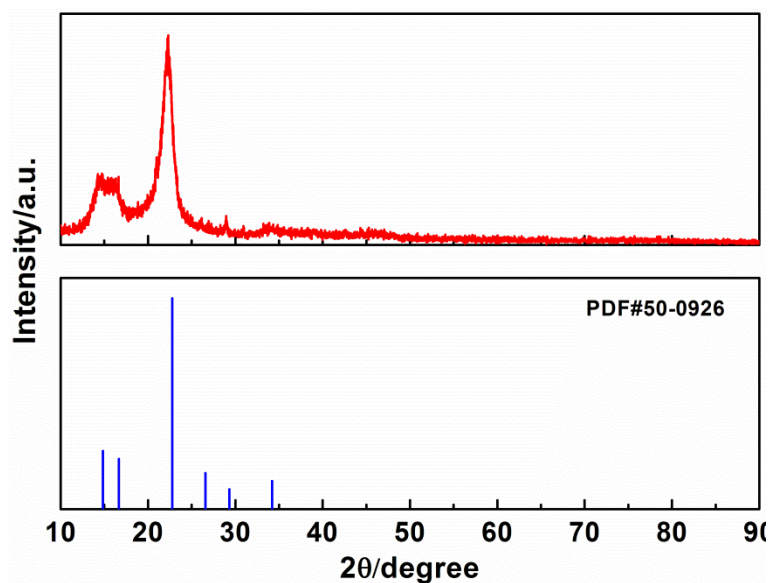


Fig. S2 The XRD patterns of trace amount parts derived from supernatant flots when ST-CE is dispersed in water.

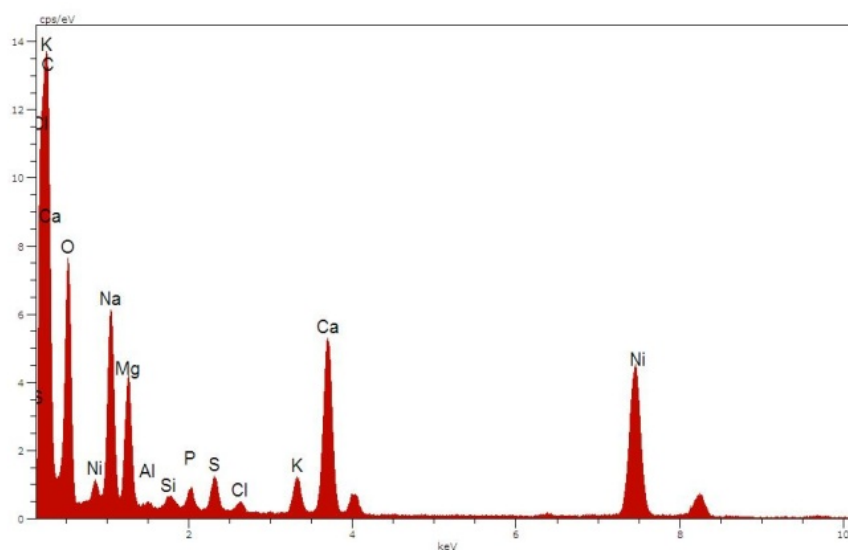


Fig. S3 The EDS measurement of as-prepared ST-CE

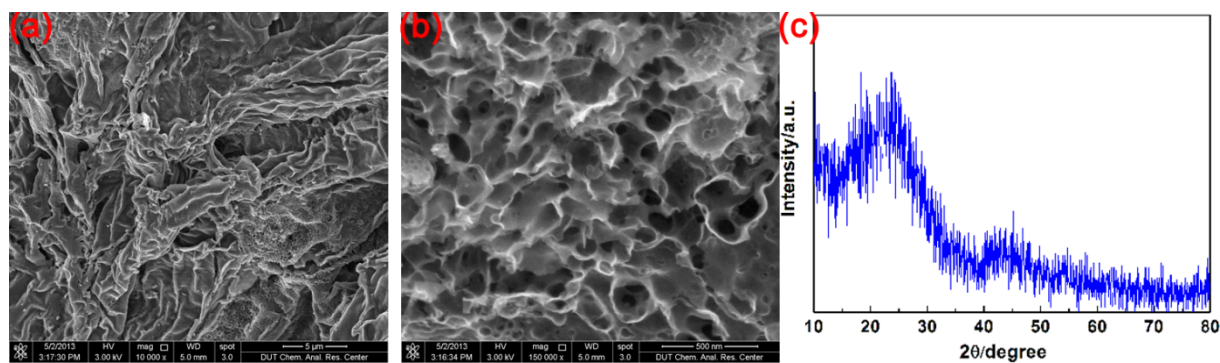


Fig. S4 The SEM images and XRD pattern of as-prepared ST-CE after treatment by hydrochloric acid

The as-prepared ST-CE was treated by hydrochloric acid for removing redundant metal ion and nonmetal elements. The redundant metal ion and nonmetal elements will be changed into salts by the acid treatment and subsequently be removed easily by rinsing with abundant deionized water. The SEM image (Fig.S 4(a) and 4(b)) shown that the specific morphology is gone. Fig.S 4(c) shows the XRD pattern of ST after treatment by hydrochloric acid and the diffraction peaks at 23.62° and 42.96° correspond to amorphous carbon. The EDS values were summarized in Table S1. The

result shows that carbon is main component after treatment by acid and a few the other elements.

Table S1 EDS values based on ST-CE treated by hydrochloric acid

| Elements | wt. % | at. % |
|----------|--------|--------|
| C K | 90.51 | 93.98 |
| O K | 5.87 | 4.58 |
| Na K | 0.20 | 0.11 |
| Si K | 0.85 | 0.38 |
| P K | 0.21 | 0.08 |
| S K | 1.65 | 0.64 |
| Cl K | 0.31 | 0.11 |
| K K | 0.23 | 0.07 |
| Ca K | 0.17 | 0.05 |
| Total | 100.00 | 100.00 |

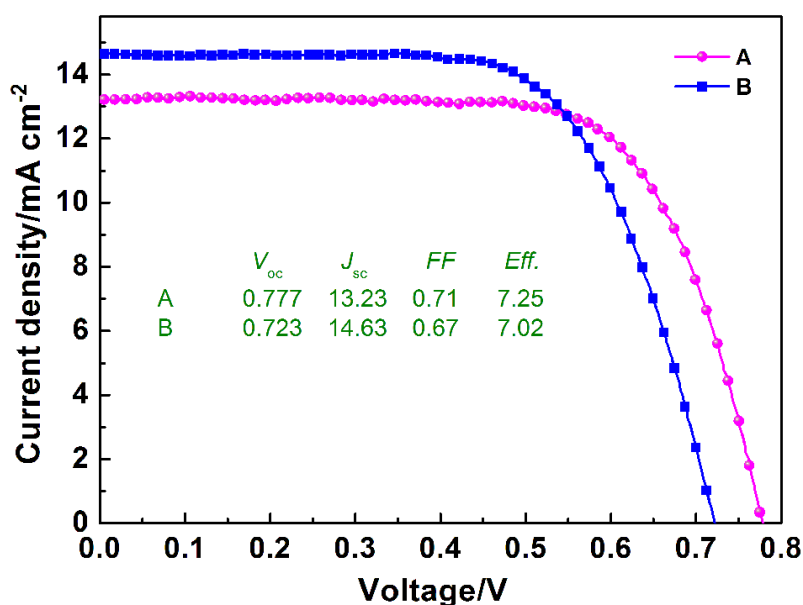


Fig. S5 Photocurrent density-photovoltage ($I-V$) curves for DSCs using before (A) and after (B) acid treatment for as-prepared ST-CE

Figure S5 shows the $I-V$ performance of DSCs based on ST-CE before and after treatment. The relevant parameters were inserted in the figure. Comparing these parameters, it is clearly that the similar PCEs have been obtained due to the

counterbalance of the higher V_{oc} of before-treatment sample and higher J_{sc} of after-treatment one.

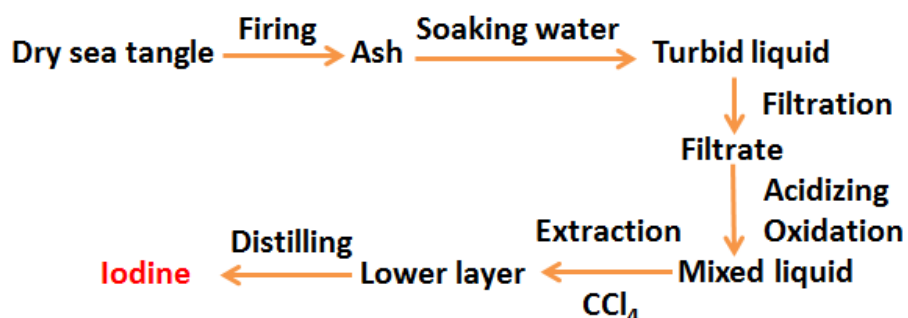
Materials and Methods

Preparation of natural dye sensitizer

The ST dye was extracted using ethanol with the following steps: fresh ST (purchased from Dalian Fisheries wholesale market) was washed with water and dried at 60 °C to remove surface water. The plant was then immersed in absolute ethanol at room temperature in the dark for 24 h. The resulting solution was then filtrated, and the filtrates were concentrated at 40 °C by rotate evaporators to obtain the sensitizers solution.

The extracting technology of iodine from ST

The procedures can be briefly described as follows. Among them, the acid and oxidant are 2 M H_2SO_4 and 6 % H_2O_2 , respectively.



Preparation of ST carbon-based counter electrode

The ST counter electrode (ST-CE) was prepared by simple one-step carbonization at 800 °C under N_2 atmosphere to present the black color with the bright appearance.

The slurry of counter electrodes were constructed with ST (200mg) and isopropanol (3 mL), which needed to homogenize for 3 h. The CE based on fluorine doped tin oxide (FTO) glass was prepared with a simple spray-coating technique developed by our group. The CEs were then heated at 500 °C for 0.5 h under a N_2 atmosphere.

Preparation of dye-sensitized solar cells

The TiO₂ electrodes are commercially available (Yingkou Opvtech New Energy Co., Ltd), and were sintered at 500°C for 30 min before sensitized. After cooling down to 80°C, the electrodes were dipped into the solutions of nature dye and cis-bis(isothiocyanato) bis (2, 2'-bipyridyl-4, 4'-dicarboxylato)-ruthenium (II) bis-tetrabutyl-ammonium (N719) for 20 h at 25 °C, respectively. With the dye-sensitized TiO₂ electrodes, CEs were assembled to fabricate DSCs by sandwiching an electrolyte with 0.1 M LiI, 0.03 M I₂, 0.1 M guanidine thiocyanate (GuSCN) and 0.5 M 4-tert-butylpyridine (TBP) in acetonitrile.

Characterization

The surface morphology of ST was observed using scanning electron microscopy (SEM, FEI QUANTA 450). The X-ray diffraction experiments were carried out with an automatic X-ray powder diffract meter (D/Max 2400, RIGAKU). Current-voltage curves of the DSCs were measured using a Keithley digital source meter (Keithley 2601, USA). The intensity of the incident light simulates an AM 1.5 solar light through a solar simulator (PEC-L15 Japan). The incident light intensity was calibrated using a silicon photocell (BS-520, Japan) and was set at 100 mW cm⁻². The electrochemical impedance spectroscopy (EIS, Zenium Zahner, Germany) was actualized with the symmetric cell in the dark at a -0.75 V bias. The measured frequency ranged from 100 mHz to 1 MHz, and the AC amplitude was set at 10 mV. The CV curves and Tafel polarization curve were obtained using an electrochemical workstation (CHI 660 (SHANGHAI, CHEN HUA)).