# Supporting information

## A unique carbon with a high specific surface area produced by the carbonization of agar in the presence of graphene

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## 1. Experimental Section

### The preparation process for the samples:

80 mg Graphite oxide (GO), which was prepared by a modified Hummers method, was added into deionized water (80 mL) and sonicated with a high power ultra-sonication device (JY92-N, China, 160 W) for 1 h to obtain a uniform GO suspension. Meanwhile, 4 g agar was dissolved in 50 mL deionized water at 95 ℃ with continuous stirring for 5 h, and after the agar is fully dissolved, the GO suspension was added into the agar hydrosol and stirred for 2 h at 95 ℃ to obtain a uniform mixture. Then, the mixture was cooled in air and formed a jelly-like cylinder. Such cylinder is suffered a freeze drying and the successively carbonization at 900 ℃ under Ar atmosphere for 3 h to obtain the HESAC.

For reference, glucose and sucrose were used to instead of agar, and obtained the GO/GLU and GO/SUC respectively, which were prepared in the same way as HESAC.

Pure GO and agar were suffered the same process as that of HESAC, and the obtained samples after thermal treatment were denoted as graphene powder and carbonized agar, respectively.

CMK-3 and AC were purchased from Jcnano, China and Maxsorb, Japan, respectively.

## 2. Sample characterization

## Structure characterization:

XRD measurements were conducted at room temperature using a specular reflection mode (Bruker D-8, Cu Kα radiation, λ=0.154056 nm). SEM and TEM observations were performed on a Hitachi S-4800 (Hitachi, Japan) and a JEM 2100F (JEOL, Japan), respectively. Nitrogen adsorptions were measured by using a BEL mini-instrument, and the specific surface areas were obtained by Brunauer-Emmett-Teller (BET) analyses of the adsorption isotherm. Thermogravimetric analysis (TG, Rigaku, Japan) and thermogravimetric differential scanning calorimetry (DSC, Rigaku, Japan) measurement were performed in different atmosphere. X-ray photoelectron spectroscopy (XPS) analyses were conducted with a Physical Electronics PHI5802 instrument using X-rays magnesium anode (monochromatic Kα X-rays at 1253.6 eV) as the source. Raman spectrums were recorded using a micro-Raman spectroscope (JY HR800) utilizing 532.05 nm incident radiation and a 50× aperture.

## Electrochemical performance measurement:

The electrochemical experiments were carried out using a three-electrode system with an aqueous system (electrolyte: 6 M KOH solution). The working electrode, composed of 90 wt% HESAC and 10 wt% polytetrafluoroethylene (PTFE) binder, was pasted on the Ni-foam current electrode, nickel foam and Ag/AgCl electrode as the counter and reference electrodes.

All of the cyclic voltammograms (CV), galvanostatic charge/discharge tests and electrochemical impedance spectroscopy (EIS) were measured by a Bio-logic VMP3 electrochemical workstation. CV tests were conducted between -1.0 and 0 V (vs. Ag/AgCl) at different scan rate of 5~1000 mV/s. The EIS plots were obtained in the frequency range from 100 kHz to 10 mHz at an open-circuit potential.

## 3. Supplementary figures

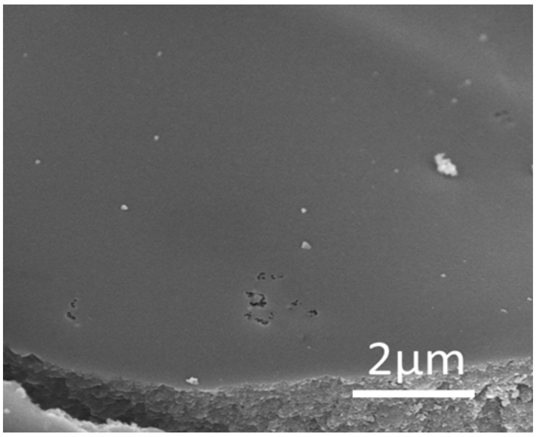

**Figure S1.** SEM image of carbonized agar.

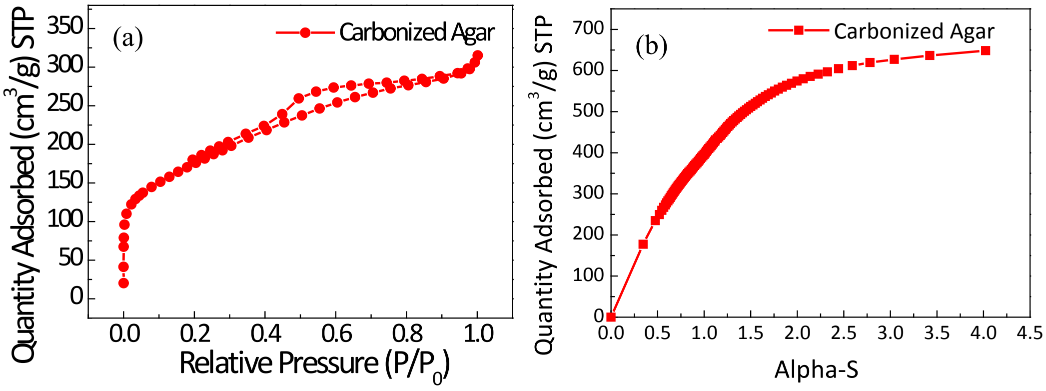

**Figure S2.** Nitrogen adsorption isotherms (a) and $\alpha_s$ plot (b) of carbonized agar.

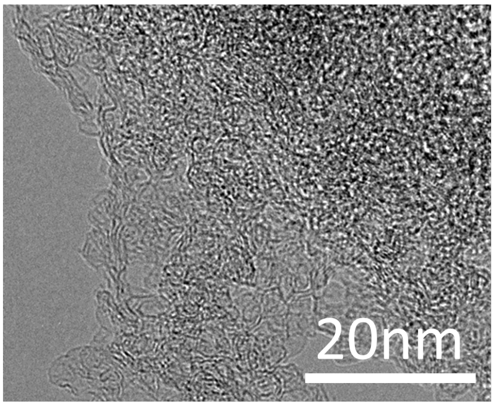

**Figure S3.** TEM image of HESAC with higher magnification. Even with higher magnification, we cannot identify micropores and small mesopores but some curved carbon layers in the image since this carbon is an external surface dominated carbon.

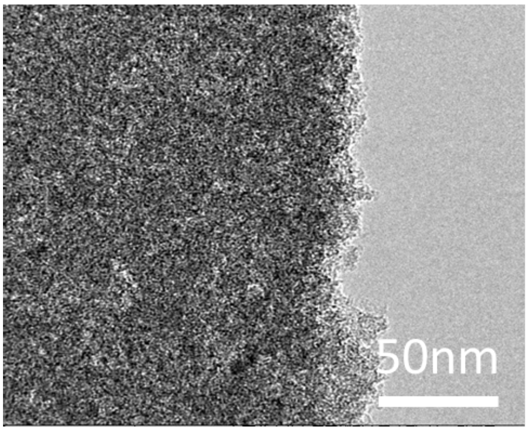

**Figure S4.** TEM image of carbonized agar.

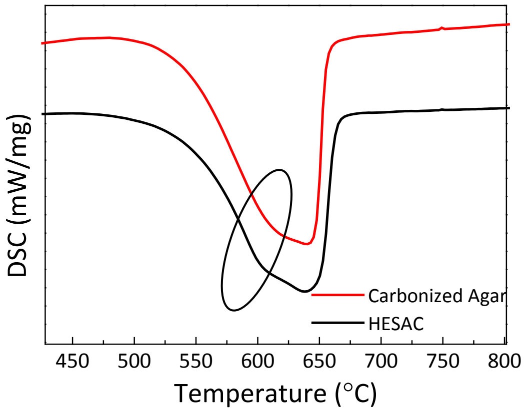

**Figure S5.** DSC curves of HESAC and carbonized agar. All the samples were heated at a scan rate of 10 ℃/min in $O_2$. The marked area shows a lower oxidation temperature, suggesting the surface of HESAC is more accessible to the oxygen.

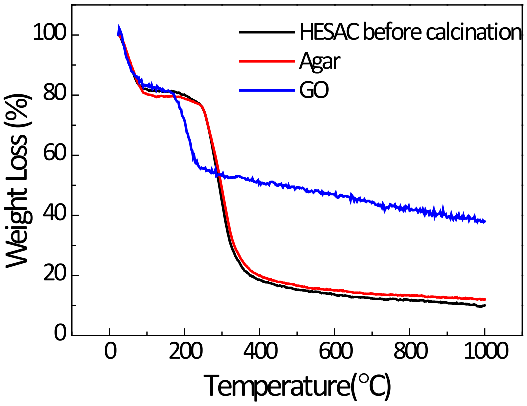

**Figure S6.** TGA curves of HESAC before calcination, agar and GO. All the samples were heated at a rate of 5 ℃/min in $N_2$. The initial weight loss for each sample before ~200 ℃ may come from the absorbed water. For the HESAC case, the carbonization yield relative to the mixture precursor (4000 mg graphite oxide and 80 mg agar) is ~24%. For the case of a pure graphene, the yield relative to graphene oxide as the precursor is ~62%. Both values are obtained according to the weight loss in the temperature range of 150-900 $^{o}$C in TG curves. Thus, the obtained ~980 mg HESAC ((4000 mg agar + 80 mg graphene oxide) × 0.24) contains ~50 mg graphene (80 mg graphene oxide × 0.62) after the carbonization process and and the graphene fraction contained in the HESAC is ~5 wt%.

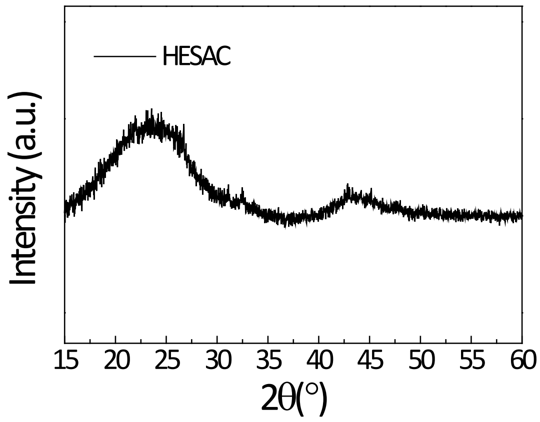

**Figure S7**. XRD pattern of HESAC .

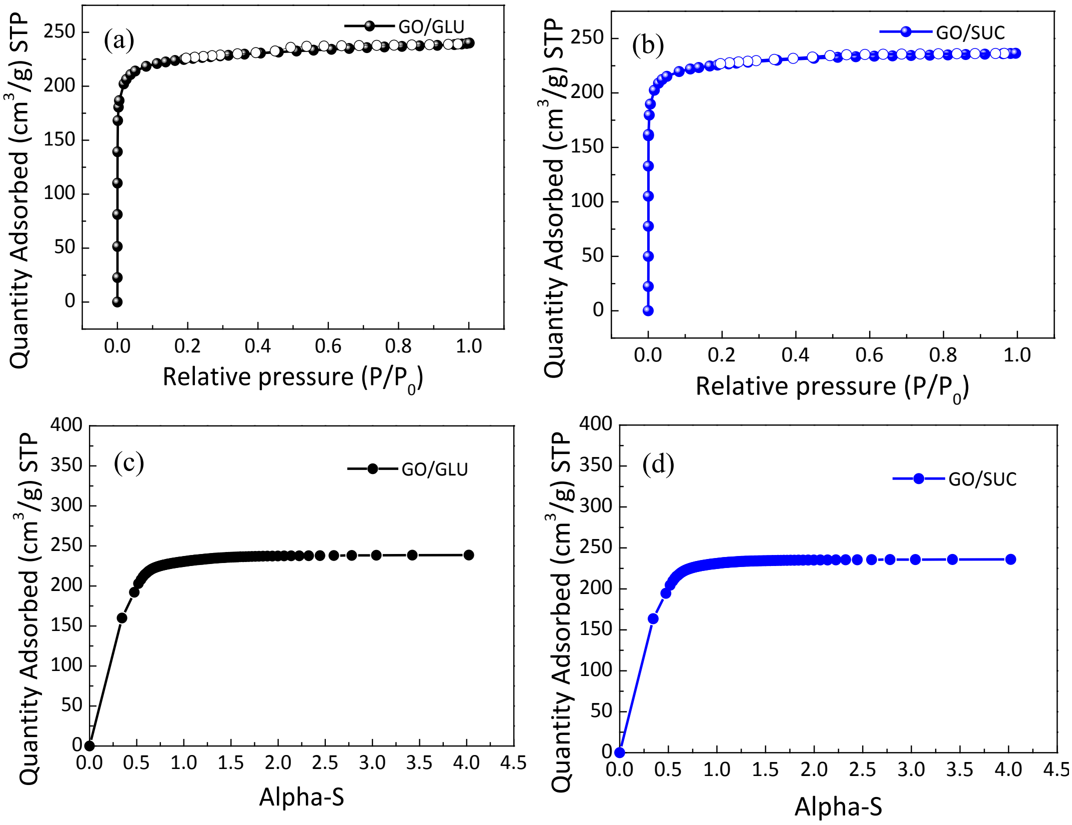

**Figure S8.** Nitrogen adsorption isotherms of GO/GLU (a) and GO/SUC (b) and $\alpha_s$-plots of GO/GLU (c) and GO/SUC (d).

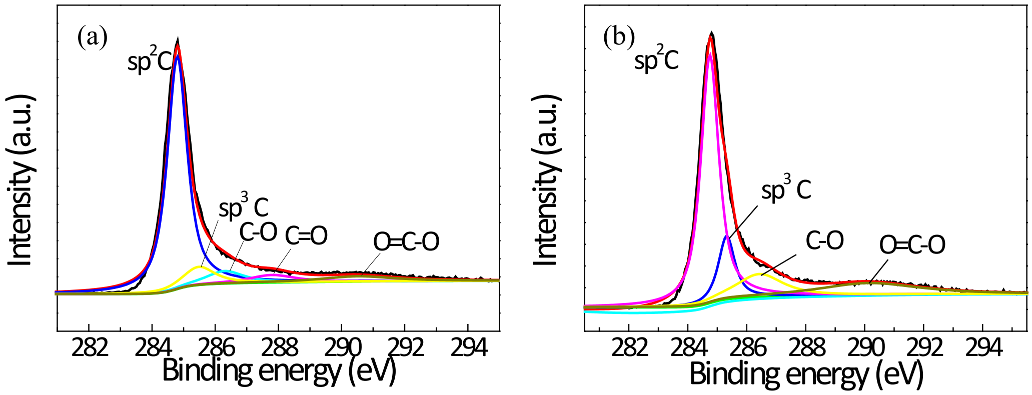

**Figure S9.** Typical C 1s XPS survey spectra of the HESAC (a) and carbonized agar (b).

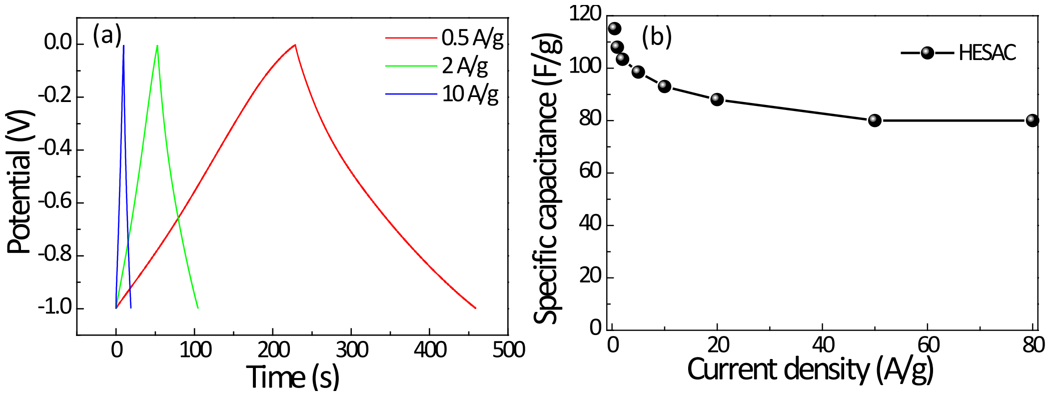

**Figure S10.** Charge/discharge curves (a) and the specific capacitance (b) of HESAC with different current densities. The charge/discharge curve indicates the capacitance is mainly contributed by the formation of EDL, and the capacitance retention reaches about 67% with the current density increase from 0.5 A/g to 80 A/g.

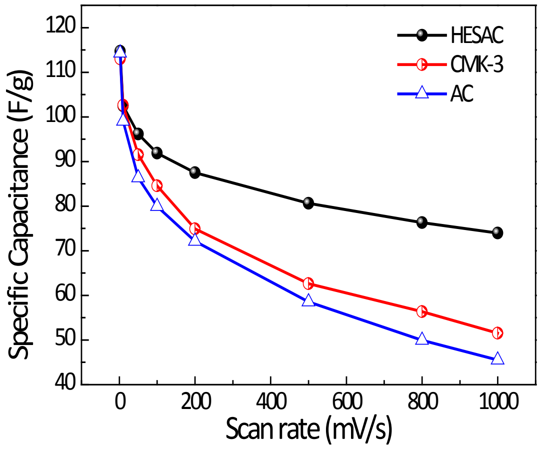

**Figure S11.** Specific capacitance of HESAC, CMK-3 and AC versus different scan rates.

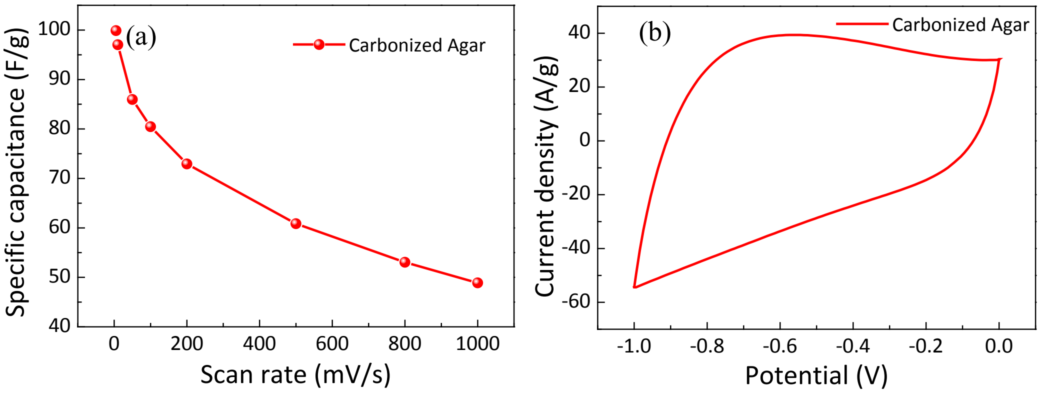

**Figure S12.** (a) Specific capacitance retention of carbonized agar versus different scan rates; (b) CV curve of carbonized agar at the scan rate of 500 mV/s.

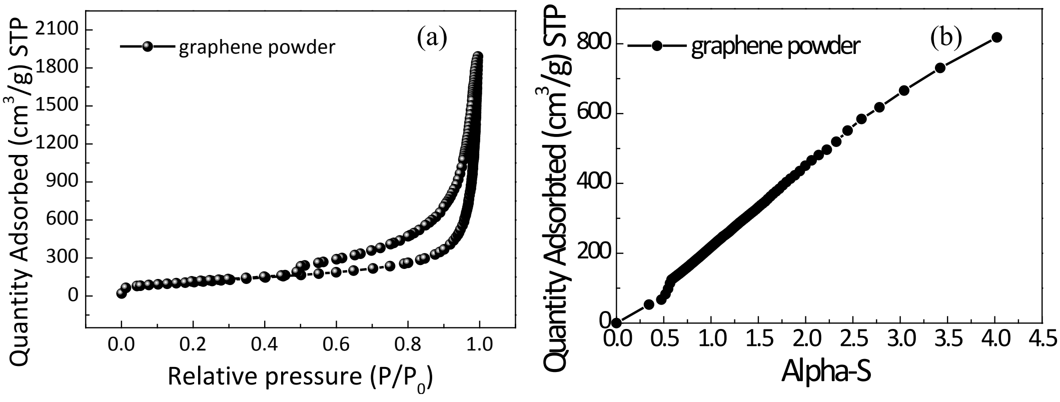

**Figure S13.** Nitrogen adsorption-desorption isotherm (a) and $\alpha_s$ plot (b) of graphene powder.

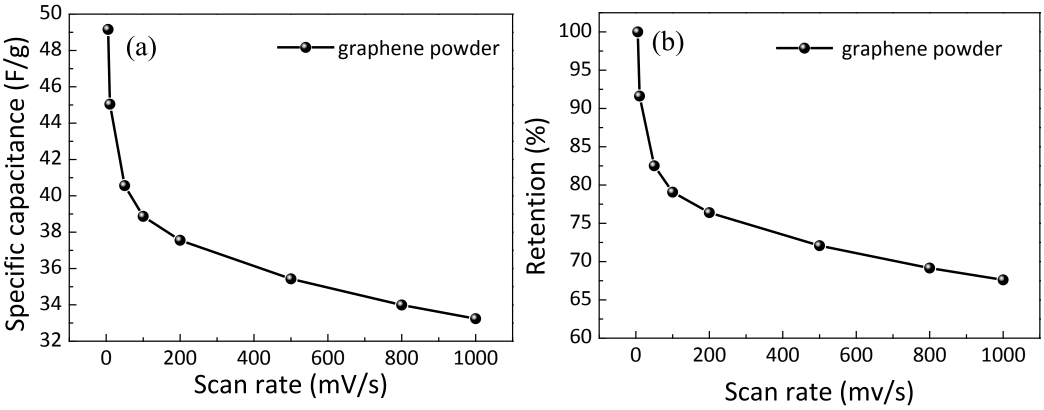

**Figure S14.** Specific capacitance (a) and the corresponding retention (b) of graphene powder versus different scan rates.

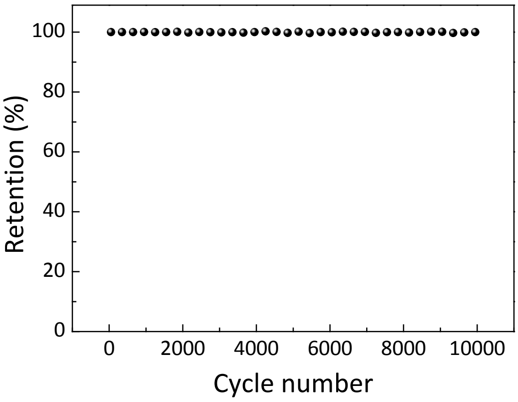

**Figure S15.** Cyclic stability of the HESAC upon charge/discharge at a current density of 5 A/g.