Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting Information

Porous Carbon Microtubes Derived from Willow Catkins for Supercapacitor Application

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1. SEM image of the activated carbon obtained by direct KOH activation of willow catkin at 800 °C

As shown in Fig. S1, MPNC-800 obtained by direct KOH activation of willow catkin exhibits the irregular granular aggregates, which is entirely different from the natural tubular morphology of willow catkins (Fig.2a). As the KOH activation process deepened at higher temperature, the structure of the carbon materials just collapses, presumably due to strong interaction with chemical agents.

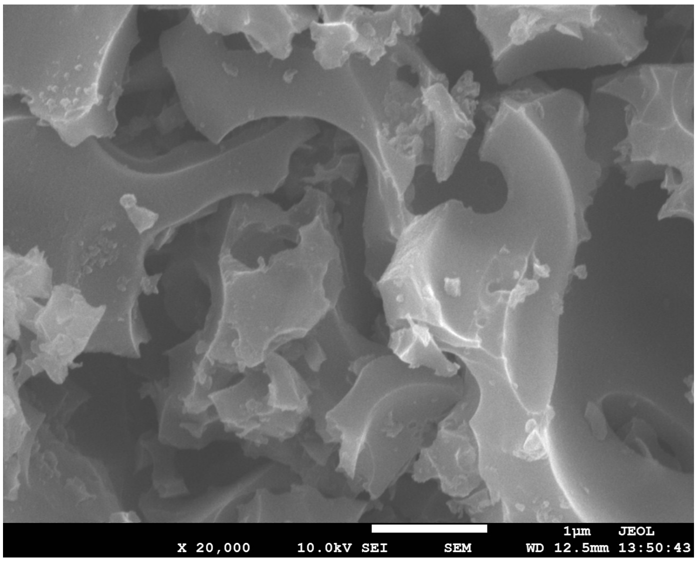

Fig. S1. SEM image of the activated carbon obtained by direct KOH activation of willow catkin at 800 °C

2. TEM images of the activated carbon derived from willow catkins (HPNCT-

800).

These carbon microtubes were further characterized by transmission electron microscopy (TEM) (Fig.S2a and b). Generally, activated carbons are normally composed of randomly stacked graphite-like planes with a high level of disorder, which results in a high porosity and surface area [S1]. The carbon microtubes consisted of disordered carbon layers were clearly seen in the HPNCT-800 sample, as shown in Fig.S2a. Moreover, meso/micropores and channels can also be clearly observed in Fig.S2a and b. These mesopores and interconnections of the carbon materials provided a favorable path for transportation and penetration of electrolyte ions, which were important for fast ion transfer. Therefore, these porous carbon materials derived from wilow catkins could be promising electrode materials for supercapacitors.

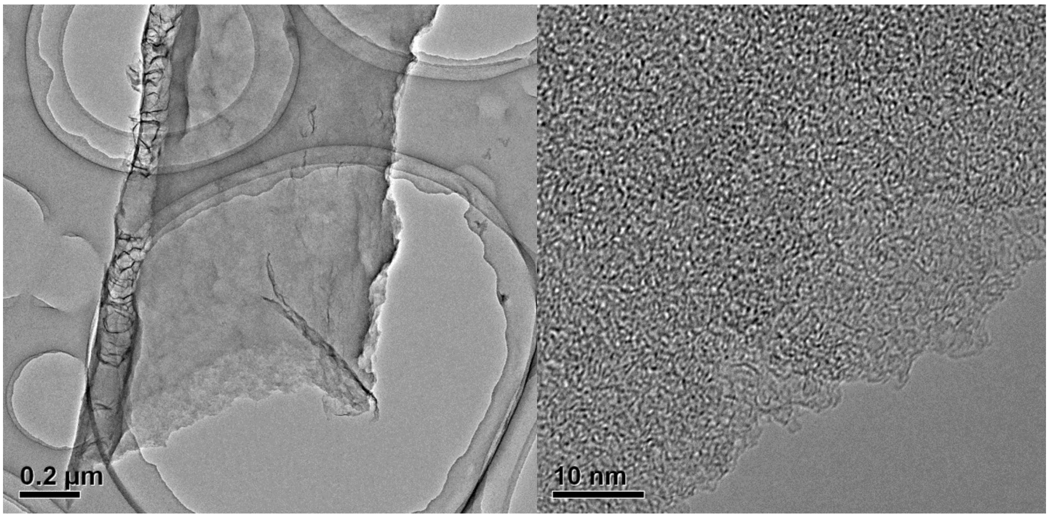

Fig. S2. Fig. S2. TEM images of HPNCT-800 at different magnifications.

3. **Fig.S3 compares the density of loose powders of HPNCT-800 with that of activated carbon derived coal and with that of graphene.**

Fig.S3 compares the density of loose powders of HPNCT-800 with that of activated carbon derived coal and with that of graphene. Since the diameter of the glass vials is identical in each case, the relative densities of the loose powders are the inverse of their packed height with the same sample mass. Thus the bulk density (tapped) of HPNCT-800 is about 0.36 g mL^{-1}, which is substantially lower than that of activated carbon derived coal (0.52 g mL^{-1}), being far larger than that of graphene (0.004 g mL^{-1}).

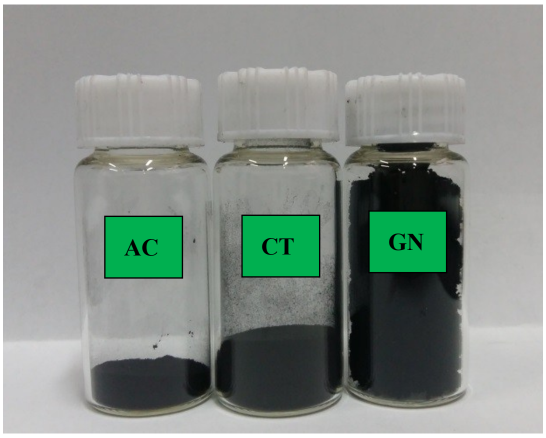

Fig.S3 Comparing the density of loose powders of HPNCT-800 (CT) with that of activated carbon derived coal (AC) and with that of graphene (GN).

Other criterions that should be considered are the carbon yield and ash of the willow catkins. The carbon yields of HPNCT-x are all around 20%, but that of MPNC-800 is only 17.5% (see in Table1), indicating molten salts remarkably affect the pyrolysis at higher temperatures, decreasing the apparent carbon yield.

4. TG and DTG curves of HPNCT-800 under air atmosphere

The TG curve in Fig.S4 of Supporting Information clearly shows two weight loss steps in the temperature ranges of 75-300 °C and 400-650 °C, which can be ascribed to the removal of chemically adsorbed H_2O and the combustion of HPNCT-800, respectively. After 650, the TG trace become stable without further mass loss, indicating the complete combustion of HPNCT-800 sample. The ash content in the HPNCT-800 sample is estimated to be 1.5%. The percent ash content of the activated carbon is higher than that of willow catkin (see in Table S1). This may be due to the decreasing volatile and fixed carbon contents of the activated carbon at higher temperature, while the actual ash amount unchanged under any heat treatment.

Moreover, the carbon contents of these kinds of waste biomasses in Table S1 are lower as compared to anthracite, coal or peat. Therefore, the yields of the activated carbon from these precursors are expected to be lower. However, its lower cost gives significant impact more than its lower yield [S2, S3]. At the same time, the high content of volatile matters exists in the biomass has been ideal to produce a highly porous structure of activated carbon [S4]. So, the useful of the end products of the waste, particularly activated carbon, and the economic input derived from these useful products eventually can off-set the costs of treatment and disposal [S5, S6]. More importantly, the ash content of willow catkins is about 1.12% (see in Table.S1), which is lower than that of other waste biomasses (Supporting Information). This is crucial for its practical application.

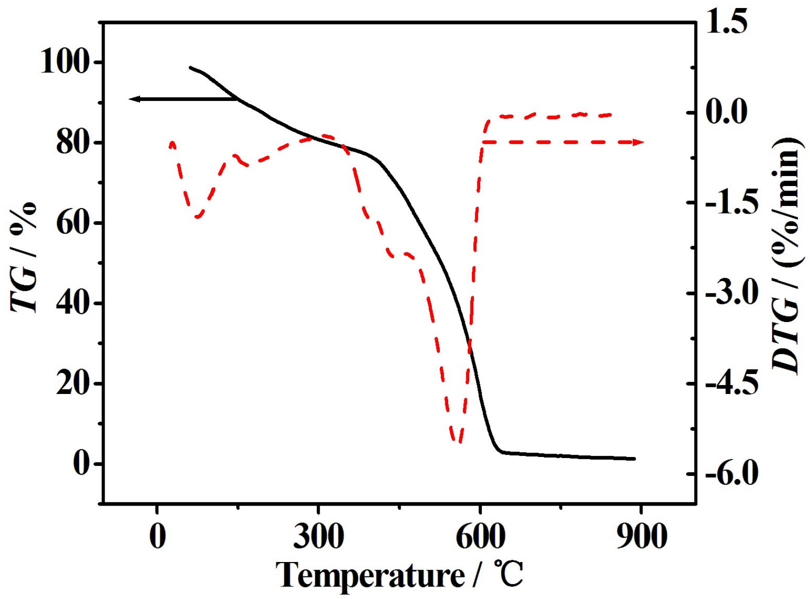

Fig.S4. TG and DTG curves of HPNCT-800 under air atmosphere

Table. S1. Elemental analysis and ash of the waste biomasses

Waste biomasses	Elemental analysis (wt.%)			Ash (%)	Ref.
	C	H	N	Ash	
Palm stem	45.56	5.91	0.82	4.02	S7
Bamboo	45.53	4.61	0.22	6.51	S8
Durian shell	39.30	5.90	1.00	4.84	S9
Banana empty fruit bunch	41.75	5.10	1.23	15.73	S10
Pomegranate seed	49.65	7.54	4.03	1.83	S11
Wheat straw	46.50	6.30	0.90	3.23	S12
Bagasse	41.55	5.55	0.03	6.2	S13
Rice husk	36.52	4.82	0.86	16.7	S13
Willow catkin	47.11	5.89	0.83	1.12	Our work

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