Electronic Supplementary Information

Synthesis of nitrogen-functionalized macroporous carbon particles *via* spray pyrolysis of melamine-resin

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1. Comparison of the nitrogen content in melamine-derived carbon

Table S1. Summary of the nitrogen content in melamine-derived carbon synthesized *via* liquid phase routes

No	Carbonization temperature (°C)	Atmosphere	Heating rate (°C min^{-1})	Holding time (h)	N-content (%)	Note	Ref.
1	700	NH_3	Unknown	1.5	4.1	8 h for template removal	1
2	700	N_2	7.5	1	4.0	-	2
3	600	Unknown	10	10	0.67	-	3
4	600	N_2	2	1.5	4.12	0.5 h for template removal	4
5	700	N_2	10	1	19	-	5

2. Estimation of double layer thickness and ζ-potential distribution

The droplets system is a mixture between charged melamine-resin oligomer and charged PSL particles. Therefore, we may assume that the system is highly charged. The colloidal system is

then simplified as an electrolyte system where the following equation applies to estimate the double layer thickness (x).

$$x = \frac{1}{\kappa} \quad \text{S.1}$$

$$\kappa = \left(\frac{2000F^2}{\varepsilon_0 DRT}\right)^{1/2}\sqrt{I} \quad \text{S.2}$$

F is the Faraday constant and R is the gas constant per mole. D is the relative permitivity and ε_0 is the permittivity of free space. The ionic strength, I, is defined as

$$I = \frac{1}{2}c_i z_i \quad \text{S.3}$$

c and z is concentration and ionic valence (=1), respectively.

The potential at a distance of h, E_h, from the PSL surface is estimated from the following equation.

$$E_h = E_0 e^{(-\kappa h)} \quad \text{S.4}$$

where E_0 is the ζ-potential at the surface of PSL. The potential distribution is illustrated in Figure S1.

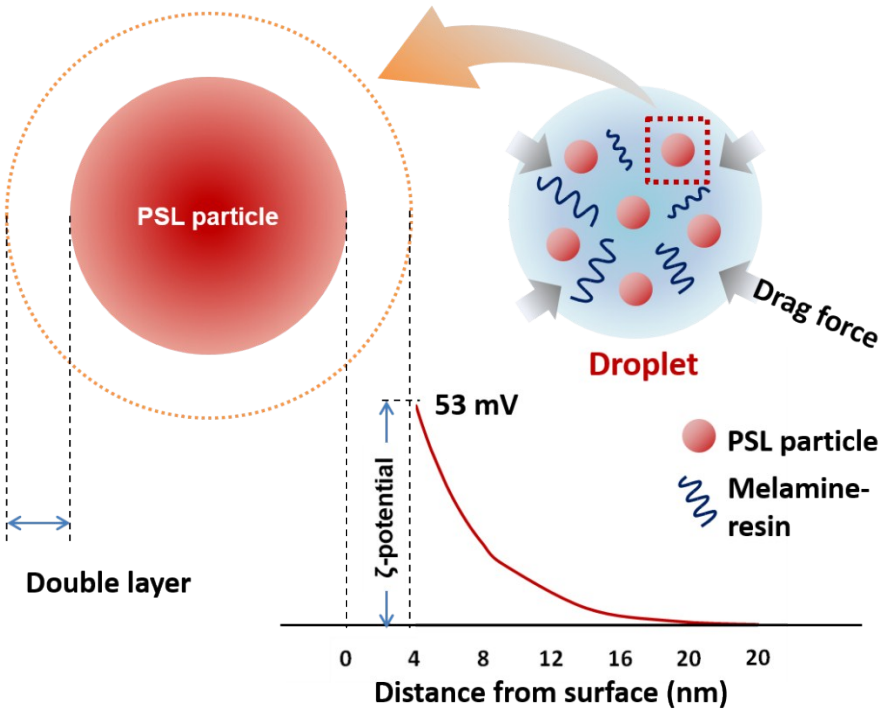

Figure S1. Illustration of the ζ-potential distribution around the PSL particles and the direction of drag force due to the water evaporation

3. Barrett-Joyner-Halenda analysis

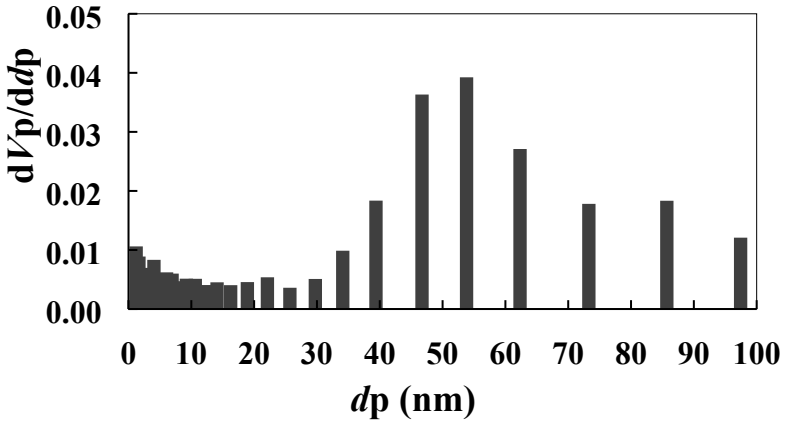

Figure SI.2. Pore size distribution of the particles prepared using 270 nm-sized PSL with PSL to melamine resin ratio of 1.6:1 and at a carbonization temperature of 800 °C resulted from Barrett-Joyner-Halenda analysis

References

1. Y. Zhao, R. Nakamura, K. Kamiya, S. Nakanishi and K. Hashimoto, *Nat Commun*, 2013, **4**.
2. E. Fiset, T. E. Rufford, M. Seredych, T. J. Bandosz and D. Hulicova-Jurcakova, *Carbon*, 2015, **81**, 239-250.
3. H. Li, W. Kang, L. Wang, Q. Yue, S. Xu, H. Wang and J. Liu, *Carbon*, 2013, **54**, 249-257.
4. M. Li and J. Xue, *The Journal of Physical Chemistry C*, 2014, **118**, 2507-2517.
5. C. Pevida, T. Drage and C. E. Snape, *Carbon*, 2008, **46**, 1464-1474.