Preparation of silver nanoparticles with hyperbranched polymer as stabilizer for inkjet printing flexible circuits

Yueyue Hao, Jian Gao, Zesheng Xu, Nan Zhang, Jing Luo* and Xiaoya Liu
The Key Laboratory of Synthetic and Biological Colloids, Ministry of Education, School of Chemical and Material Engineering, Jiangnan University, Wuxi, Jiangsu 214122, P. R. China

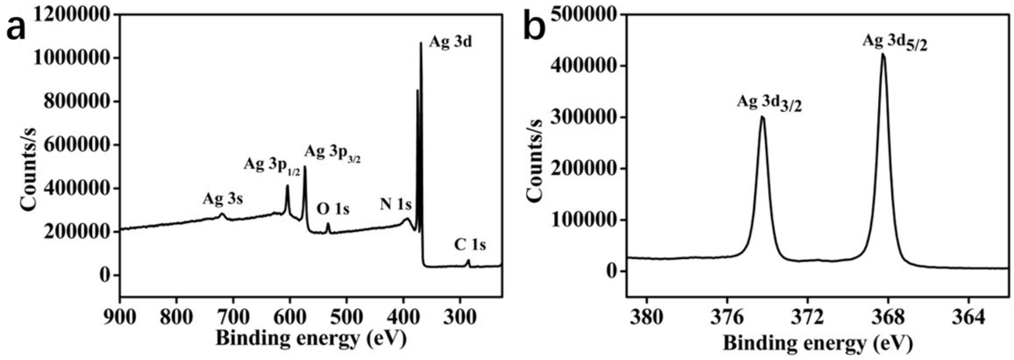

Fig.S1 XPS spectra of CHBPs-Ag NPs (exposed at ambient condition for 30 days): (a) XPS survey spectrum; (b) binding energy spectrum for Ag3d

A high resolution X-ray photoelectron spectrometer (XPS) (Axis supra, Kratos) was employed to exclude the presence of Ag_2O or other impurities on the NP surface. The binding energy was referenced to the standard C 1s at 284.8 eV. The XPS survey spectrum of the purified CHBP-Ag NPs was shown in Fig.S1 (a). The atoms of C, N, O and Ag were detected, and no other obvious peaks were found, indicating the high purity of the sample. The binding energies at 719.3 eV, 604 eV, 573 eV arose from Ag 3s, Ag $3p_{1/2}$, Ag $3p_{3/2}$ respectively [1-3]. From the spectrum of Ag 3d (Fig.S1(b)), the binding energies for Ag $3d_{5/2}$ and Ag $3d_{3/2}$ were found to be 368.3 eV and 374.28 eV respectively, which is in accordance with the respective core levels of bulk Ag crystals (368 and 374 eV) [4]. As we have known, the binding energies for Ag $3d_{5/2}$ and Ag $3d_{3/2}$ of Ag_2O were 367.7eV and 373.9 eV, respectively [5-6]. These results suggested the absence of Ag_2O. Moreover, the narrow width of the peaks suggested that only a single-element silver was present in the system and provided evidence for the encapsulation of zero valence silver nanoparticles by hyperbranced macromolecules. This result was also provided in the supporting information.

* Corresponding author. Fax: 86-510-85917763; Tel: 86-510-85917763; E-mail: jingluo19801007@163.com.

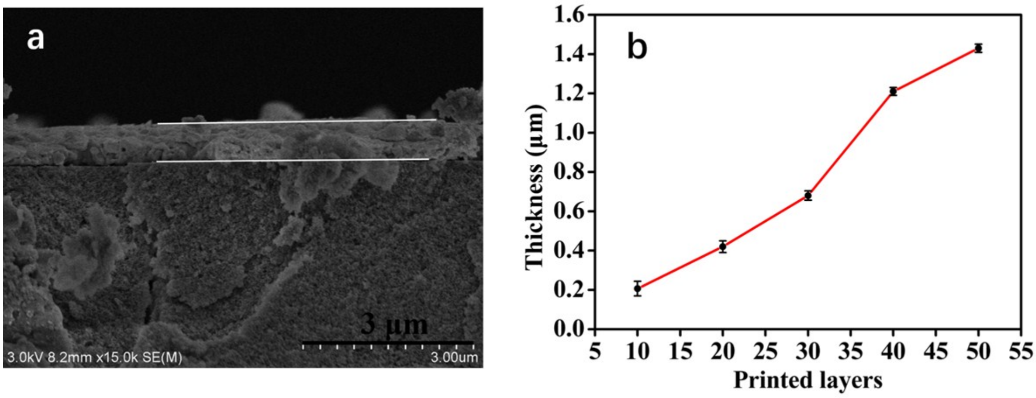

Fig. S2 (a) Cross-section of the printed silver pattern formed after heat-curing at 180 ^{o}C (30L); (b) Thicknesses of the printed silver patterns as a function of the number of printing cycles. (180 ^{o}C)

As shown in Fig.S2, the thickness of printed patterns could be measured by SEM. It was clearly seen that the thicknesses increased nonlinearly with the printed layers increased due to more silver nanoparticles were deposited onto the substrates. The thickness of printed patterns for 10 layers was about 0.2 μm，and increased to 0.42 μm for 20 layers, 0.68 μm for 30 layers, 1.21 μm for 40 layers, 1.43 μm for 50 layers.

Table S1 Resistivity of printed silver patterns (180 ^{o}C, 80 min)

Printed layers	Thickness	Sheet resistance	resistivity
30L	0.68 μm	0.16 Ω/□	10.83 μΩ cm

[1] H. Konno, M. Nagayama, Journal of Electron Spectroscopy & Related Phenomena, 1980, 18, 341-343.
[2] Y. Liu, R. G. Jordan, S. L. Qiu, Physical Review B Condensed Matter, 1994, 49, 4478.
[3] R. Nyholm, N. Martensson, Journal of Physics C Solid State Physics, 1980, 13, L279.
[4] J. Sharma, N. K. Chaki, A. B. Mandale, R. Pasricha and K. J. Vijayamohanan, Colloid Interface Sci., 2004, 1, 145-152.
[5] V. K. Kaushik. Journal of Electron Spectroscopy & Related Phenomena, 1991, 56, 273-277.
[6] L. H. Tjeng, M. B. J. Meinders, J. V. Elp, Physical Review B, 1990, 41, 3190.