Supplementary Materials

One-step route to Ag nanowires with diameter below 40 nm and aspect ratio above 1000

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Experimental.

Materials. $AgNO_3$ (≥99.8%, Shanghai Qiangshun Chemical Reagent Co., Ltd.) and ethylene glycol (EG, Sinopharm Chemical Reagent Co., Ltd.) were used as the source material and the reductant. Poly(vinylpyrrolidone (PVP) (Average MW of 55000, PVP-55000) (Sinopharm Chemical Reagent Co., Ltd.), PVP (Average MW of 1300000, PVP-1300000) (Aladdin Industrial corporation), and PVP (Average MW of 360000, PVP-360000) (Sigma-Aldrich) were used as capping agent. All reagents were used as-received without further purification.

Synthesis of AgNWs. AgNWs were synthesized by the reduction of silver nitrate in the presence of PVP in EG. PVP was dissolved with 22 mL of ethylene glycol (details were included in Table S1-S4). Subsequently, 2.5 mL of $FeCl_3$ solution (600 μM in EG) and $AgNO_3$ solution (0.180 g in 3 mL of EG) were added rapidly into PVP solution within 1 min. The reaction was performed at a certain temperature for different time durations as indicated in Table S1-S4. After cooling to room temperature, the solutions were washed with ethanol, centrifuged, and dispersed in ethanol. The purification process was repeated for 3 times. A final dispersion of AgNWs in ethanol was obtained.

Characterization. The morphologies of AgNWs were characterized by scanning electron microscopy (SEM) (Sirion 200 FEG) and transmission electron microscopy (TEM) (JEM-2010 transmission electron microscope). The crystallinity of AgNWs was characterized by powder X-ray diffraction (XRD, Philips X'pert Pro). Optical transmittance spectrum was obtained on a UV-vis-NIR spectrometer (Shimadzu SolidSpec-3600).

Scheme S1. The growth mechanism of AgNWs using PVP molecules of (a) short chain length, (b) long chain length, and (c) mixed long and short chain length.

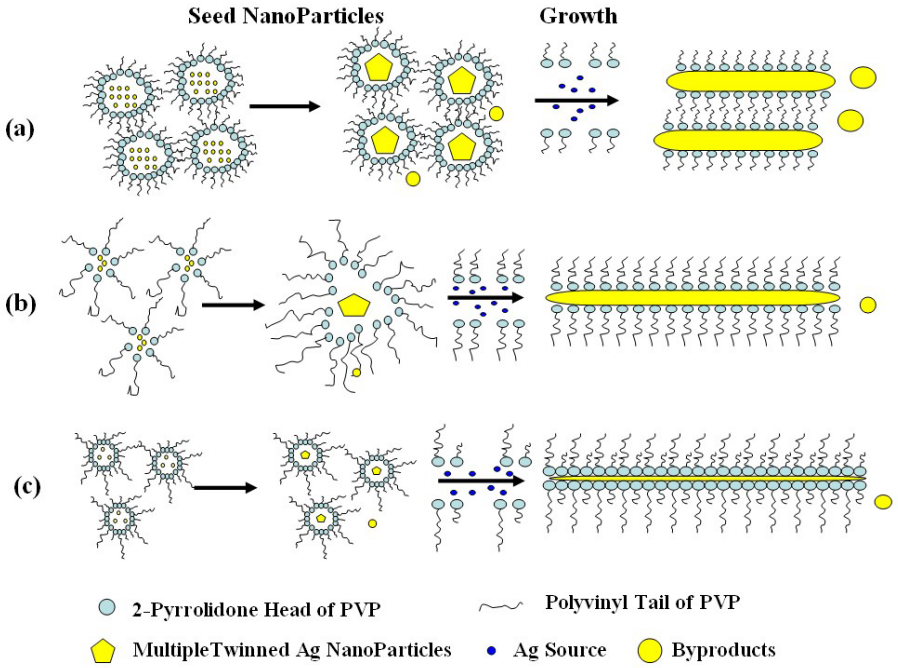


Figure S1. SEM images of AgNWs synthesized at 130°C with (a, b) PVP-360000+PVP-55000 and (c, d)PVP-1300000+PVP-55000.

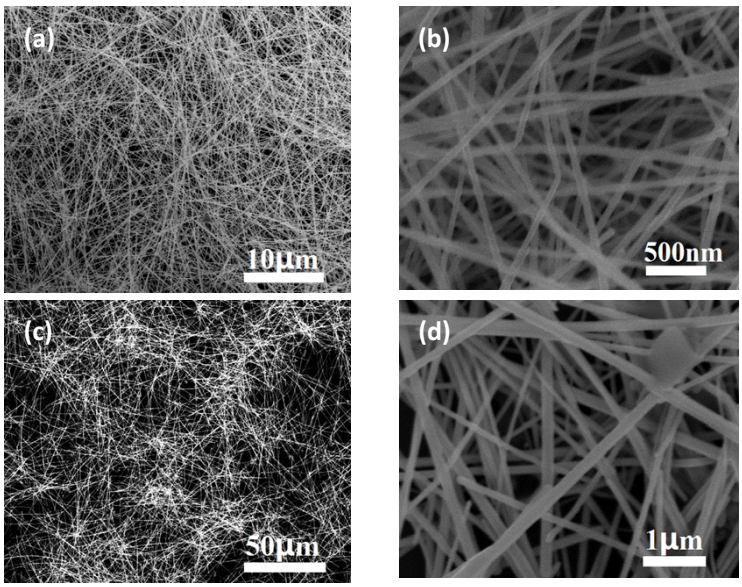


Figure S2. Diameter and length distributions of AgNWs synthesized at 140°C for PVP-360000+PVP-55000 of different weight ratio: (a, a') 1:1, (b, b') 2:1, (c, c') 3:1, and (d, d') 4:1.

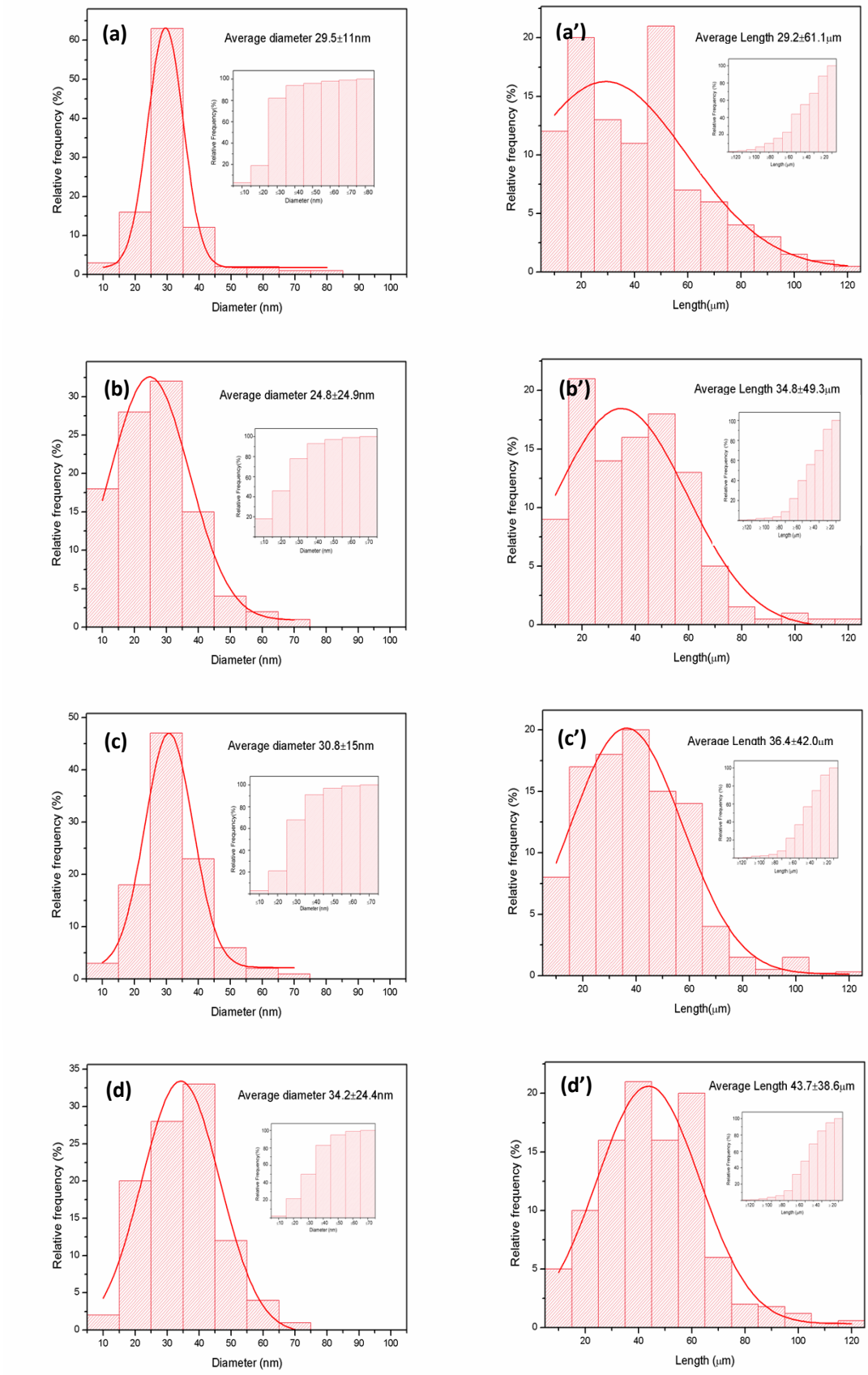


Figure S3. XRD pattern of the final products of sample synthesized at 130°C for PVP-360000+ PVP-55000 with a weight ratio of 1:1.

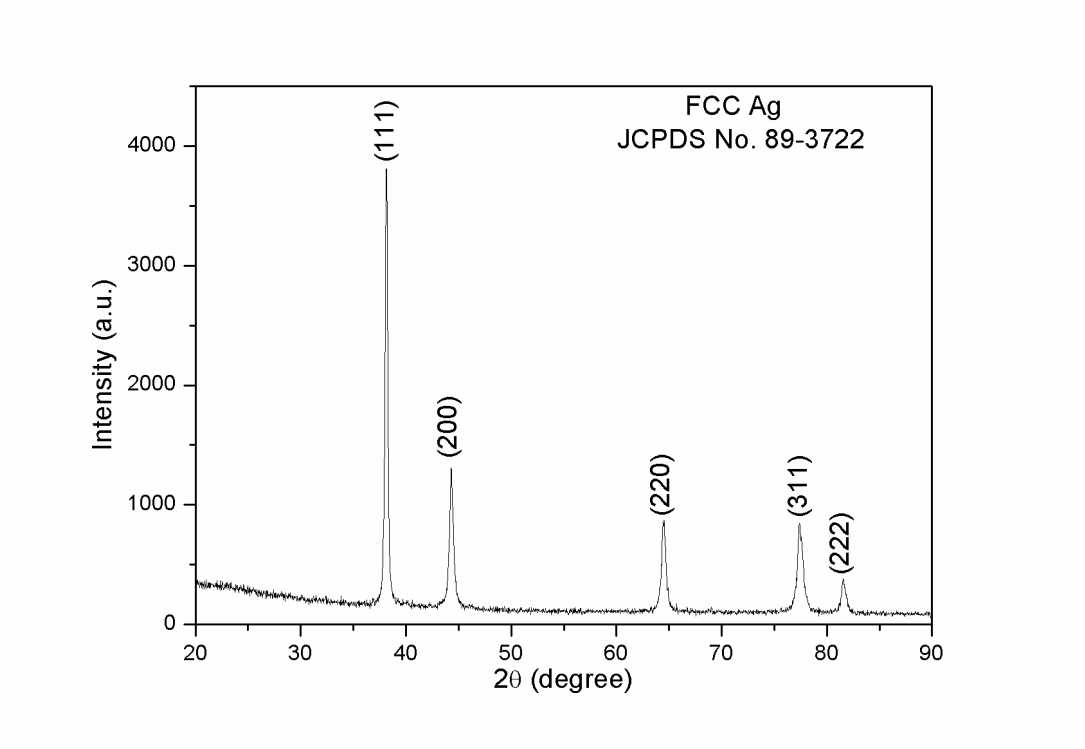


Figure S4. TEM characterization of AgNWs synthesized with PVP-360000+PVP-55000 (weight ratio of 2:1) at 140°C for 3 min. (a) Low and (b) high magnification TEM image of Ag seeds, and (c) HRTEM image of newly formed decahedral seeds.

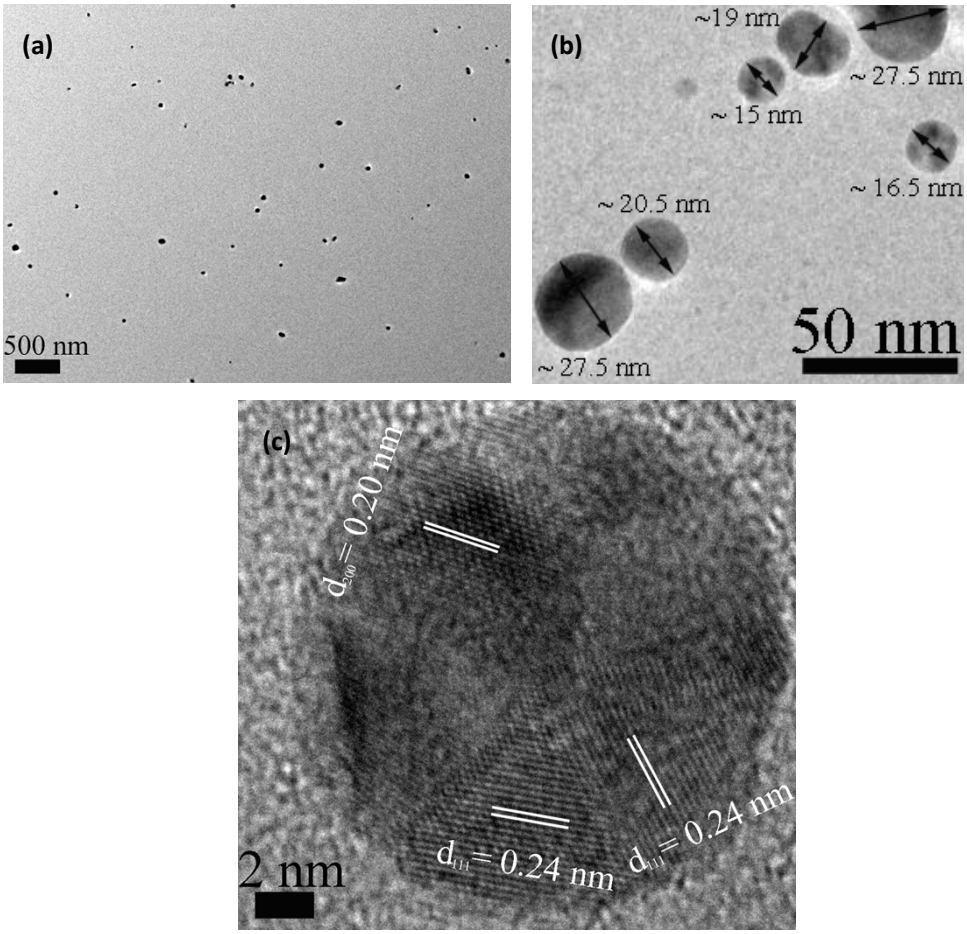


Figure S5. TEM characterization of AgNWs synthesized with PVP-360000+PVP-55000 (weight ratio of 2:1) at 140°C for 12 min. (a) Low magnification TEM image of Ag seeds and nanowires, and (b) high magnification TEM image of Ag nanowires.

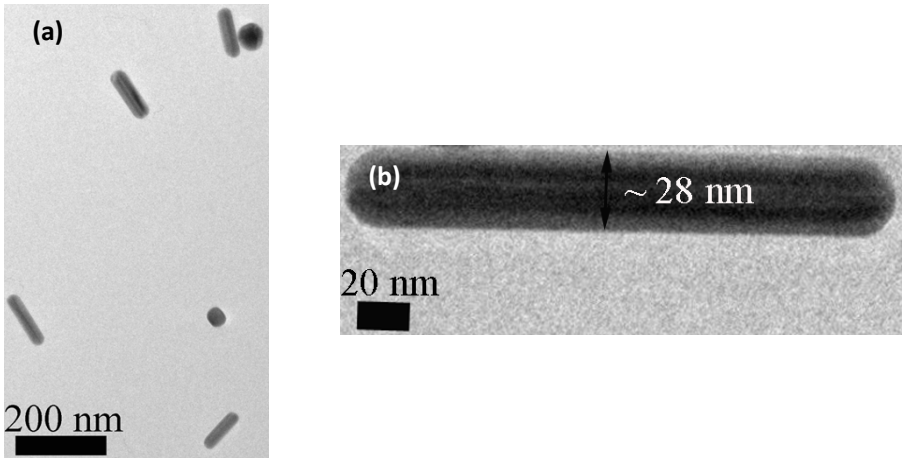


Figure S6. TEM and SEM characterizations of AgNWs synthesized with PVP-360000+PVP-55000 (weight ratio of 2:1) at 140°C for 18 min. (a) Low magnification TEM image of Ag seeds and nanowires, (b) high magnification TEM image of Ag nanowires, and (c) SEM image of Ag seeds and nanowires.

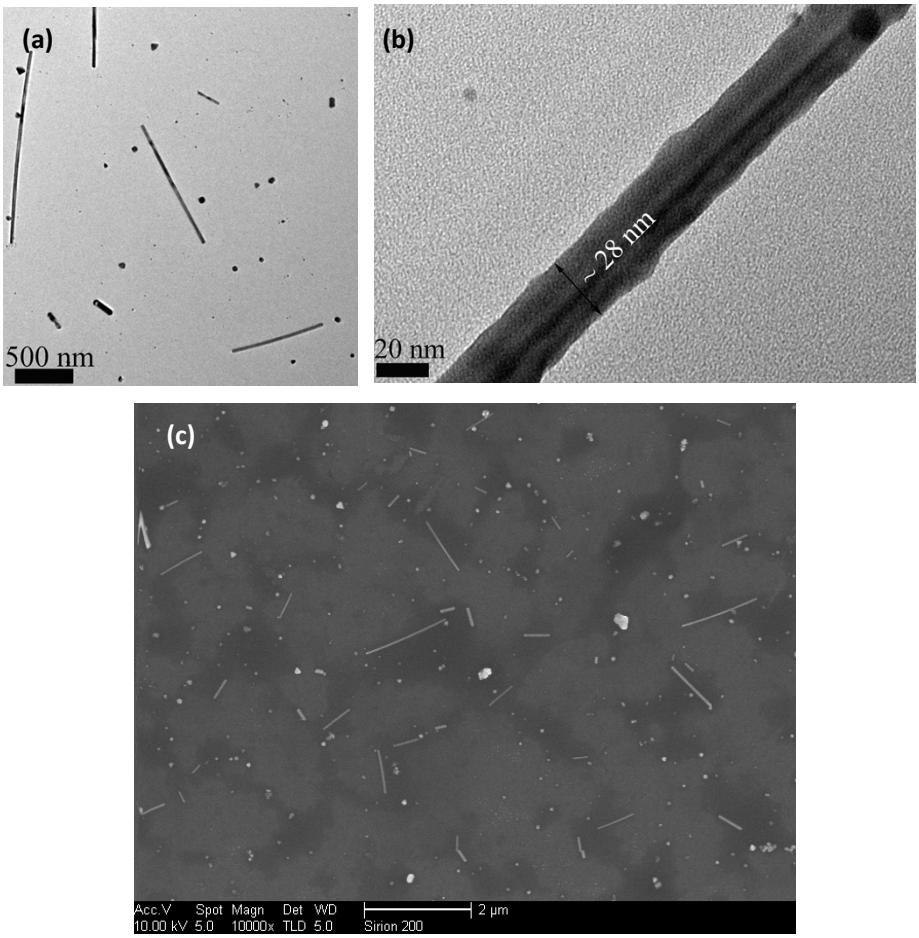
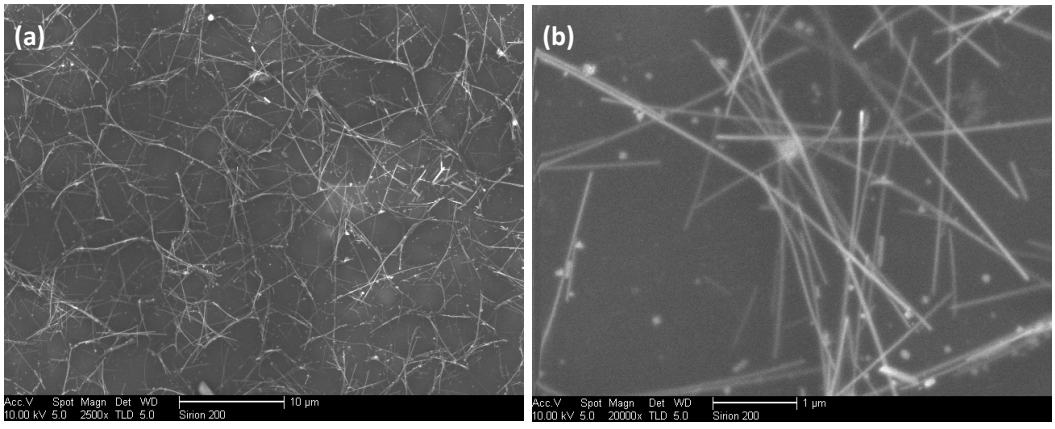


Figure S7. SEM characterization of AgNWs synthesized with PVP-360000+PVP-55000 (weight ratio of 2:1) at 140°C for (a, b) 25 min, and (c, d) 40 min.



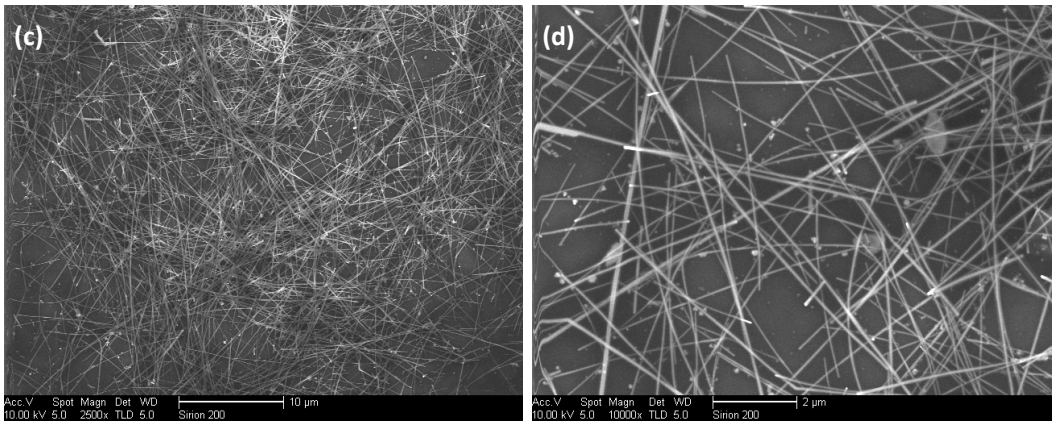


Figure S8. TEM characterization of AgNWs synthesized with PVP-360000 at 140°C for 9 min. (a) Low magnification TEM image of Ag seeds and nanowires; High magnification TEM image of Ag (b) seeds, and (c) nanowires.

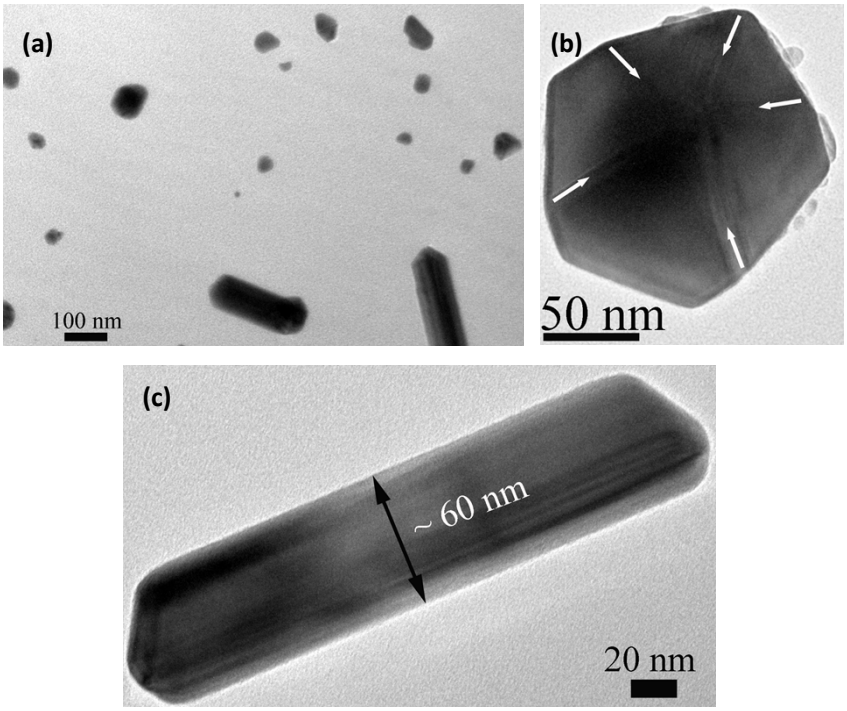


Figure S9. TEM characterization of AgNWs synthesized with PVP-55000 at 140°C for 9 min. (a) Low magnification, and (b) high magnification.

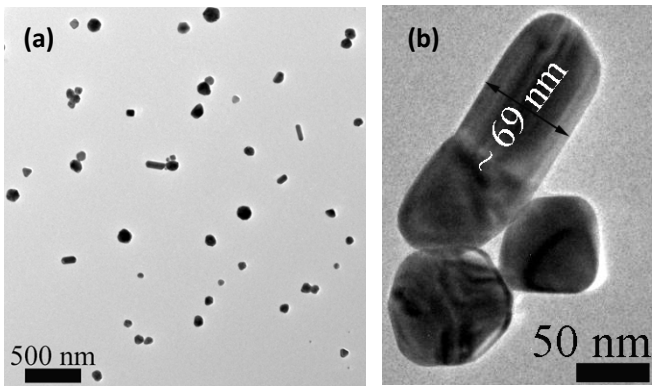


Figure S10. TEM characterization of AgNWs synthesized with PVP-360000+PVP-55000 (weight ratio of 3:1) at 140°C for 12 min. (a) Low magnification, and (b) high magnification.

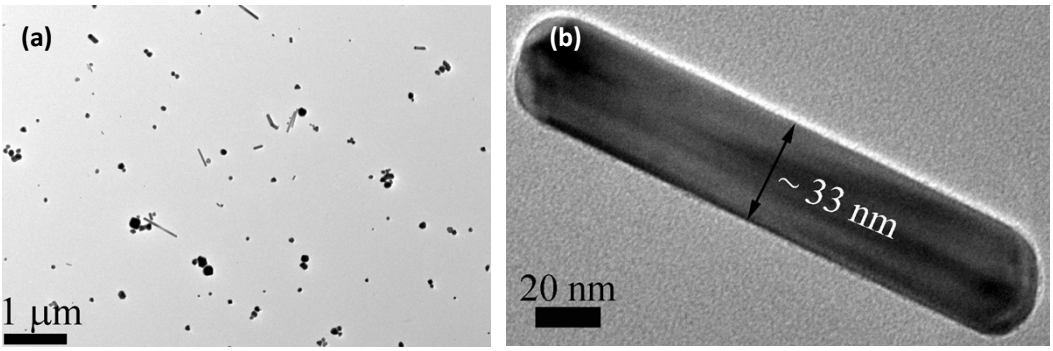


Figure S11. TEM characterization of AgNWs synthesized with PVP-360000+PVP-55000 (weight ratio of 4:1) at 140°C for 18 min. (a) Low magnification, and (b) high magnification.

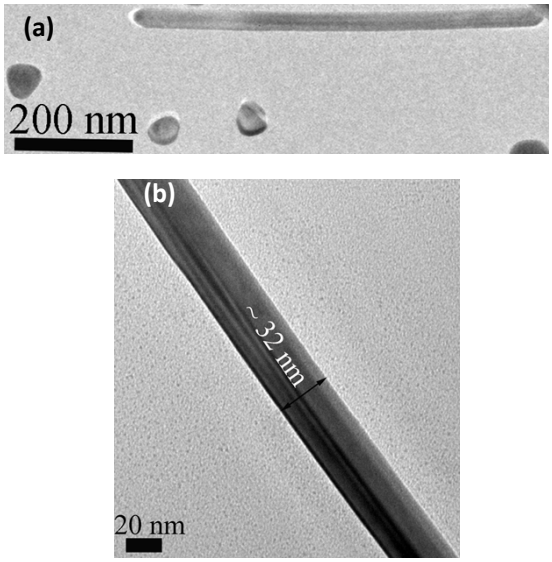


Figure S12. TEM characterization of AgNWs synthesized with PVP-360000+PVP-55000 (weight ratio of 2:1) through replacing $FeCl_3$ by $Fe(NO_3)_3$ at 140°C for (a) 3 min, and (b, c) 50 min.

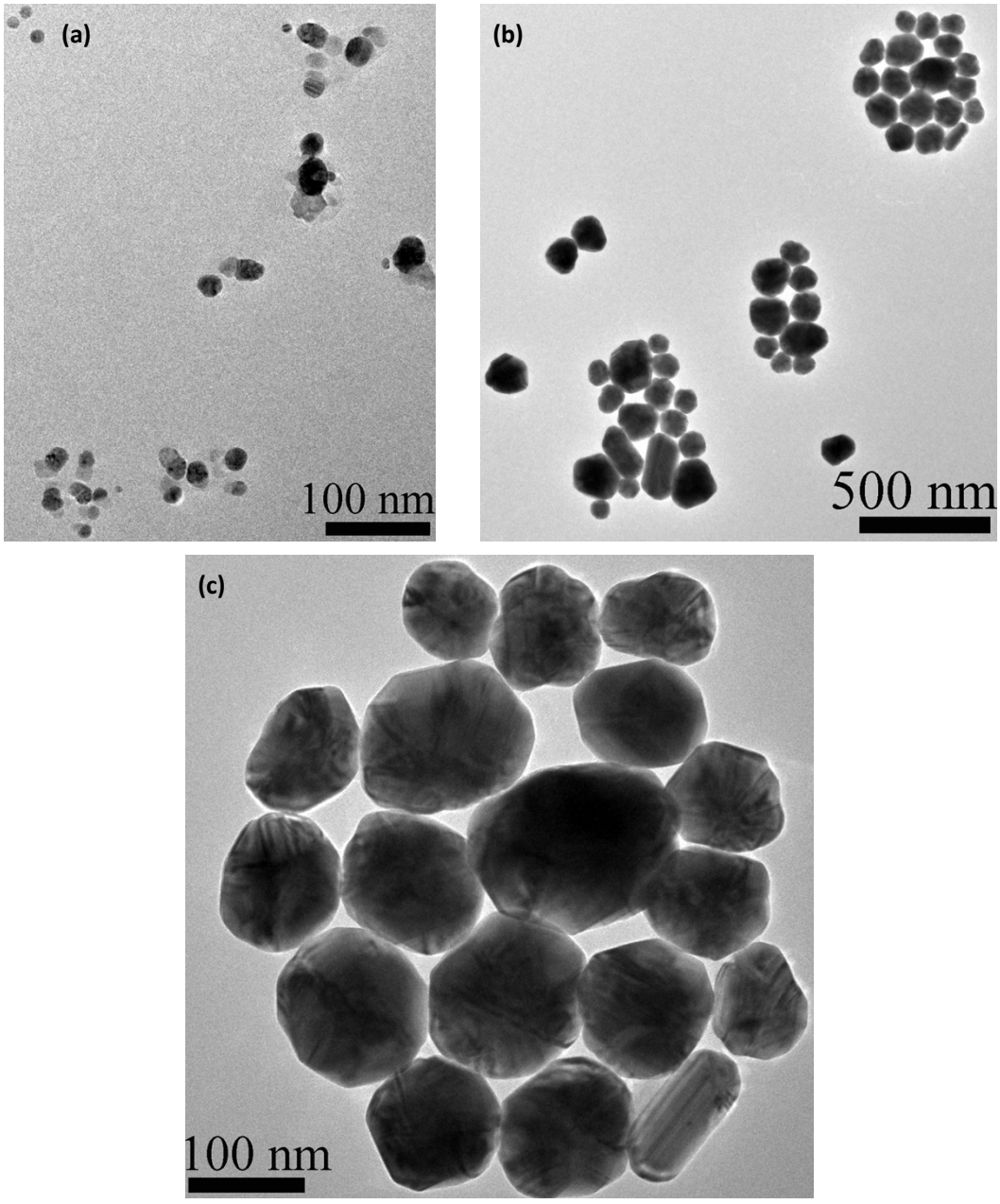


Figure S13. Optical transmittance spectrum of AgNW dispersions with same concentration, which have been normalized at the intrinsic absorption edge of Ag at ~ 318 nm.

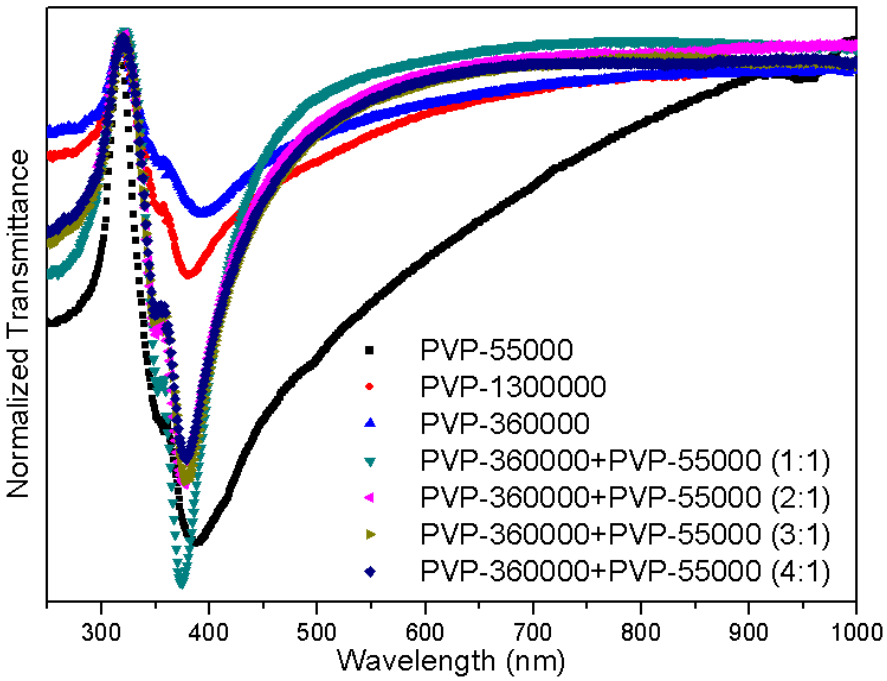


Figure S14. Visual effect comparison among TCFs of same sheet resistance for touch panel screen application made from AgNWs of different diameters (D) and lengths (L): (a) D > 100 nm, L < 30 μm; (b) D ~ 80 nm, L < 50 μm; (c) D < 40 nm, L > 50 μm.

Table S1. Preparation conditions of AgNWs with different PVP molecules.

Sample	$AgNO_3$ (g)	PVP (g)	EG (mL)	Temperature (°C)	Reaction time (min)	Final product (yields) and size of nanowires
1	0.180	0.163(Mw=55000)	25	120	390	NPs (~12%) and NWs (~88%); *D*: ~100 nm, *L*: ~25 μm
2	0.180	0.163(Mw=360000)	25	140	50	NPs (~5%) and NWs (~95%); *D*: ~60 nm, *L*: ~46 μm
3	0.180	0.163(Mw=1300000)	25	140	50	NPs (~15%) and NWs (~85%); *D*: ~80 nm, *L*: ~50 μm

Table S2. Preparation conditions of AgNWs under different temperatures.

Sample	$AgNO_3$ (g)	PVP (g)	EG (mL)	Temperature (°C)	Reaction time (min)	Final product (yields) and size of nanowires
1	0.180	0.163(Mw=1300000)	25	110	720	NPs (~85%) and NWs (~15%); *D*: ~160 nm, *L*: ~5 μm
2	0.180	0.163(Mw=1300000)	25	120	300	NPs (~35%) and NWs (~65%); *D*: ~140 nm, *L*: ~20 μm
3	0.180	0.163(Mw=1300000)	25	130	150	NPs (~20%) and NWs (~80%); *D*: ~90 nm, *L*: ~60 μm
4	0.180	0.163(Mw=1300000)	25	140	50	NPs (~15%) and NWs (~85%); *D*: ~80 nm, *L*: ~50 μm
5	0.180	0.163(Mw=1300000)	25	150	30	NPs (~60%) and NWs (~40%); *D*: ~70 nm, *L*: ~15 μm

Table S3. Preparation conditions of AgNWs with mixed PVP molecules.

Sample	$AgNO_3$ (g)	PVP (g)	EG (mL)	Temperature (°C)	Reaction time (min)	Final product (yields) and size of nanowires
1	0.180	0.08 (Mw=55000) +0.08 (Mw=1300000)	25	130	150	NPs (~6%) and NWs (~94%); *D*: ~70 nm, *L*: ~50 μm
2	0.180	0.08 (Mw=55000) +0.08 (Mw=1300000)	25	140	50	NPs (~3%) and NWs (~97%); *D*: ~60 nm, *L*: ~40 μm
3	0.180	0.08 (Mw=55000) +0.08 (Mw=360000)	25	130	150	NPs (~2%) and NWs (~98%); *D*: ~40 nm, *L*: ~40 μm
4	0.180	0.08 (Mw=55000) +0.08 (Mw=360000)	25	140	50	NPs (~4%) and NWs (~96%); *D*: ~30 nm, *L*: ~29μm

Table S4. Preparation conditions of AgNWs with mixed PVP molecules at different weight ratios.

Sample	$AgNO_3$ (g)	PVP (g)	EG (mL)	Temperature (°C)	Reaction time (min)	Final product (yields) and size of nanowires
1	0.180	0.08 (Mw=55000) +0.08 (Mw=360000)	25	140	50	NPs (~4%) and NWs (~96%); *D*: ~30 nm, *L*: ~29 μm
2	0.180	0.05 (Mw=55000) +0.10 (Mw=360000)	25	140	50	NPs (~6%) and NWs (~94%); *D*: ~25 nm, *L*: ~35 μm
3	0.180	0.04(Mw=55000) +0.12 (Mw=360000)	25	140	50	NPs (~8%) and NWs (~92%); *D*: ~31 nm, *L*: ~36 μm
4	0.180	0.03 (Mw=55000) +0.13(Mw=360000)	25	140	50	NPs (~12%) and NWs (~88%); *D*: ~34 nm, *L*: ~44μm