S Figure 1. XRD of Cu2O products in different surfactant: (a) BTM; (b) CPC; (c) SDBS; (d) SDS; (e) PEG and (f) Tween 80.

The XRD patterns of Cu2O obtained in other surfactant have been showed in S Figure 1. There was no big difference between different samples formed by different surfactant indicating that the surfactant did not influence the final production (S Figure 1).
**S Figure. 2.** SEM images of Cu$_2$O products prepared with different surfactant: (a): SDBS; (b): SDS; (c): AOT; (d): CTAB; (e): BTM; (f): CPC; (g): PEG; (h): PVP; (i): Tween 80.

The SEM imagines of Cu$_2$O formed in surfactant were shown in **S Figure 2.** It can be clearly found that the morphologies of Cu$_2$O formed in different surfactant were almost same except AOT. The morphologies of Cu$_2$O formed by wet chemical reduction in the solution containing AOT surfactant are spherical, while the morphologies of Cu$_2$O formed in other surfactant solution are octahedron.

The morphologies formed in AOT were spherical which was made with some small particles.
S Figure 3. Photo-electronic activity of Cu$_2$O production in different surfactant: (a) BTM; (b) CPC; (c) SDBS; (d) SDS; (e) PEG; (f) Tween 80;

From the S Figure 3, it can be clearly seen that the open circuit potential of Cu$_2$O production formed in cationic surfactant showed negative potential under light illumination. While the open circuit potential of Cu$_2$O formed in anionic surfactant or non-ionic surfactant showed positive potential under illumination. The results of $V_{OC}$ can formed that the type of Cu$_2$O formed in SDBS, AOT, PEG, PVP or tween 80 was p-type semiconductor. While Cu$_2$O formed in BTM or CPS surfactant was n-type semiconductor.