Supporting Information

Asymmetric AgPd-AuNR heterostructure with enhanced photothermal performance and SERS activity

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Figure S1. TEM image and extinction spectrum of AuNRs

Figure S2. TEM images of AuNRs@Ag core-shell nanostructures with different thicknesses of Ag shell. a) AgNO₃ 60 μL. b) AgNO₃ 100 μL. c) AgNO₃ 200 μL. d) AgNO₃ 300 μL. e) AgNO₃ 400 μL. f) AgNO₃ 500 μL. From a to f, the width of AuNR@Ag nanorods varied from 28.3 ± 1.3 nm, 29.8 ± 1.6 nm, 36.2 ± 1.8 nm, 41.2 ± 2.3 nm, 44.6 ± 2.0 nm to 45.9 ± 3.1 nm.
Figure S3. Extinction spectra of AuNRs@Ag core-shell nanostructures with different volume of AgNO$_3$ ranging from 60 µL to 500 µL.

Figure S4. TEM images of AuNRs@AgPd structures prepared with 60 µl (a), 100 µl (b), 200 µl (c), 300 µl (d), 400 µl (e) and 500 µl (f) AgNO$_3$ (0.01 M) solution, respectively.

Figure S5. SEAD patterns of nanodumbbell, dandelion and lollipop nanostructures
Figure S6. XPS spectra of the dandelion NPs (a-d) and nanodumbbell (e-f). (a,e) Survey spectrum, (b,c,d,f,g, h) the high resolution spectra of Au 4f, Ag 3d and Pd 3d.
Figure S7 XRD patterns of nanodumbbell (a) and dandelion NPs (b)

Figure S8. TEM images of AuNRs@AgPd nanostructures with different amount of AA and CTAC. a) no CTAC and no AA. b) no CTAC, 20 μL AA. c) no CTAC, 60 μL AA. d) no AA, 30 μL CTAC. e) no AA, 60 μL CTAC. The volume of AgNO₃ is 500 μL.
Figure S9. TEM images of AuNRs@AgPd nanostructures with different amount of AA and CTAC. a) 30 µL CTAC and 20 µL AA. b) 30 µL CTAC and 60 µL AA. c) 60 µL CTAC and 20 µL AA. d) 60 µL CTAC and 60 µL AA. The volume of AgNO₃ is 500 µL.

Figure S10. TEM images of AuNRs@AgPd nanodumbbell nanostructures with different amount of AA. a) 20 µL AA. b) 30 µL AA. c) 40 µL AA. d) 60 µL AA. The volume of AgNO₃ is 300 µL.
Figure S11. TEM images of nanodumbbell (top) and dandelion (bottom) nanostructures with different amount of H$_2$PdCl$_4$. a,e) 10 $\mu$L. b,f) 20 $\mu$L. c,g) 60 $\mu$L. d,h) 80 $\mu$L.

Figure S12. TEM images of AuNRs@AgPd dandelion nanostructures at different reaction stages. a) After the very early Pd precursor injection without additional CTAC and AA. b) 1 min. c) 5 min. d) At high relative ratio of AgNO$_3$. The reaction time is 1h.

Figure S13. Extinction spectra of gold nanorods, nanodumbbell and dandelion NPs.
**Figure S14.** The temperature rise traces of the gold nanorods solution at 1.45 W of the 808 nm laser.

**Figure S15.** The digital photographs of the dandelion NPs(a-c), nanodumbbell NPs(d-f) and gold nanorods(g-i) solutions before (left), after (middle) illuminated by laser and the digital photographs of final steady-state temperature (right).
Figure S16. Raman spectra of the reduction of 4-NTP to 4-ATP by nanodumbbell NPs at different reaction time.