Supplementary Information

Novel synthesis of 0D, 1D and 2D nano-Cs_xWO_3 and their tunable optical-thermal response performance

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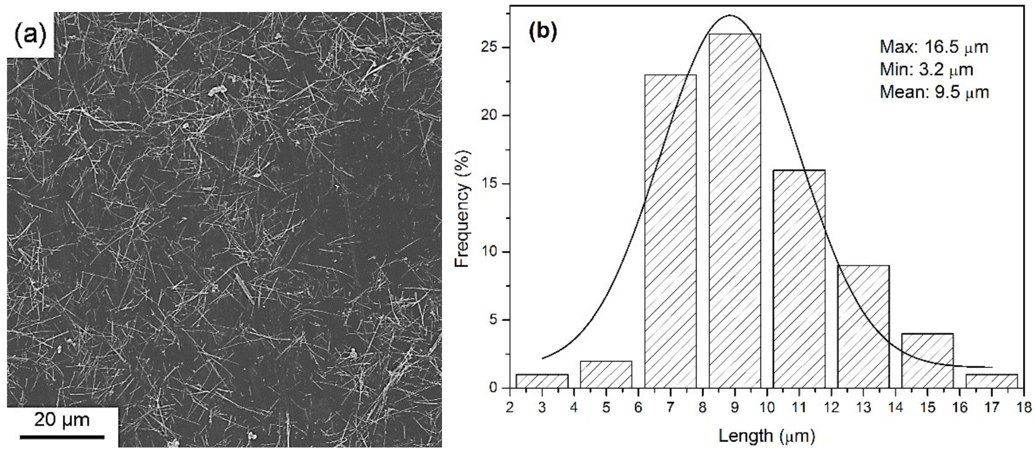

Fig. S1. Low-magnification (a) and the size distribution in length direction (b) of the 1D $Cs_{0.3}WO_3$ nanofibers.

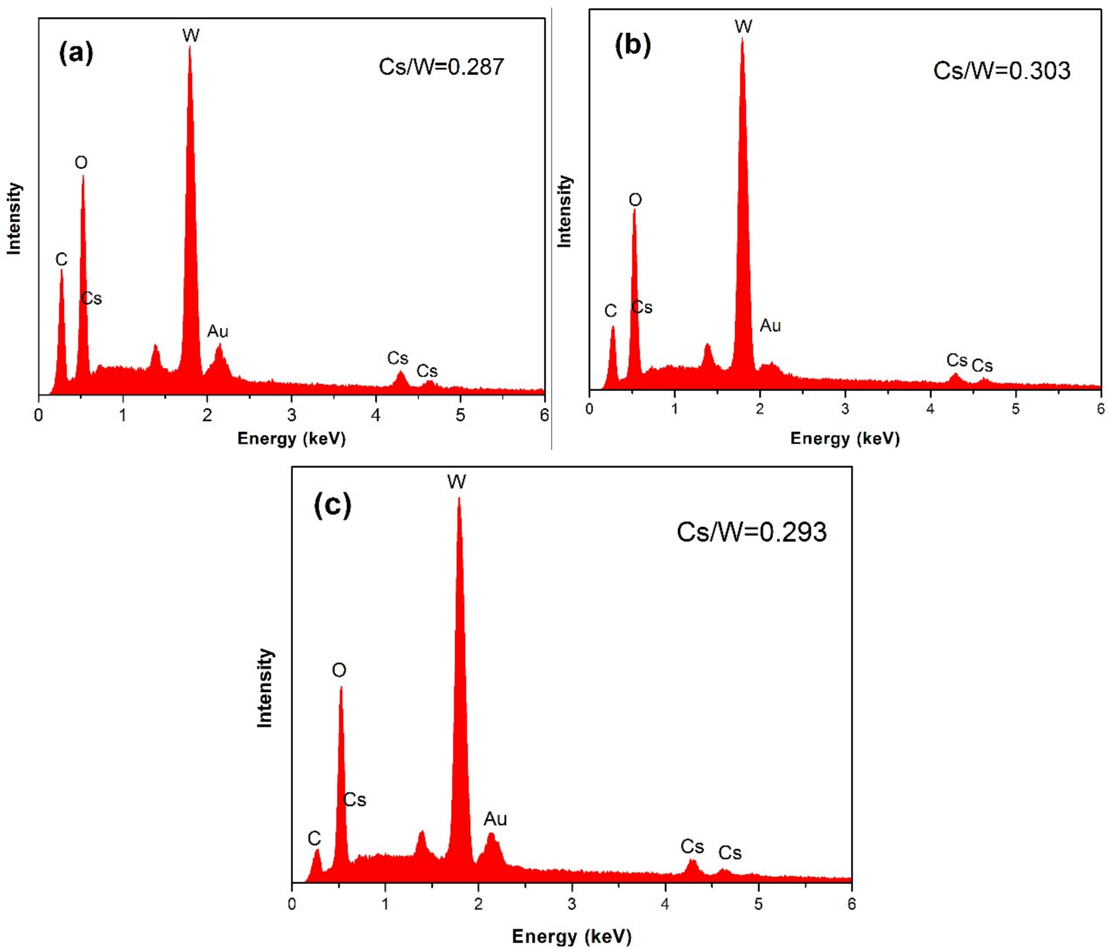

Fig. S2. ESD patterns of the obtained $Cs_{0.3}WO_3$ samples with different morphologies: (a) 2D nanosheets, (b)1D nanofibers and (c) 0D nanoparticles.

Table S1 EDS analysis of the obtained $Cs_{0.3}WO_3$ samples with different morphologies.

Morphology	Atomic percent (%)					Estimated Cs/W atomic ratio by EDS
	O	C	W	Au	Cs	
2D nanosheets	27.83	9.38	43.44	6.87	12.47	0.287
1D nanofibers	22.69	10.96	45.94	6.49	13.92	0.303
0D nanoparticles	20.67	9.89	47.13	8.50	13.81	0.293

Calculation of the photothermal conversion efficiency

The photothermal conversion efficiency of the obtained $Cs_{0.3}WO_3$ samples was calculated according to previous reports.[1, 2] The detailed calculation was carried out as following equations:

The total energy balance of this system as following equation:

$$\sum_{\mathrm{i}} m_i C_{p,i} \frac{dT}{dt} = Q_{CWO} + Q_{\mathrm{S}} - Q_{loss} \qquad (1)$$

where m and C_p are the mass and heat capacity, respectively. The suffix "i" of m and C_p refers to solvent (water) or dispersed matter ($Cs_{0.3}WO_3$ samples with different morphologies). T is the solution temperature. Q_{CWO} is the photothermal energy absorbed by $Cs_{0.3}WO_3$ samples per second:

$$Q_{CWO} = I(1-10^{-A_\lambda})\eta \qquad (2)$$

where I is the laser power, A_λ is the absorbance of $Cs_{0.3}WO_3$ samples at the wavelength of 980 nm in aqueous solution, and η is the photothermal conversion efficiency of $Cs_{0.3}WO_3$ samples which means the ratio of absorbed light energy converting to thermal energy.

Q_{loss} is thermal energy lost to the surroundings:

$$Q_{loss} = hA\Delta T \qquad (3)$$

Where h is the heat transfer coefficient, A is the surface area of the container, and ΔT is the changed temperature, which is referred to T-T_{surr} (T and T_{surr} are the solution temperature and ambient temperature of the surrounding, respectively).

Q_{s} is the heat associated with the light absorbed by solvent per second. In the situation of heating pure water, the heat input is equal to the heat output at the maximum steady-statue temperature, so the equation can be:

$$Q_s = Q_{loss} = hA\Delta T_{\text{max,H}_2\text{O}} \qquad (4)$$

Where $\Delta T_{\text{max,H}_2\text{O}}$ is the temperature change of water at the maximum steady-state temperature.

As it to the experiment of $Cs_{0.3}WO_3$ samples dispersion, the heat inputs are the heat generated by $Cs_{0.3}WO_3$ samples (Q_{CWO}) and the heat generated by water (Q_{s}), which is equal to the heat output at the maximum steady-statue temperature, so the equation can be:

$$Q_{\text{CWO}} + Q_{\text{s}} = Q_{\text{loss}} = hA\Delta T_{\text{max,mix}} \qquad (5)$$

Where $\Delta T_{\text{max,mix}}$ is the temperature change of the $Cs_{0.3}WO_3$ samples dispersion at the maximum steady-state temperature. According to the Eqs. 2, 4 and 5, the photothermal conversion efficiency (η) can be expressed as following:

$$\eta = \frac{hA(\Delta T_{\text{max,mix}} - \Delta T_{\text{max,H2O}})}{I(1-10^{-A_\lambda})} \qquad (6)$$

In this equation, only hA is unknown. In order to get the hA , we introduce θ, which is defined as the ratio of ΔT to ΔT_{max}:

$$\theta = \frac{\Delta T}{\Delta T_{\text{max}}} \qquad (7)$$

Substituting Eq. 7 into Eq. 1:

$$\frac{\mathrm{d}\theta}{dt}=\frac{hA}{\sum_i m_i C_{p,i}}\left[\frac{Q_{\mathrm{CWO}}+Q_{\mathrm{s}}}{hA\Delta T_{\max}}-\theta\right] \qquad (8)$$

When the laser was shut off, the $Q_{\mathrm{CWO}}+Q_{\mathrm{s}}=0$, Eq. 8 could be expressed to:

$$dt=-\frac{\sum_i m_i C_{p,i}}{hA}\frac{d\theta}{\theta} \qquad (9)$$

Eq. 9 changes the expression:

$$t=-\frac{\sum_i m_i C_{p,i}}{hA}\ln\theta \qquad (10)$$

Where $\frac{\sum_i m_i C_{p,i}}{hA}$ can be calculated by linear relationship of time versus -ln(θ). Compared with solvent (water, 2×10^{-3} Kg), mass of $Cs_{0.3}WO_3$ samples (2×10^{-7} Kg) is too little. Generally, the specific heat of water is much higher than other materials. Consequently, the m_{CWO} and $C_{p,\mathrm{CWO}}$ are neglected. $m_{\mathrm{H_2O}}$ is 2×10^{-3} Kg. $C_{p,\mathrm{H_2O}}$ is 4.2×10^{3} $\mathrm{J\cdot Kg^{-1}\cdot {}^{o}C^{-1}}$. So hA of 2D, 1D and 0D $Cs_{0.3}WO_3$ is equal to 0.0264, 0,0241 and 0.0253, respectively.

Now go back to Eq. 6 again, every parameter is clear now. $\Delta T_{\mathrm{max,mix}}$ of 2D, 1D and 0D $Cs_{0.3}WO_3$ is 46.5, 33.2 and 27.3 ºC, respectively. $\Delta T_{\mathrm{max,H_2O}}$ is 5.6 ºC . I is 2.49 W where the area of light spot is 1.5 cm^2 (1.66W·cm^{-2}). A_λ of 2D, 1D and 0D $Cs_{0.3}WO_3$ is equal to 2.7, 1.5 and 1.0, respectively. Therefore, the photothermal conversion efficiency (η) of Cs_xWO_3 samples can be calculated.

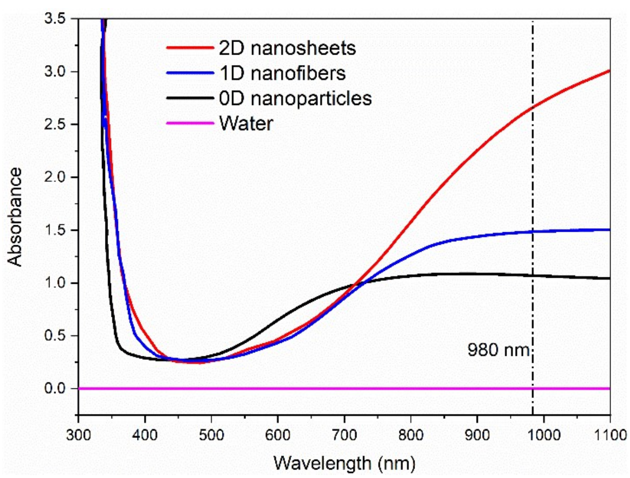

Fig. S3. UV-vis-NIR absorption spectra of $Cs_{0.3}WO_3$ samples with different morphologies dispersed (100 μg·mL^{-1}) in water.

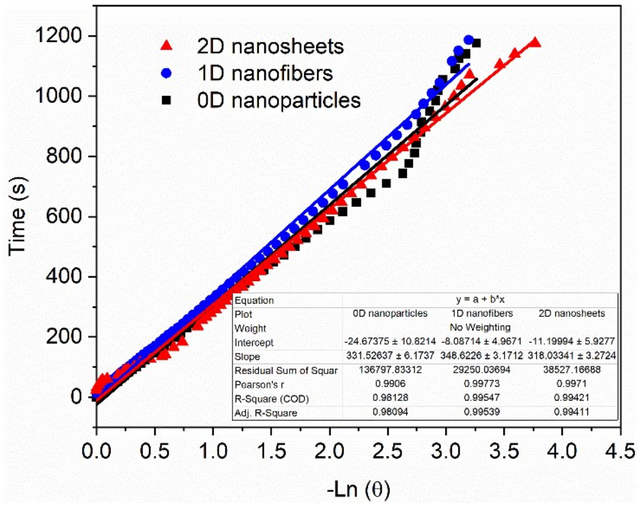

Fig. S4. Linear time data versus-ln (θ) obtained from the cooling period of NIR laser off.

References

1. Y. Liu, K. Ai, J. Liu, M. Deng, Y. He and L. Lu, *Advanced Materials*, 2013, **25**, 1353-1359.
2. W. Ren, Y. Yan, L. Zeng, Z. Shi, A. Gong, P. Schaaf, D. Wang, J. Zhao, B. Zou, H. Yu, G. Chen, E. M. B. Brown and A. Wu, *Advanced Healthcare Materials*, 2015, **4**, 1526-1536.