Fabrication of tungsten-doped manganese nanoflowers and evaluation of their photothermal therapeutic efficacy

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Abstract

Pristine manganese nanoflowers (MNF) have potential applications in photothermal therapy. The objective was to fine-tune the morphology to reach the desired temperature while avoiding permanent damage, a goal successfully accomplished through tungsten doping. In this study, we effectively incorporated tungsten metal into the flower morphology, resulting in defects and the formation of secondary mesopores within the channel, which subsequently led to a temperature reduction of nearly 20°C. The flawed surface clearly exhibited a peak in the mesopore-micropore region, which can be linked to the introduction of foreign metal doping. This approach to doping can be extensively employed to adjust the molecular structure during the application of photothermal therapy treatment.

Synthesis and characterization

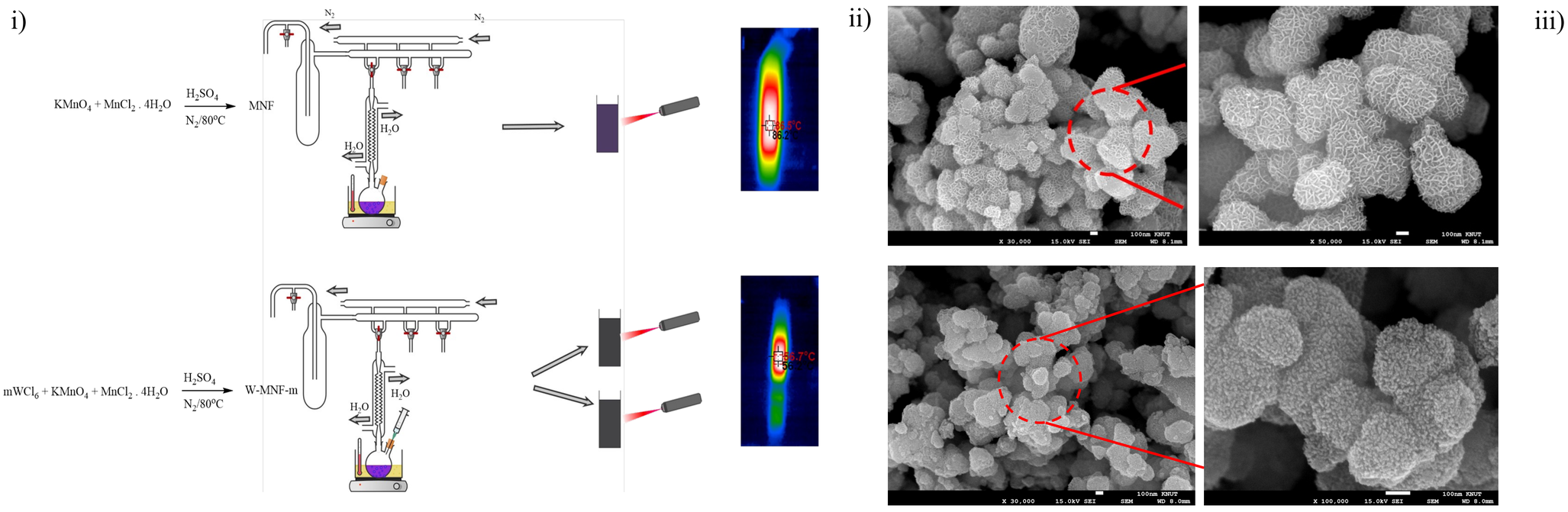


Figure 1. i) Schematic diagram of synthesis of MNF and tungsten doped MNF. ii) SEM image of pristine MNF (top) and doped MNF (bottom). iii) IR of pristine MNF (top) and doped MNF (bottom).

BET for surface analysis

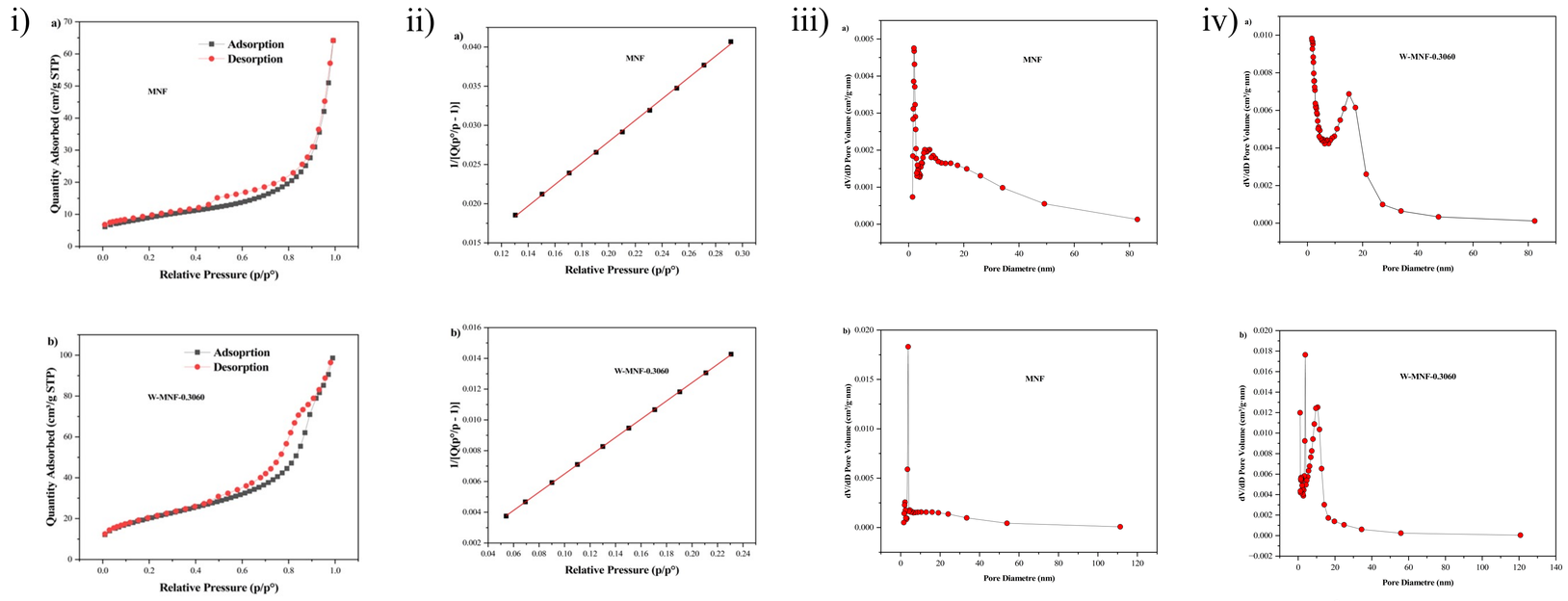


Fig 2. i) Isotherm linear plot a) MNF and b) W-MNF-0.3060, ii) BET surface area plot, (1/[Q(p^0/p -1)] vs relative pressure) for a) MNF and b) W-MNF-0.3060, iii) a) adsorption and b) desorption dV/dD pore volume vs pore diametre plot for MNF and iv) a) adsorption and b) desorption dV/dD pore volume vs pore diametre plot for W-MNF-0.3060.

XPS for doped MNF

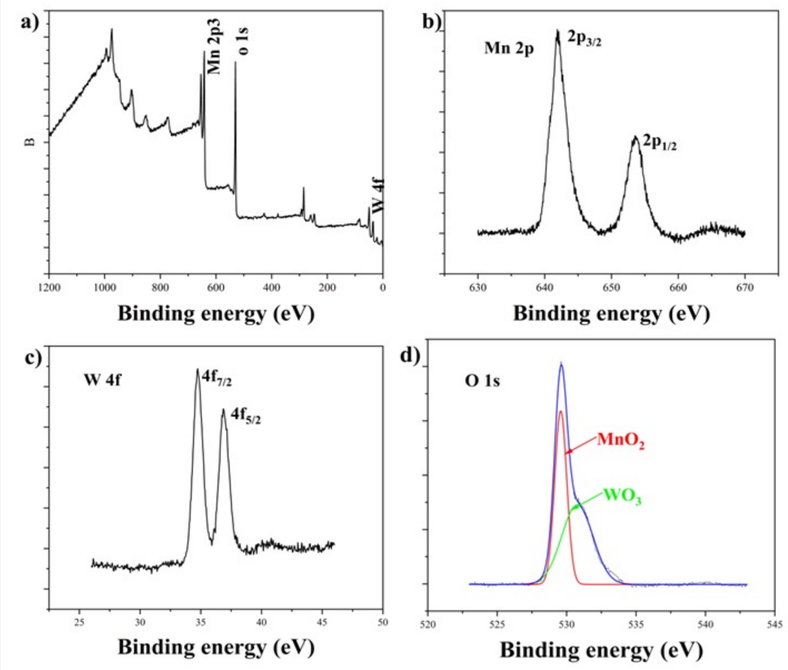


Fig 3. XPS analysis for doped MNF to assign bonding intricacies, a) survey, b) Mn2p, c) W4f and, d) O1s.

Photothermal assessment

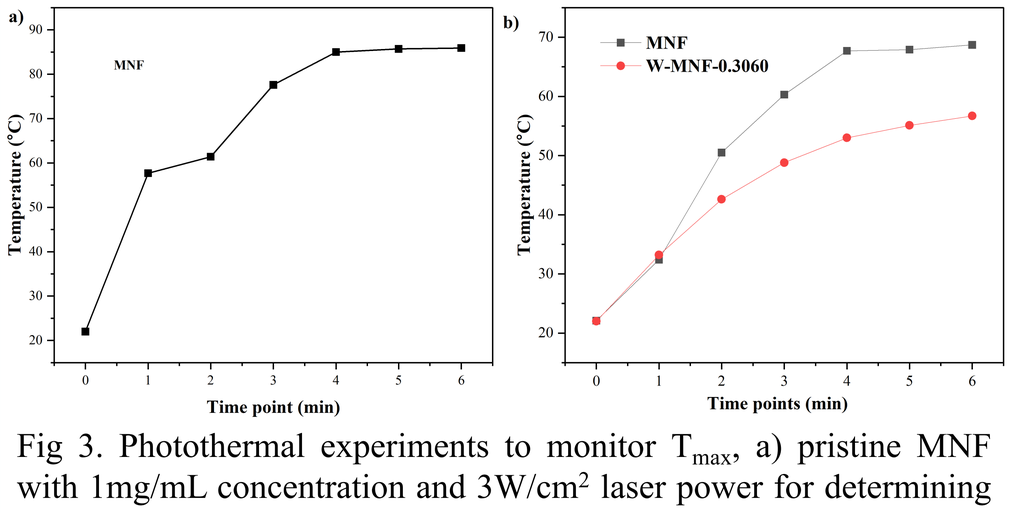


Fig 3. Photothermal experiments to monitor T_{max}, a) pristine MNF with 1mg/mL concentration and 3W/cm² laser power for determining the initial constraints and b) MNF, W-MNF-0.3060 with 500µg/mL concentration and 2.1 W/cm² laser power.

Cytotoxicity

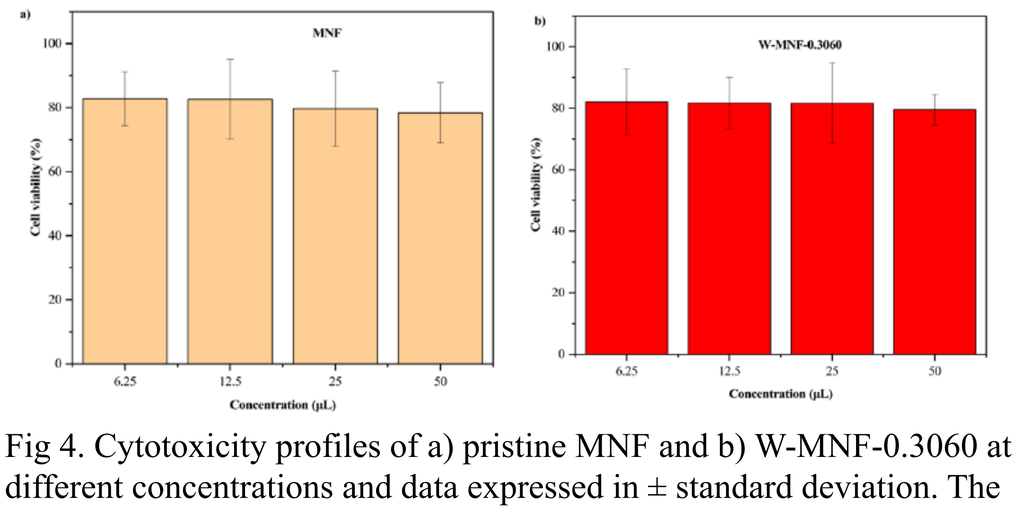


Fig 4. Cytotoxicity profiles of a) pristine MNF and b) W-MNF-0.3060 at different concentrations and data expressed in ± standard deviation. The experiment was repeated thrice (n = 5).

Conclusion

We have effectively deployed a synthetic method where doping can be successfully used to create a nanostructure, generating T_{max} of 56.7°C, which falls within the theoretical boundary of necrosis. This method can be useful in future for various metal doping to attain effective outcomes.

Acknowledgement

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