Electronic Supplementary Information (ESI)

for

Hydrogel microneedles with multifunctional strategy for prolonged

hyperuricemia management

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2. Materials and methods

2.1 Synthesis of ZIF-8

ZIF-8 nanoparticles (NPs) were synthesized following a previously reported method with slight modification [1]. Briefly, 297.5 mg of $Zn(NO_3)_2 \cdot 6H_2O$ were dissolved in 15 mL methanol and stirred for 20 min to form a transparent solution. Thereafter, 45 mL methanol solution containing 2-MIM (656.8 mg) was added to the above mixture drop by drop and magnetically stirred for 2 h. The resultant ZIF-8 NPs were precipitated by centrifugation (10000 rpm, 10 min) and washed with methanol.

2.2 Synthesis of MnO₂ nanoflowers

 MnO_2 nanoflowers (Nfs) were synthesized according to the method reported in the literature [2]. Initially, 500 mg of KMnO₄ was fully dissolved in 250 mL of deionized water and rapidly stirred for 15 min. Then, 5 mL of oleic acid was introduced and kept stirring for another 3 h to obtain the brown-black suspension. The MnO_2 was collected by centrifugation at 12000 rpm for 10 min and washed thrice with ethanol and deionized water to remove the residual reactants. Afterwards, the purified MnO₂ was dispersed in deionized water for further use.

[1] Huiyuan Chu, Jiwei Shen, Chaozhan Wang, Yinmao Wei. Biodegradable irondoped ZIF-8 based nanotherapeutic system with synergistic chemodynamic/photothermal/ chemo-therapy. Colloids and Surfaces A: Physicochemical and Engineering Aspects 2021, 628, 127388.

[2] Yike Hou, Shuqi Huang, Zhe Tang, Zhangsen Yu, Muhammad Zubair Iqbal,Xiangdong Kong. Photo-responsive ovalbumin-Loaded MnO₂ Nanoparticles for

enhanced T1-magnetic resonance imaging and immunotherapy of cancer. Particle & Particle Systems Characterization. 2024, 41, 2300082.



Figure S1. SEM and TEM images of AP@ZIF-8



Figure S3. N2 absorption-desorption isotherms of ZIF-8, APZ, and APZM



Figure S4. The swelling ratio of MeHA hydrogel



Figure S5. The standard curve of AP



Figure S6. The blood compatibility of APZM (a) and MeHA hydrogel (b)



Figure S7. Images of heart, liver, spleen, lungs, and kidneys retrieved from the treated mice.



Figure S8. H&E staining images of tissue slices of the heart, spleen and lungs