Supplementary information

Photothermal Activation by Hollow Multishelled Structure for Efficient Uranium Extraction

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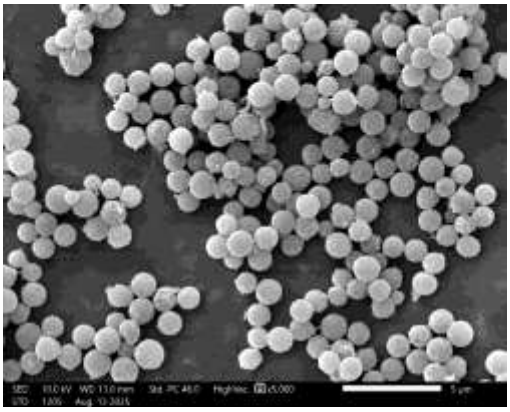

Figure S1. SEM image of the Ta_2O_5/C-HoMS.

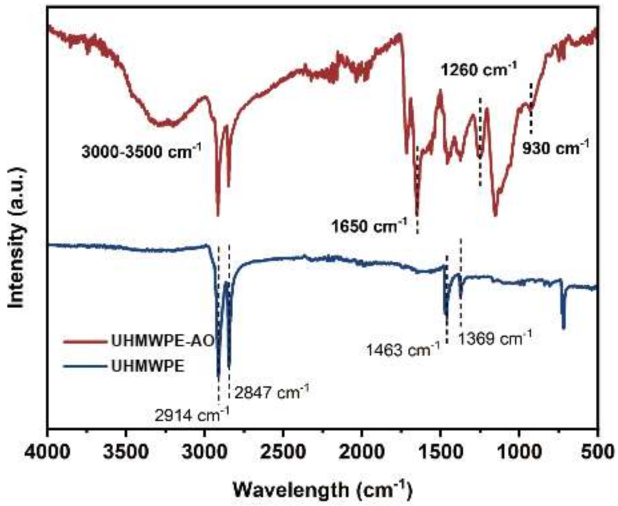

Figure S2. FTIR curves of the fibers before and amidoxime modification.

FTIR analysis was performed to confirm the amidoxime functionalization. Fiber after amidoxime loading new characteristics adsorption bands at 1650 cm^{-1} and 930 cm^{-1}, corresponding to C=N and N-O stretching vibrations of amidoxime group respectively. The peaks at 2914 and 2847 cm^{-1} are assigned to $-CH_2$ stretching vibrations of the polymer backbone. These spectral changes collectively confirm successful grafting of amidoxime ligands onto the fiber surface.

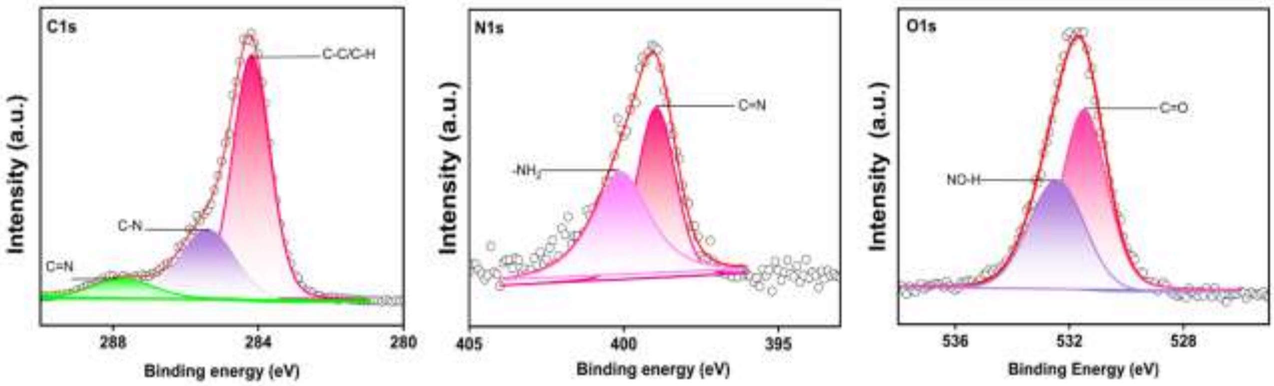

Figure S3. C 1s, N 1s, O 1s XPS spectra of amidoxime-modified fiber.

Figure S4. Continuous flow cell for photothermal enhanced uranium extraction.

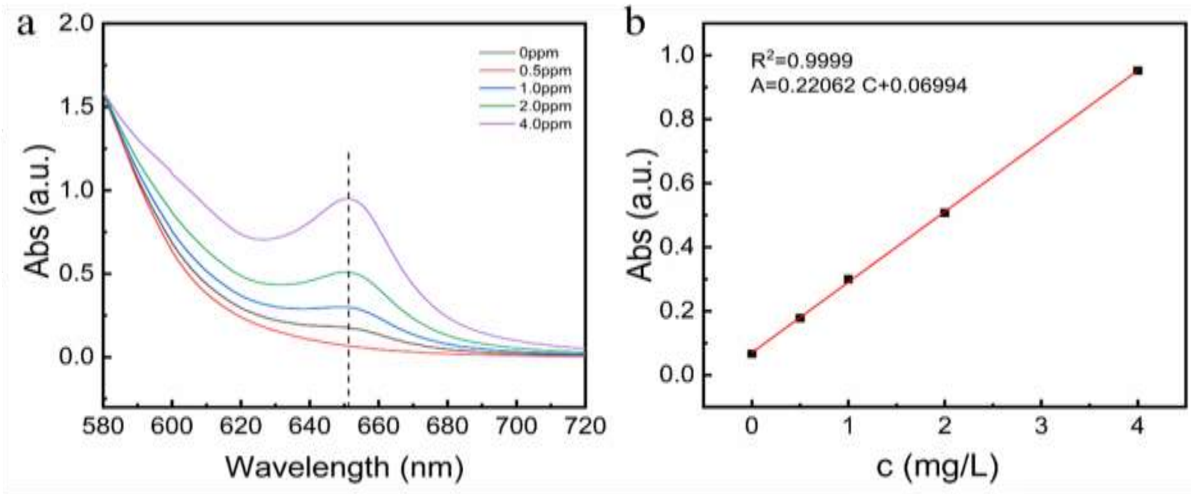

Figure S5. Calibration curve for uranium quantification using the Arsenazo III method. (a) Absorption spectra of uranium standard solutions at concentrations of 0, 0.5, 1, 2, and 4 mg/L measured after complexation with Arsenazo III. The characteristic absorption peak is located at 651 nm. (b) Linear relationship between uranium concentration and absorbance at 651 nm. The calibration curve shows excellent linearity ($R^2 = 0.9999$) within the tested range.

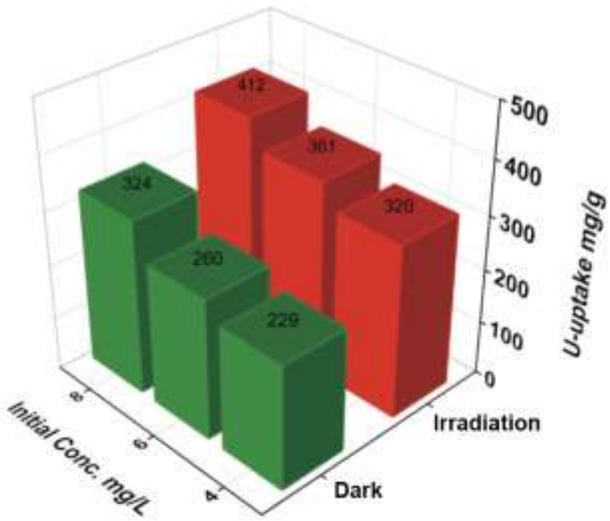

Figure S6. Comparison of uranium adsorption capacities under light and dark conditions. The equilibrium adsorption amounts of uranium from solutions with initial concentrations of 4, 6, and 8 mg/L. For each concentration, adsorption was tested under simulated solar irradiation and in the dark using the corresponding adsorbent. The photo-thermal adsorbent consistently exhibits higher uranium uptake under irradiation across all concentrations.

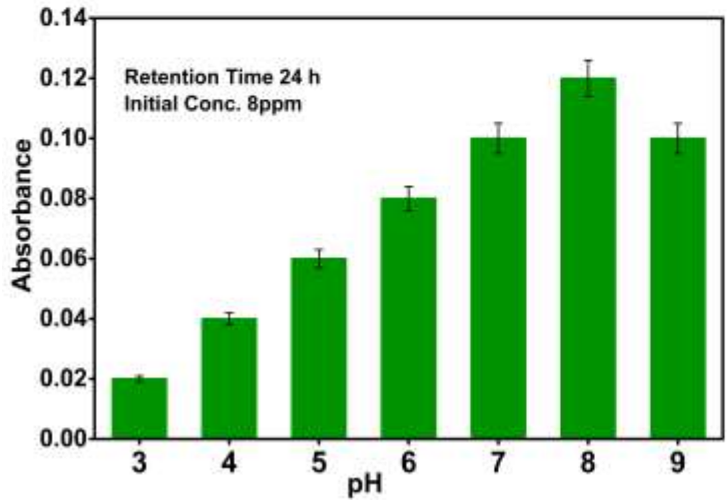

Figure S7. Effect of pH on uranium adsorption. The pH-dependent uranium adsorption behavior of the amidoxime-functionalized fiber was investigated in saline solution containing 8 mg/L U(VI) at 25 °C across a pH range of 3-9. The adsorption capacity increased with pH, reaching a maximum at pH 8, followed by a decline under more alkaline conditions. At lower pH, protonation of the amidoxime groups reduces their affinity for UO_2^{2+} ions. As the pH rises, deprotonation enhances chelation between the functional groups and uranyl species, promoting adsorption up to the optimum pH. Beyond pH 8, the predominance of negatively charged uranyl-carbonate complexes, coupled with increased negative surface charge on the fiber, leads to electrostatic repulsion and a decrease in uptake efficiency.

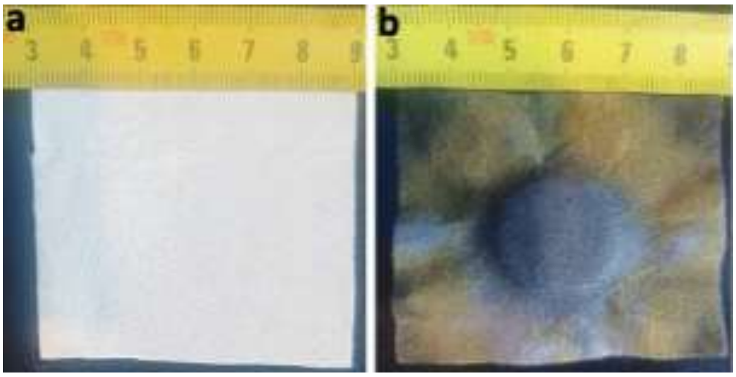

Figure S8. Photographs of the amidoxime-functionalized fiber before and after uranium adsorption. (a) Pristine fiber before adsorption. (b) Fiber after adsorption, showing a distinct color change to dark yellow brown, indicating the successful uptake of uranium from solution.