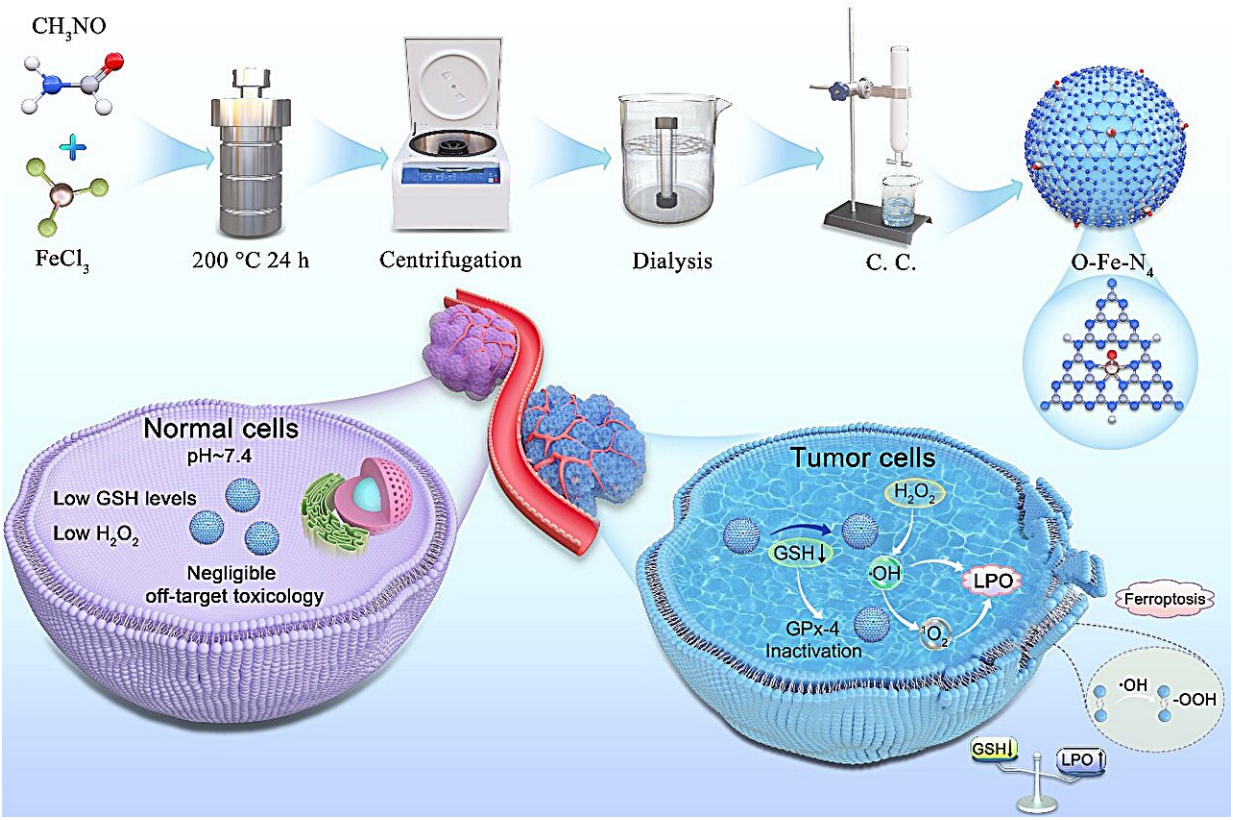
Novel single-atom nanozymes show promise for hypoxia-tolerant singlet oxygen-battery

August 5 2024



Synthetic strategy of O-Fe-N_4 SAEs for enhanced cascade catalytic $^1O_2$-induced therapy. Credit: LIU Hongji

A research group led by Prof. Wang Hui from the Hefei Institutes of Physical Science of the Chinese Academy of Sciences introduced an

axial O atom-modulated Fe-N_4 nanozymes for realizing efficient H_2O_2 Russell reaction to singlet oxygen ($^1O_2$) at hypoxic environment without external stimulus.

The study was published in *Advanced Science*.

$^1O_2$-elevated strategies show promise in inhibiting malignant tumor proliferation but face challenges such as inefficient and invasive external stimulation, hypoxic tumor microenvironments, and overexpressed redox species. Russell-type chemodynamic therapy (CDT) offers an oxygen-independent alternative to sensitize $^1O_2$ generation, reducing normal tissue damage.

However, only Cu-based and Mo-based nanomaterials have been used in Russell-type CDT, as other materials are inert. Single-atom enzymes (SAEs) with tunable electronic structures and uniform active sites offer potential for designing Russell-type nano reagents, but their symmetric electron distribution often results in suboptimal catalytic performance.

In this study, researchers designed a novel single-atom enzyme (SAE) featuring an axial O atom-engineered Fe-N_4 structure. Density functional theory calculations revealed that the addition of the axial O atom shifts the d-band center of the Fe-N_4 site towards the Fermi level, reducing activation energy and enhancing $^1O_2$ selectivity and production efficiency. The five-coordinated O-Fe-N_4 structure ensured clear catalytic activity.

Remarkably, the O-Fe-N_4 nanozyme demonstrated self-cascade enzymatic performance, with glutathione oxidase-mimicking activity and reactive oxygen species-induced performance, preventing the loss of reactive oxygen species.

Both in vivo and in vitro experiments showed that the reduction of

glutathione peroxidase 4 and lipid peroxidation collectively inhibited the proliferation of triple-negative breast cancer cells.

The O-Fe-N_4 SAEs not only address the inherent limitations of the $^1O_2$ -elevated tumor therapy strategy but also provide valuable insights into the advanced catalytic efficiency of Fe-N_4 catalysts, according to the team.

More information: Hongji Liu et al, Axial O Atom-Modulated Fe(III)-N4 Sites for Enhanced Cascade Catalytic 1O2-Induced Tumor Therapy, *Advanced Science* (2024). DOI: 10.1002/advs.202307254

Provided by Chinese Academy of Sciences