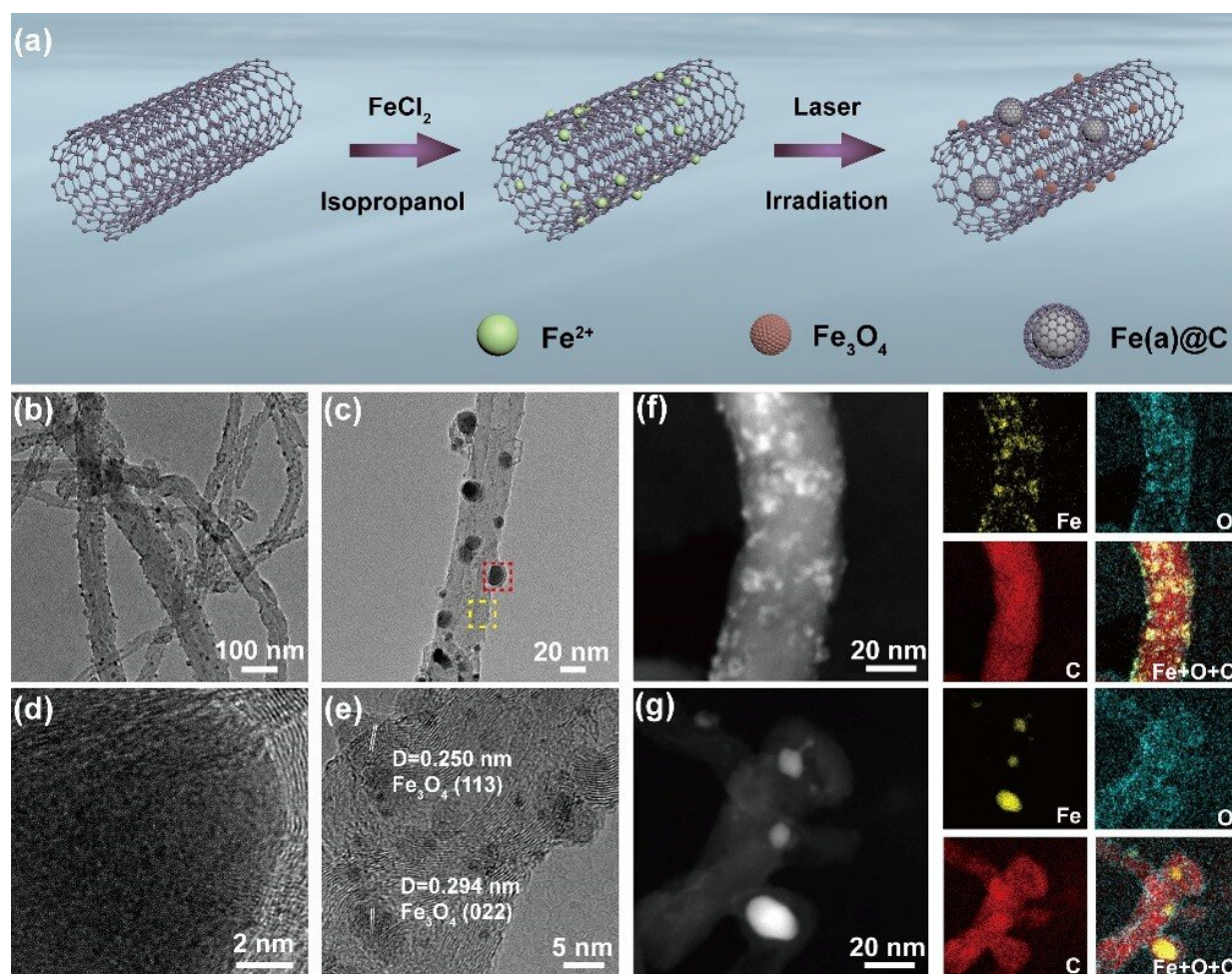


Ambient electrosynthesis of urea with nitrate and carbon dioxide over iron-based dual-sites

November 25 2022, by Zhang Nannan



(a). Schematic illustration of the synthetic process of Fe(a)@C-Fe₃O₄/CNTs; (b). Low- and (c) high-magnification TEM images of Fe(a)@C-Fe₃O₄/CNTs. HRTEM images of Fe(a)@C (d) (from the red dashed box in c) and Fe₃O₄ NPs (e) (from the yellow dashed box in c); (f), (g) HAADF-STEM images and corresponding elemental mapping images of Fe₃O₄ and Fe(a)@C. Credit: Geng

Jing

Urea ($\text{CO}(\text{NH}_2)_2$) has been applied both in agricultural and pharmaceutical field. The widely used Bosch-Meiser process has high energy consumption and CO_2 emission. Therefore, it is imperative to explore energy-saving and economical routes for urea synthesis under mild conditions.

The electrosynthesis of urea with CO_2 and NO_3^- under ambient conditions is an efficient way, but it is far from application. This is because the key step needs an efficient electrocatalyst enabling adsorption and activation of NO_3^- and CO_2 to accomplish the C-N coupling.

Researchers from the Hefei Institutes of Physical Science of the Chinese Academy of Sciences have now developed a liquid-phase laser irradiation route to fabricate symbiotic carbon encapsulated amorphous iron ($\text{Fe}(\text{a})@C$) and [iron oxide nanoparticles](#) (Fe_3O_4 NPs) on carbon nanotubes (denoted as $\text{Fe}(\text{a})@C\text{-Fe}_3\text{O}_4/\text{CNTs}$).

The as-fabricated $\text{Fe}(\text{a})@C\text{-Fe}_3\text{O}_4/\text{CNTs}$ contained two Fe-based [active components](#), namely, $\text{Fe}@C$ NPs with the particle sizes of 10~20 nm and Fe_3O_4 NPs with the particle sizes of 1~5 nm.

The presence of two different structural units in $\text{Fe}(\text{a})@C\text{-Fe}_3\text{O}_4/\text{CNTs}$ made it possible to synergistically electrocatalytically activate CO_2 and NO_3^- to realize the C-N coupling for urea synthesis.

As expected, $\text{Fe}(\text{a})@C\text{-Fe}_3\text{O}_4/\text{CNTs}$ exhibited superior activity toward the electrocatalytic coupling of CO_2 and NO_3^- for urea synthesis, affording a urea yield of $1341.3 \pm 112.6 \mu\text{g h}^{-1} \text{mgcat}^{-1}$ and a faradic

efficiency of $16.5 \pm 6.1\%$ at -0.65 V (vs. RHE) in 0.1 M KNO_3 electrolyte.

Both experimental and theoretical results unveiled that Fe(a)@C was mainly responsible for the electrocatalytic reduction of NO_3^- to form $^*\text{NH}_2$ intermediates, while Fe_3O_4 was more beneficial for the electrocatalytic reduction of CO_2 to form $^*\text{CO}$ intermediates.

The synergistically catalytic effect contributes to the excellent electrocatalytic performance of urea synthesis at ambient conditions.

The research was published in *Angewandte Chemie International Edition*.

More information: Jing Geng et al, Ambient Electrosynthesis of Urea with Nitrate and Carbon Dioxide over Iron-Based Dual-Sites, *Angewandte Chemie International Edition* (2022). [DOI: 10.1002/anie.202210958](https://doi.org/10.1002/anie.202210958)

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