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MIL-88A Derived Zerovalent Iron Embedded Mesoporous Carbon with Carbon Black Composite based Electrochemical Sensor for the Detection of Metol

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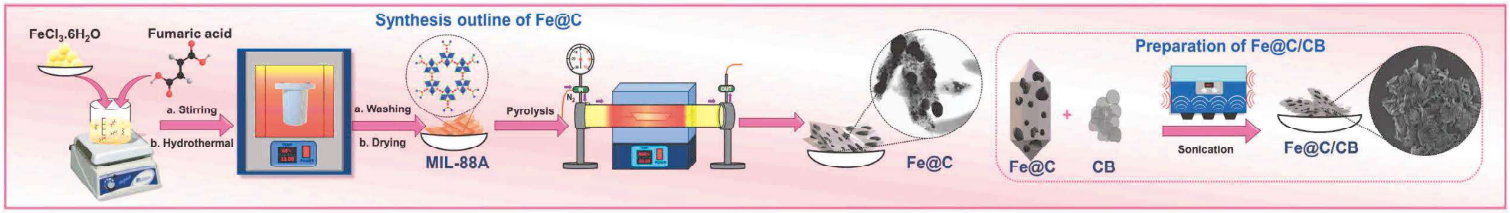
Abstract

The release of industrial effluents contributes to environmental degradation, posing a significant challenge to sustainable development. Metol (MTL) is a popular color-developing agent extensively used in the hair dyes and photographic industries. The massive usage and improper disposal of MTL into water resources would adversely affect the ecosystem. Therefore, we have prepared a MOF-derived zerovalent iron in mesoporous carbon (Fe@C) with a carbon black (CB) electrocatalyst for the detection of MTL. The structural and elemental details were examined using several spectroscopic techniques. Our prepared electrocatalyst was used to modify the screen-printed carbon electrode (SPCE). The electrochemical property of the fabricated sensor was investigated with impedance and voltammetric measurements. The catalytic activity of Fe@C/CB/SPCE towards MTL was scrutinized using different voltammetric techniques. Consequently, our Fe@C/CB/SPCE demonstrated a low detection limit (0.003 μM), high sensitivity (12.948 μA μM^{-1} cm^2), two linear ranges (at lower concentrations (0.01–27 μM), and higher concentrations (27–142 μM)), good selectivity, and appreciable stability results. The practical utility of the reported sensor was determined by monitoring MTL in various real-world water samples (tap, pond, and river). Based on the outcomes of the experiment, it would be suggested that our Fe@C/CB is a propitious catalyst for the electrochemical detection of MTL.

Experimental section



Results & Discussion

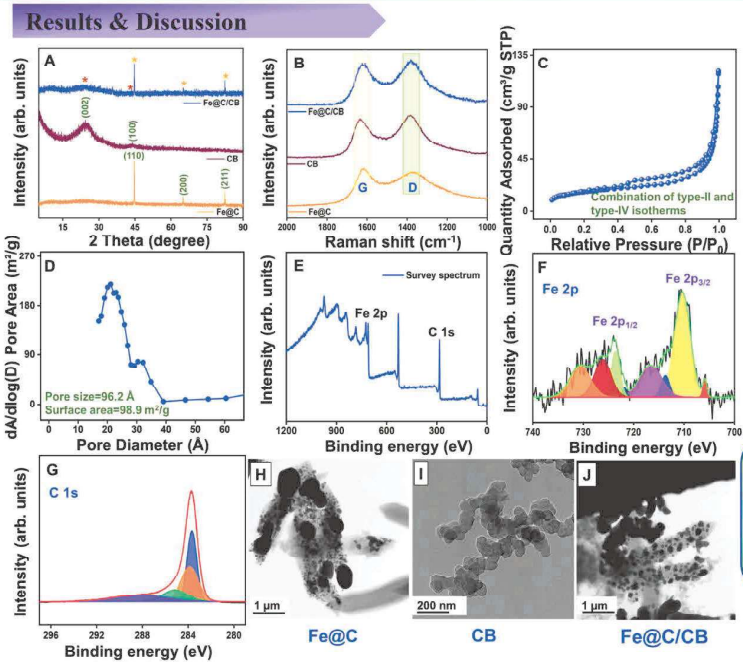


Figure 1 **(A)** PXRD, **(B)** Raman patterns of Fe@C, CB, and Fe@C/CB. **(C)** N_2 adsorption-desorption isotherms of Fe@C/CB, **(D)** Pore diameters in Å of Fe@C/CB. XPS data of **(E)** survey spectrum, (F) Fe 2p, and **(G)** C 1s of Fe@C/CB. TEM images of **(H)** Fe@@C, **(I)** CB, and **(J)** Fe@C/CB.

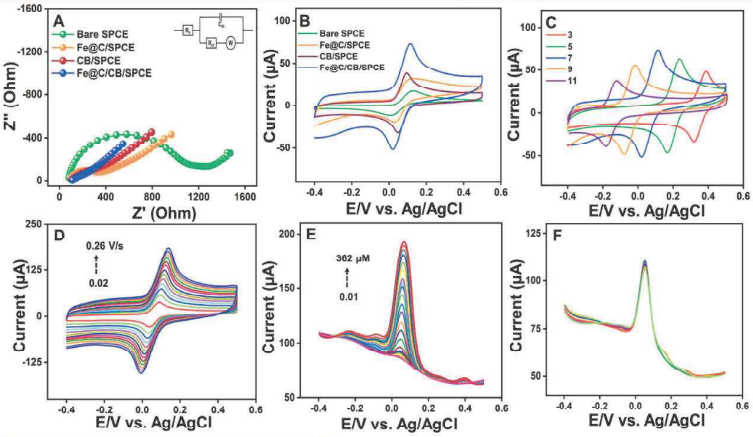


Figure 2 **(A)** EIS, and **(B)** CV curves of different electrodes. CV signals of **(C)** Different pHs and **(D)** Scan rate studies of Fe@C/CB. DPV curves of **(E)** various concentrations of MTL and **(F)** Selectivity study results of Fe@C/CB. **(G)** Electrochemical mechanism of MTL.

Conclusion

- The hexagonal 3D noble zerovalent Fe core with a carbon shell (Fe@C) has been synthesized by hydrothermal method followed by pyrolysis.
- The obtained Fe@C was composited with CB nanoparticles via sonication.
- Our Fe@C/CB-based electrochemical sensor has demonstrated a lower detection limit, wide linear range, superior sensitivity, good selectivity, and excellent stability.
- The practical reliability of the prepared electrochemical sensor in various real-world samples yielded remarkable recovery values.
- Henceforth, it can be concluded that our Fe@C/CB- based electrochemical sensor is a promising electrochemical platform for the detection of MTL.

Summary

Limit of detection	0.003 μM
Sensitivity	12.948 μA μM^{-1} cm^2
Linear Range	0.01–142 μM

Reference

- T.S. Priya, *et al*. Carbon 2024 Vol. 223 Pages 119026

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