臺北科技大學暨新北市土城醫院
學術合作專題研究計畫成果發表

Detection of Anticancer Drugs in Urine Samples Using an Electrochemical Sensor with a Modified Electrode

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Abstract

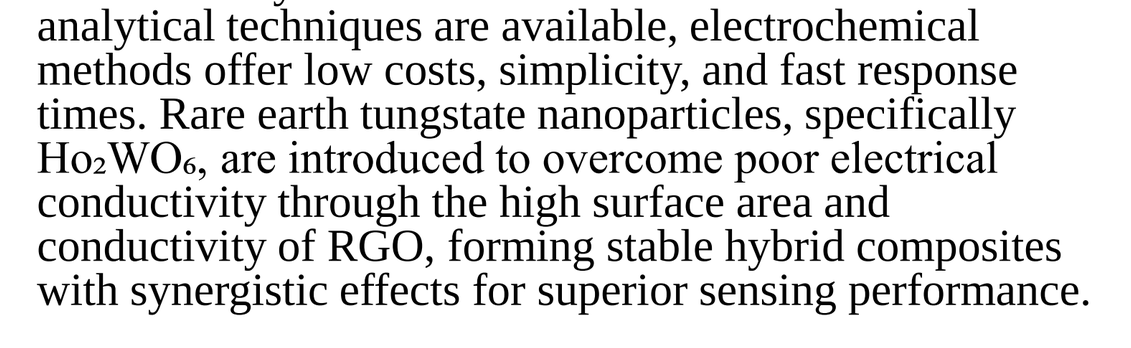
A novel and cost-effective electrochemical sensor was developed for the rapid and sensitive detection of mesalamine using a nanocomposite of rare earth tungstate incorporated with reduced graphene oxide (REW@rGO). The nanocomposite was synthesized and characterized through various analytical and spectroscopic techniques to confirm its successful formation. The synergetic effect between REW and rGO significantly enhanced the electrocatalytic performance, offering a broad linear detection range of 0.01-723 µM, a high sensitivity of 1.3406 µA μM^{-1} cm^{-2}, and a low detection limit (LOD) of 0.0039 µM. These results demonstrated that the REW@rGO-based sensor is a highly efficient platform for the real-time analysis of mesalamine in pharmaceutical and clinical applications.

Introduction

Idiopathic ulcerative colitis is an inflammatory chronic disease requiring long-term medical treatment with oral mesalazine (5-aminosalicylic acid; MLM) formulations. Despite its efficacy, MLM can be detrimental to health if not accurately monitored at clinical levels. While several analytical techniques are available, electrochemical methods offer low costs, simplicity, and fast response times. Rare earth tungstate nanoparticles, specifically Ho_2WO_6, are introduced to overcome poor electrical conductivity through the high surface area and conductivity of RGO, forming stable hybrid composites with synergistic effects for superior sensing performance.

Experimental

The nanocomposite Ho_2WO_6/RGO was synthesized via a facile hydrothermal method. Stoichiometric ratios of $Ho(NO_3)_3 \cdot 6H_2O$ and $Na_2WO_4 \cdot 2H_2O$ were dissolved separately in DI H_2O. Subsequently, urea and graphene oxide (GO) were added, and the mixture was stirred for 30 minutes before being hydrothermally treated in a Teflon-lined autoclave at 180°C for 12 hours. After cooling to room temperature, the obtained precipitate was washed, centrifuged, and dried to acquire the purified catalyst. For electrode fabrication, the Ho_2WO_6/RGO was dispersed (3 mg/mL) in DI water. A pre-cleaned glassy carbon electrode (GCE) was then modified by drop-casting 6 µL of the catalyst ink to reach an average loading of 0.254 mg·cm^{-2}.



Scheme 1. Graphical representation of the synthesis procedure of Ho_2WO_6/RGO.

Results and Discussion

The structural characteristics of the synthesized Ho_2WO_6/RGO were verified by XRD, confirming the diffraction peaks of crystalline Ho_2WO_6 with an average crystalline size of 8.76 nm. FE-SEM and HRTEM images displayed a nanoplate-like structure of Ho_2WO_6 successfully wrapped over the surface of wrinkled RGO sheets, which effectively prevented the agglomeration of nanoparticles and facilitated sensing capabilities.

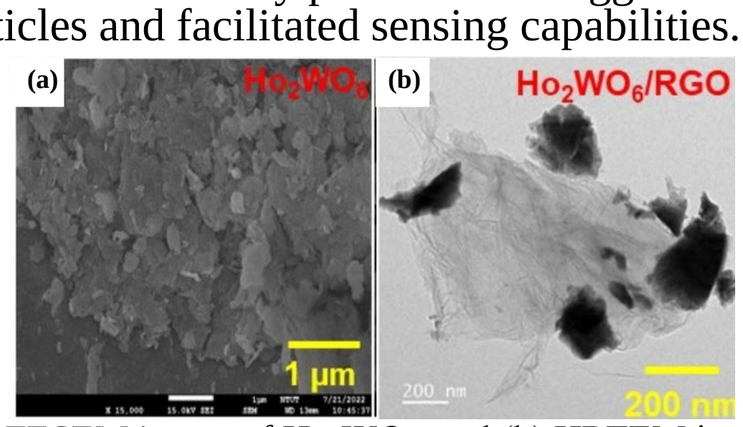


Fig. 1. (a) FESEM image of Ho_2WO_6, and (b) HRTEM image of the final Ho_2WO_6/RGO nanocomposite.

EIS demonstrated a remarkably small charge transfer resistance (R_{ct} = 74.93 Ω) for Ho_2WO_6/RGO/GCE. DPV measurements showed an outstanding sensitivity of 1.3406 µA μM^{-1} cm^{-2}, an ultra-low LOD of 0.0039 µM, and a broad linear range (0.01–723 µM).

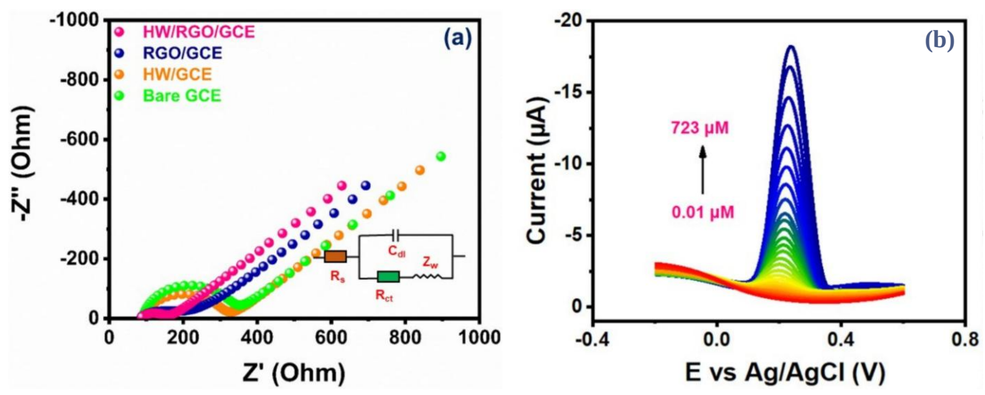


Fig. 2. (a) EIS Nyquist plot, and (b) DPV response for MLM detection.

Table 1. MLM determination in real samples.

Sample	Added (µM)	Found (µM)	Recovery (%)
Blood serum	5	4.90	98.0
	15	14.99	99.9
Human urine	5	4.99	99.8
	15	14.99	99.9

CONCLUSION

In summary, a novel Ho_2WO_6/RGO nanocomposite was successfully synthesized and applied for the electrochemical detection of mesalamine. The developed sensor exhibited an outstanding sensitivity of 1.3406 µA μM^{-1} cm^{-2} and an ultra-low LOD of 0.0039 µM with a broad linear range. Furthermore, tremendous recovery results (98.0%–99.9%) in real human blood serum and urine samples demonstrate its highly reliable and practical potential for biomedical sensing applications.

REFERENCES

[1] S.B. Hanauer, N. Engl. J. Med. 334 (1996) 841. [2] K. Hwa, et al., Mater. Today Chem. 23 (2022) 100739.