

Electrochemical sensor for detection of heavy metals concentration in water using $\text{Fe}_3\text{O}_4/\text{SPEEK}$ nanocomposite

Petu B. Letsholo^{a,b}, Omolola E. Fayemi^{a,b*}

^aMaterial Science Innovation and Modelling (MaSIM) Research Focus Area, Faculty of Natural and Agricultural Sciences, North-West University, Mafikeng Campus, Private Bag X2046, Mmabatho, 2735, South Africa

^bDepartment of Chemistry, School of Physical and Chemical Sciences, Faculty of Natural and Agricultural Sciences, North-West University, Mafikeng Campus, Private Bag X2046, Mmabatho 2735, South Africa

*Corresponding author's email: Omolola.Fayemi@nwu.ac.za

Introduction

Global water resources have been threatened by human activity and climate change for decades. The quality of water must be safe physically, chemically, and biologically to be regarded as useful for drinking and other domestic purposes. Conventional methods like ICP-OES and chromatography are expensive, need expert operators, and take a long time to prepare samples. Therefore, quantitative analysis of heavy metals in water are of paramount importance and have attracted enormous interest over the recent years. Electrochemical techniques are emerging as a technology of choice for the detection of these environmental pollutants. Metal oxide-based nanomaterials like FeO , ZnO , and AuO are crucial for synthetic heavy metals detection due to their high sensitivity, convenience, and real-time capabilities. This study uses the combination of magnetite iron oxide nanoparticles and conductive SPEEK polymer nanocomposite to fabricate an electrochemical sensor for detecting arsenic (As^{3+}) in water. The electrode demonstrates exceptional sensitivity, with a broad range and low detection limits, comparable to existing literature.

Experimental overview

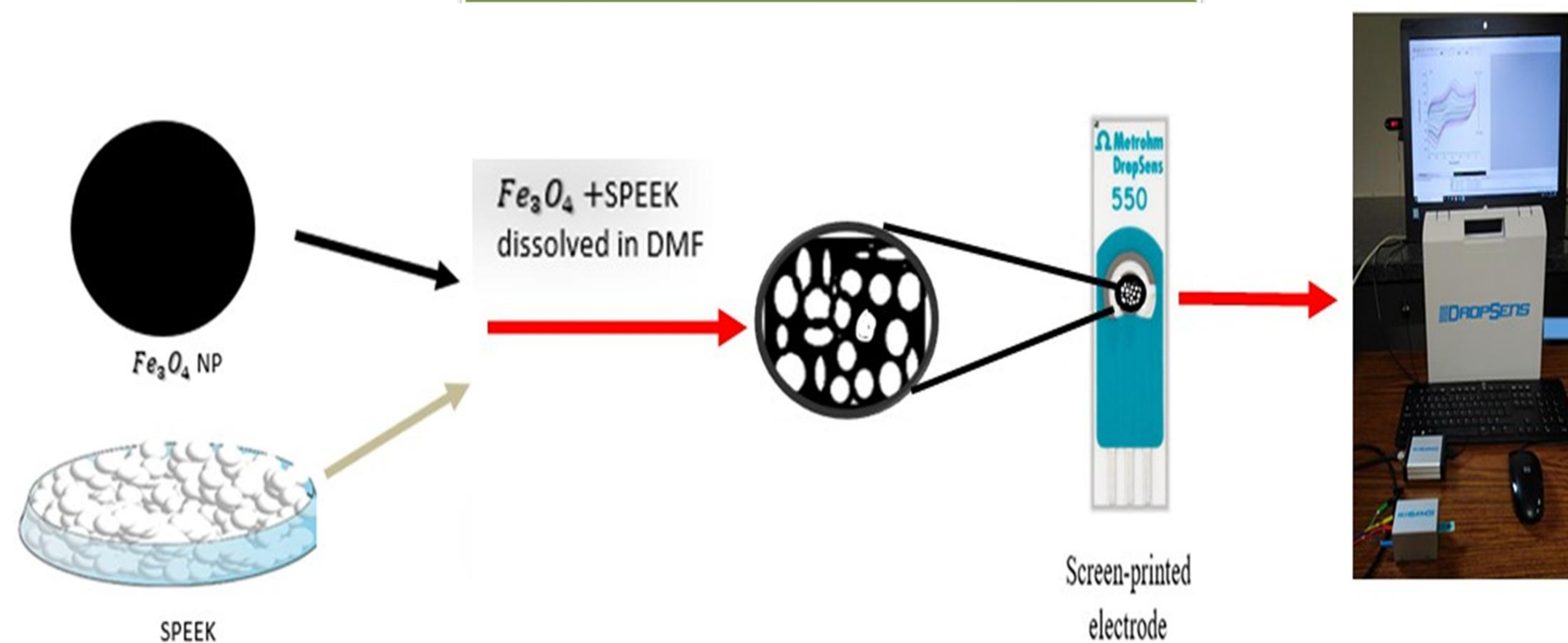


Figure 1. Drop cast modification method on screen printed platinum electrode.

Results

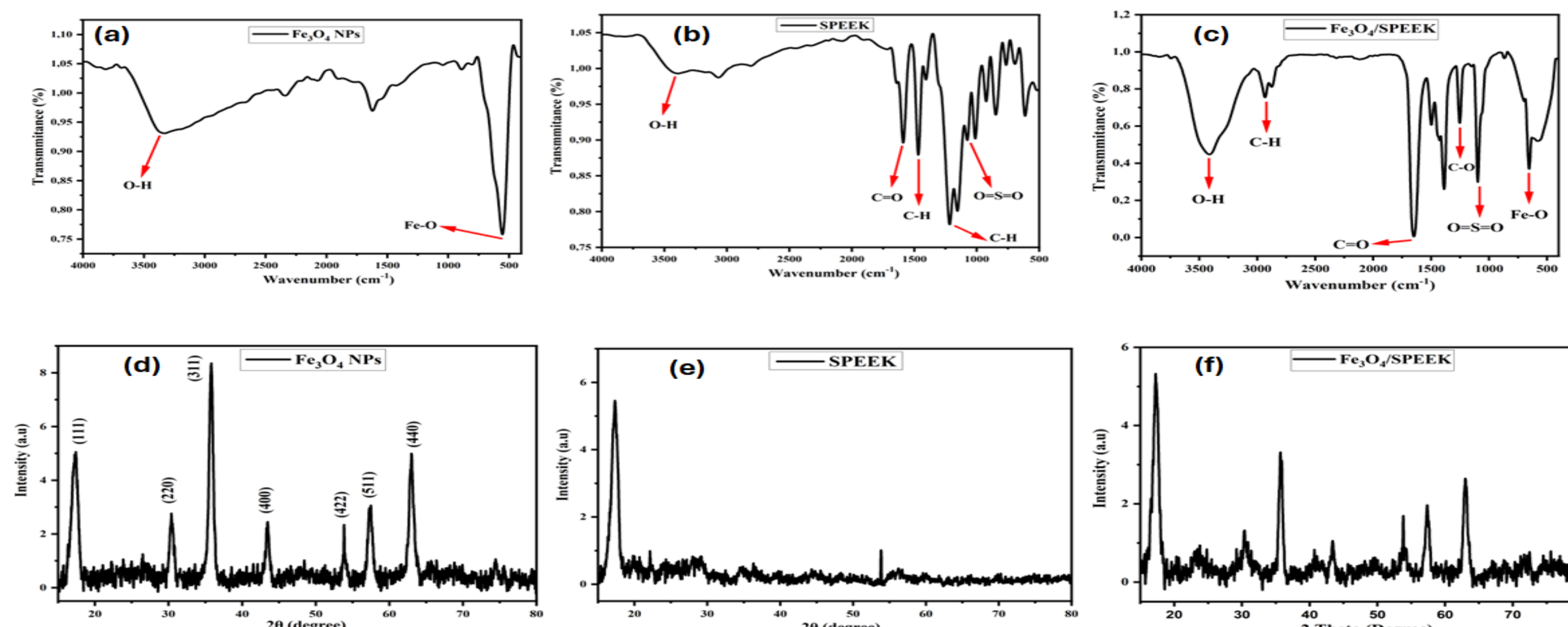


Figure 2. FTIR spectra (a,b,c) and XRD spectra (d,e,f) for the synthesized $\text{Fe}_3\text{O}_4\text{NPs}$, SPEEK polymer, and $\text{Fe}_3\text{O}_4/\text{SPEEK}$ nanocomposite.

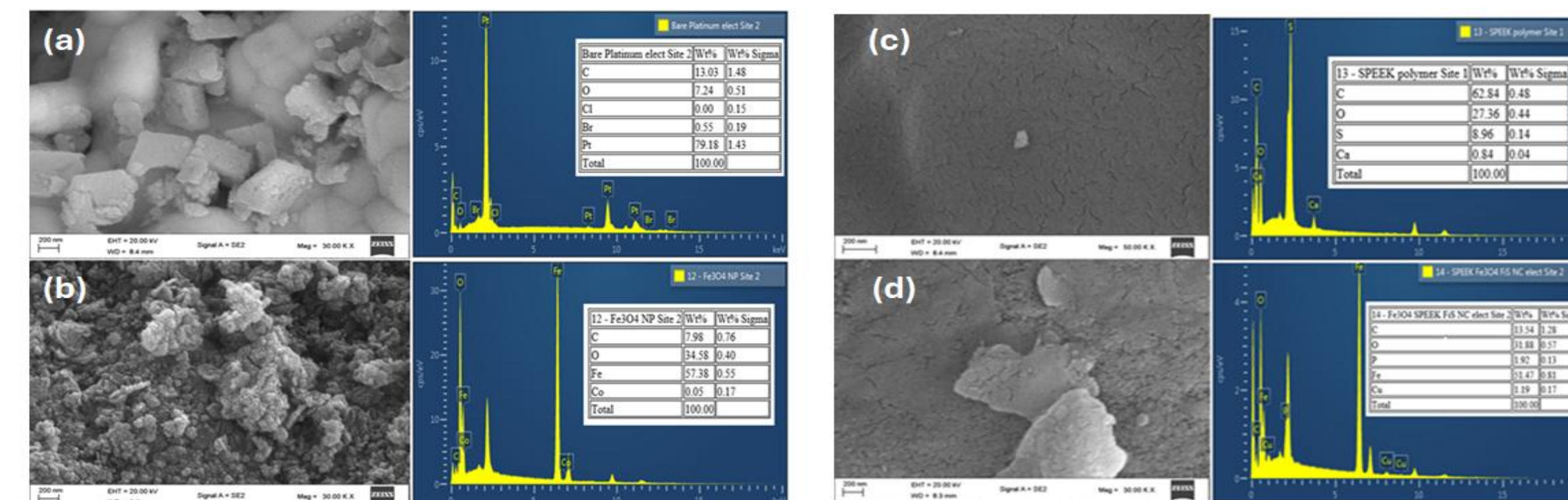


Figure 2. SEM micrographs and EDX graphs for the (a) bare platinum, (b) $\text{Fe}_3\text{O}_4\text{NPs}$, (c) SPEEK, and (d) $\text{Fe}_3\text{O}_4/\text{SPEEK}$ nanocomposite.

Electrochemical application

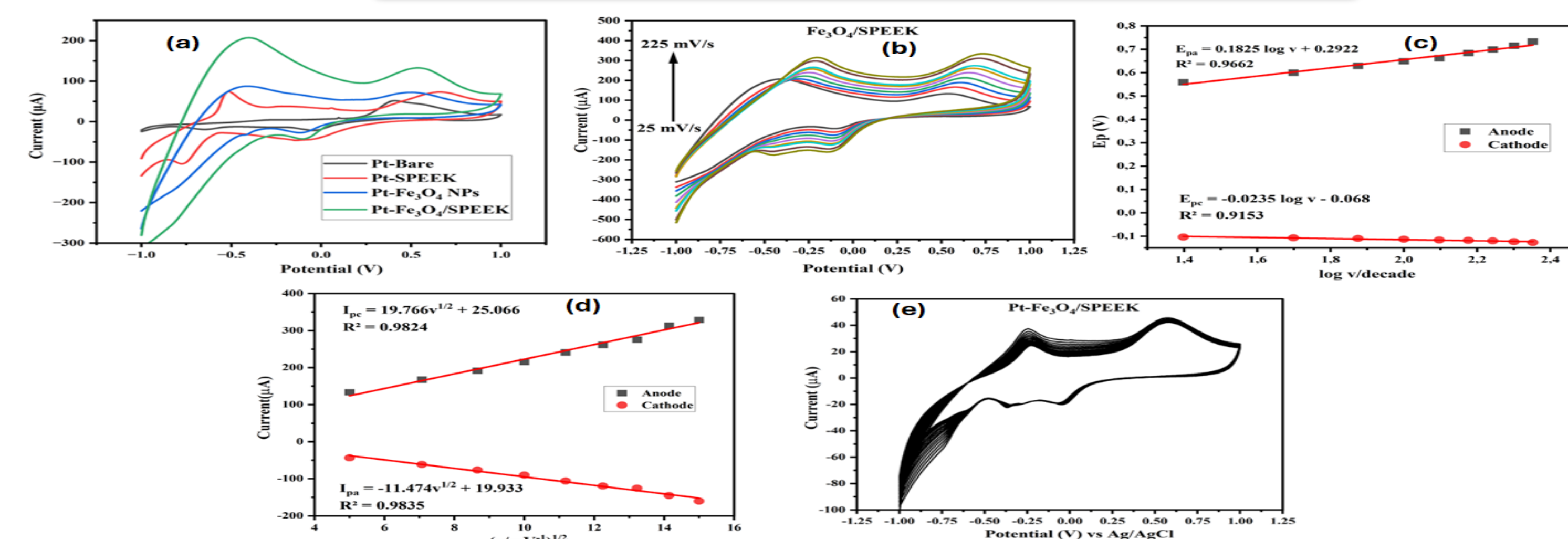


Figure 3. (a) Comparative cyclic voltammogram of Pt-bare and modified electrodes (b) scan rate CV, (c,d) linear plots of electrocatalysis (d) stability CV.

Electrochemical application

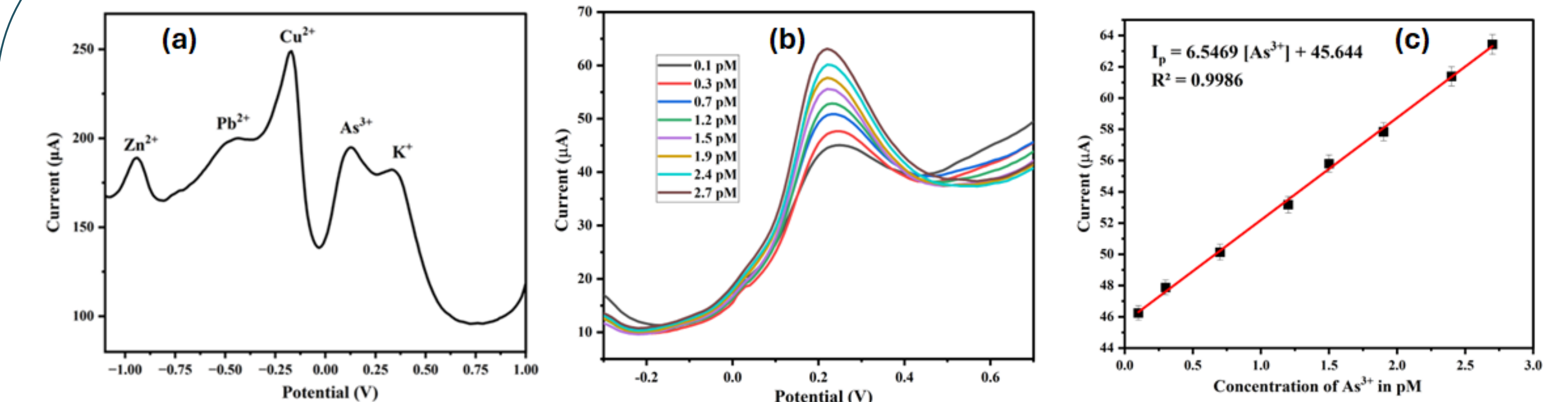


Figure 4. (a) SWV detection of HM, (b) SWV conc. study and (c) I_p vs conc. linear plot.

Table 1. As^{3+} recovery from dam water using Pt- $\text{Fe}_3\text{O}_4/\text{SPEEK}$

Sample	Added (μM)	Detected (μM)	Recovery (%)	RSD (%)
Dam water	4.8	4.16	86.67	6.60
		4.61	96.04	
		4.89	101.86	

Discussion and conclusion

This study reports the first detection of As^{3+} using a synthesized Pt- $\text{Fe}_3\text{O}_4/\text{SPEEK}$ nanocomposite. We analyzed electron transport, conductivity, sensitivity, and selectivity using CV and SWV. FT-IR, XRD, and SEM were employed to examine the elemental composition and morphology of the sensing materials. The Pt- $\text{Fe}_3\text{O}_4/\text{SPEEK}$ electrode outperformed others in As^{3+} detection, showing exceptional stability and anti-interference performance. It demonstrated significant electrocatalytic activity with a limit of detection (LOD) of 0.44 pM across a linear range of 0.1-2.7 pM. The sensor exhibited high selectivity against interfering species and strong recovery with excellent reproducibility, making it a promising solution for detecting arsenic in real water samples

Acknowledgements