Supplementary Information

Batch-processed titanium-vanadium oxide nanocomposite based solid-state electrochemical sensor for zeptomolar nucleic acid detection

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SI Table 1 TVO single device cost calculations

Chemicals	Bulk Price (in Rupees)	Price of quantity per unit device (in Rupees)
Vanadyl (acetylacetonate)	4372/100 gm	1.89/0.04 gm
1-butanol	531/500 ml	3.8/3.6 ml
benzyl alcohol	888/500 ml	0.71/0.4 ml
Titanium tetraisopropoxide	4284/500 ml	0.28/0.033 ml
Isopropyl alcohol	1475/2500 ml	1.74/2.96 ml
Device Components	**Bulk Price (in Rupees)**	**Price of quantity per unit device (in Rupees)**
Precursor solution	1.442/1000 μl	0.057/40 μl
FTO	250/30 device	8.33/1 device
Silver wire	365/2.7 gm	2.7/0.02 gm
Silver paste	5000/10 gm	0.5/0.001 gm
Total Cost:		**~12/- per device**

Calculation of crystallite size, dislocation density, and lattice strain in the nanocomposite thin film using XRD data

The well-known Debye-Scherer's equation (1) was used to calculate the crystallite size (D)[1] ,

$$D = \frac{0.9\,\lambda}{\beta cos\theta} \qquad ----- (1)$$

Where, λ= wavelength of the Cu kα radiations, β= full width at half maximum (FWHM) of the intense peak (in rad), and θ= corresponding angle value.

Using the obtained crystallite size the dislocation density of the nanocomposite films at various Ti mol% was calculated using Williamson and Smallman's formula (2). The dislocation density (δ) can be defined as the length of lines per unit area of crystal defects within a crystal[2].

$$\delta = \frac{1}{D^2} \qquad ----- (2)$$

The lattice strain (ε) was determined using the following equation (3)[3] by using FWHM value and the corresponding peak angle value (θ),

$$\varepsilon = \frac{\beta}{4tan\theta} \qquad ----- (3)$$

The obtained crystallite size, dislocation density, and lattice strain values are presented in SI Table 2.

SI Table 2 Film thickness, crystallite size, dislocation density, and lattice strain values for 0 to 50 mol% TVO

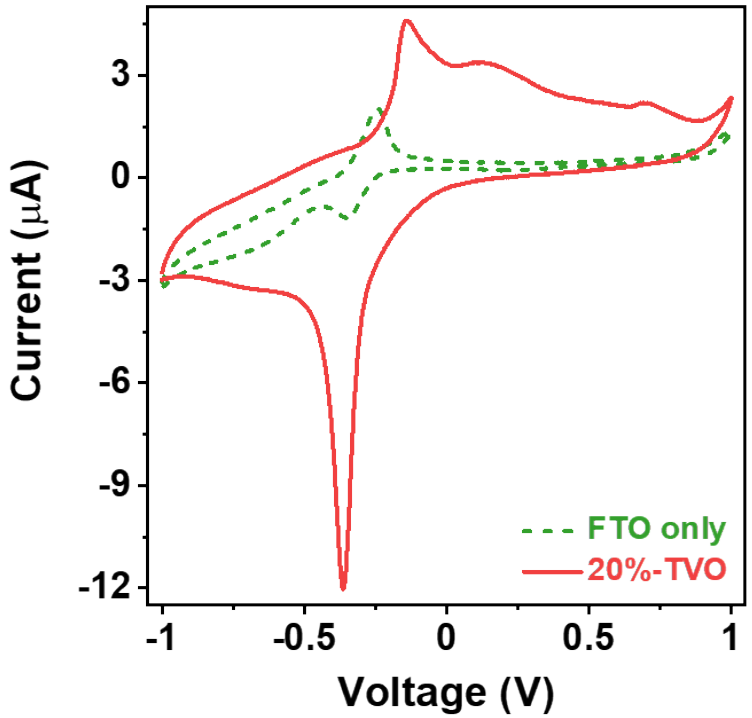
Ti content (mol %)	**Film thickness (nm)**	**Crystallite Size (nm)**	**Dislocation Density (lines. nm^{-2})**	**Lattice strain**
0	16.9	13.94	5.15×10^{-3}	14.13×10^{-3}
10	18.9	11.49	7.58×10^{-3}	17.08×10^{-3}
20	19	11.82	7.15×10^{-3}	16.58×10^{-3}
30	21.3	10.50	9.07×10^{-3}	18.71×10^{-3}
40	20.3	10.49	9.08×10^{-3}	18.72×10^{-3}
50	22.9	11.35	7.77×10^{-3}	17.34×10^{-3}

SI Table 3 S(I) (signal %-change with respect to NTC) for electrochemical detection on 20%-TVO and SPE for 10^1 – 10^4 copies of pure SARS-CoV-2 RdRp plasmid DNA and RNA.

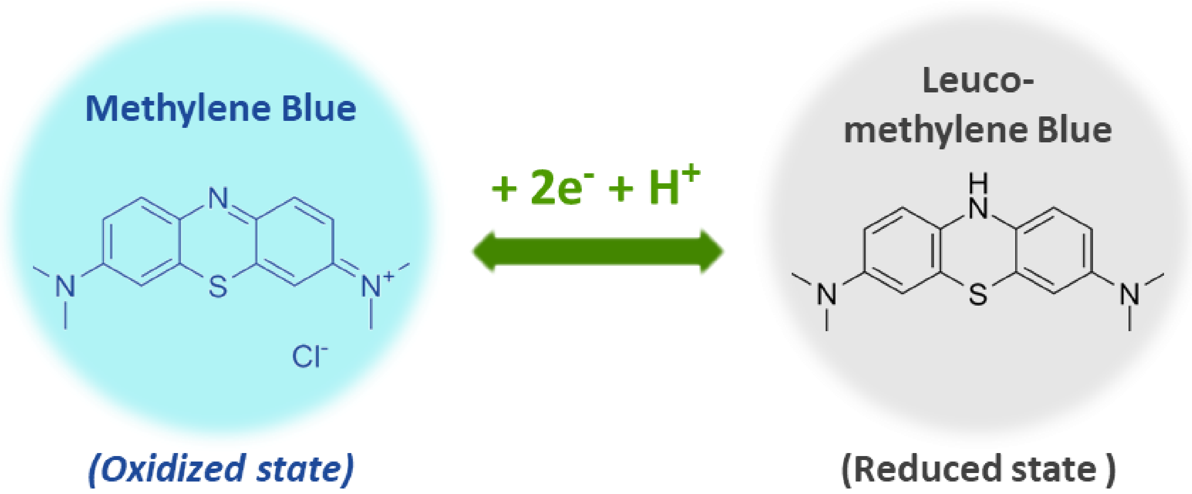
Target Concentration	S(I) for DNA		S(I) for RNA	
	20%-TVO	SPE	20%-TVO	SPE
10	9.99 ± 2.5	6.98 ± 2.3	14.20 ±4.8	25.25 ±0.5
10^2	14.30 ± 4.9	14.39 ± 1.5	20.52 ±1.4	28.97 ±1.8
10^3	25.21 ± 2.6	17.31 ± 2.4	41.02 ±6.3	38.01 ±1.6
10^4	30.87 ± 4.7	18.64 ± 1.2	55.10 ±6.5	38.00 ±2.5

SI Table 4 S(I) (signal %-change with respect to NTC) for electrochemical LAMP mediated detection of 100 – 1000 copies of magneto-extracted nucleic acid from aqueous, human genomic DNA spiked, and serum spiked sample on 20%-TVO electrode and SPE. TC sample implies non-magneto-extracted LAMP for 1000 copies.

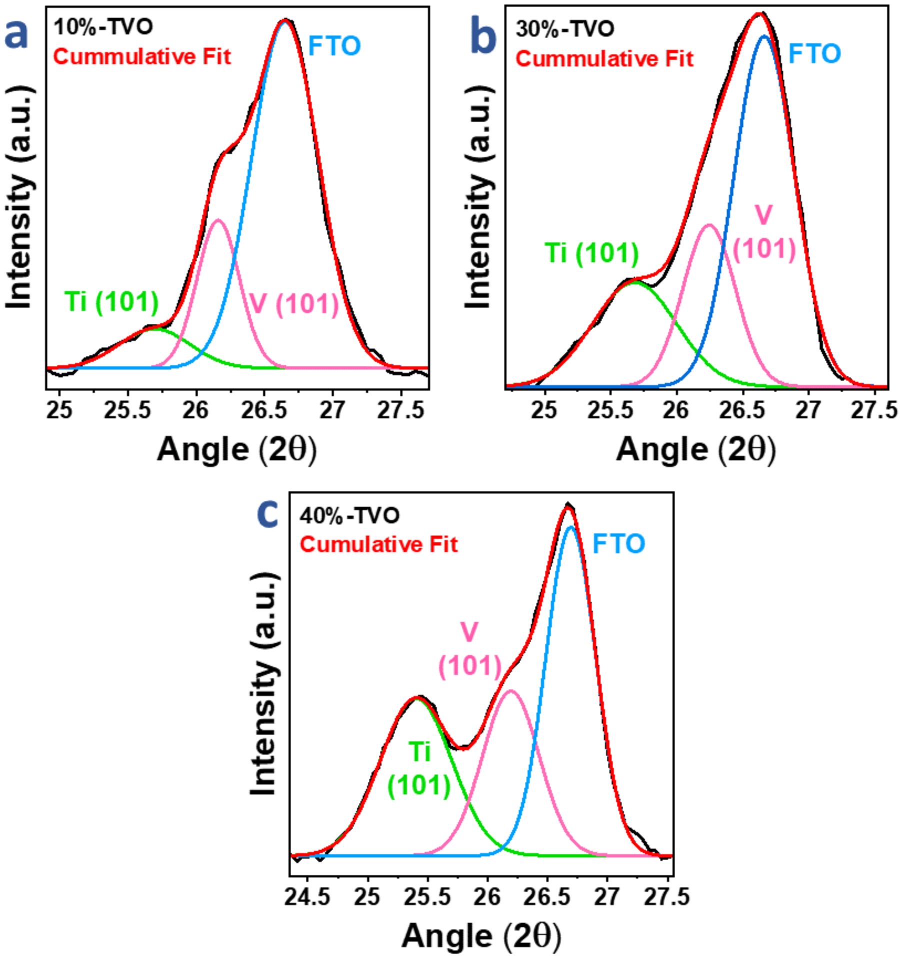
Sample	Target Concentration	S(I) for DNA		S(I) for RNA	
		20%-TVO	SPE	20%-TVO	SPE
Aqueous	**TC**	46.51 ±6.4	46.17 ±1.8	66.63 ±0.5	44.19 ±1.7
	100	16.39 ±7.4	32.17 ±1.9	53.71 ±18.8	40.18 ±2.8
	1000	37.99 ±3.8	41.49 ±0.7	63.67 ±17.2	7.23 ±0.6
Human Genomic	**TC**	56.51 ±6.4	46.80 ±0.0	36.16 ±3.6	31.04 ±1.4
	100	53.82 ±2.7	44.62 ±0.9	7.63 ±3.5	22.21 ±1.9
	1000	47.26 ±0.7	34.04 ±0.9	35.69 ±2.1	26.42 ±0.2
Serum	**TC**	59.32 ±4.2	49.19 ±3.4	25.18 ±6.5	40.08 ±2.8
	100	36.71 ±7.0	14.18 ±0.6	14.23 ±5.3	7.33 ±2.3
	1000	49.51 ±7.4	17.87 ±1.5	17.98 ±6.2	13.29 ±2.2



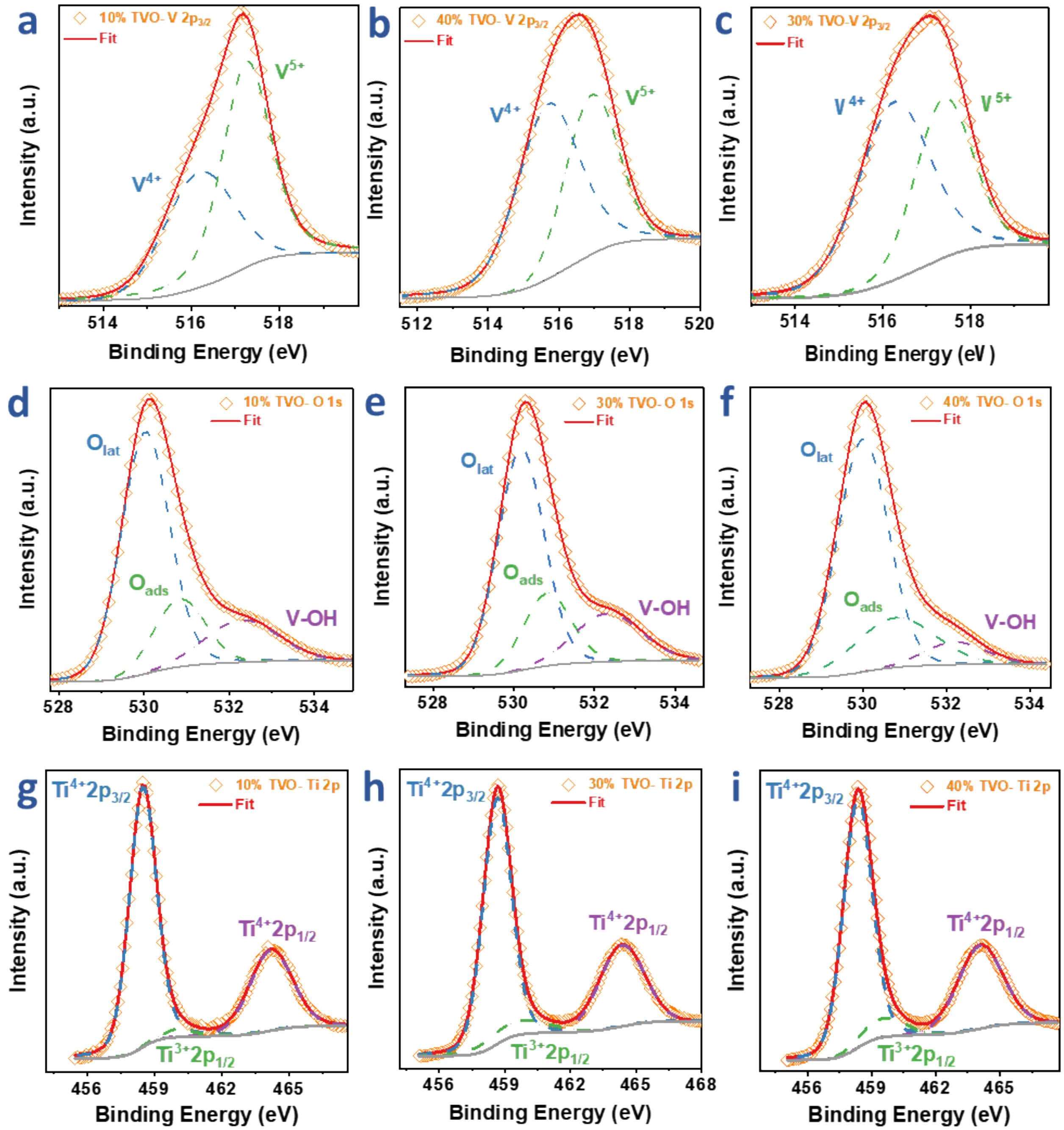
SI Figure 1 Electroanalytical data of 100μM-MB for FTO alone and 20%-TVO deposited FTO.



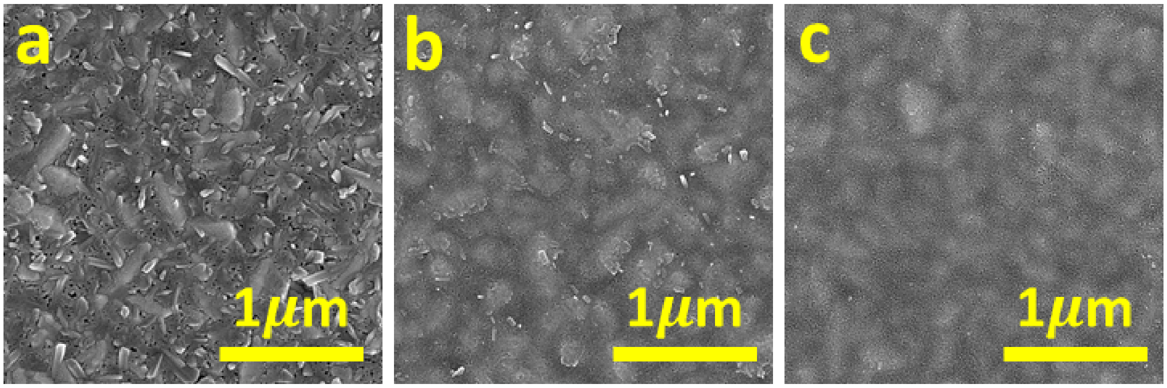
SI Figure 2 Redox pair for the electrochemical probe methylene blue (MB)



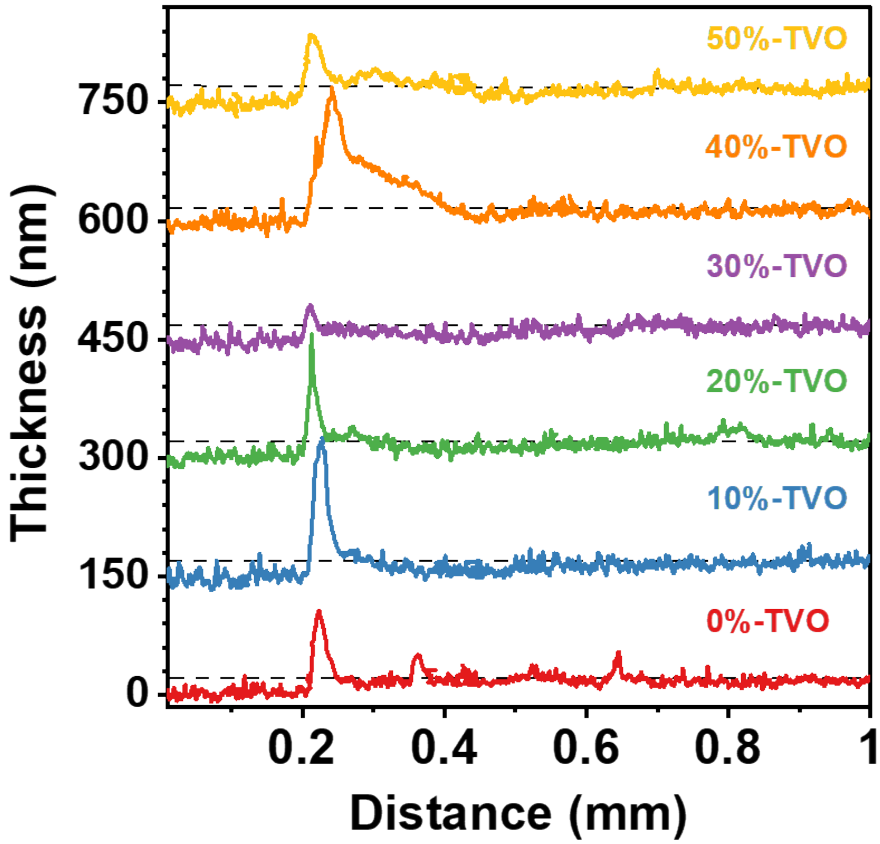
SI Figure 3 X-ray diffraction pattern (a-c) Deconvolution of 26.5° peak into FTO, V, and Ti peaks for 10, 30, 40%-TVO.



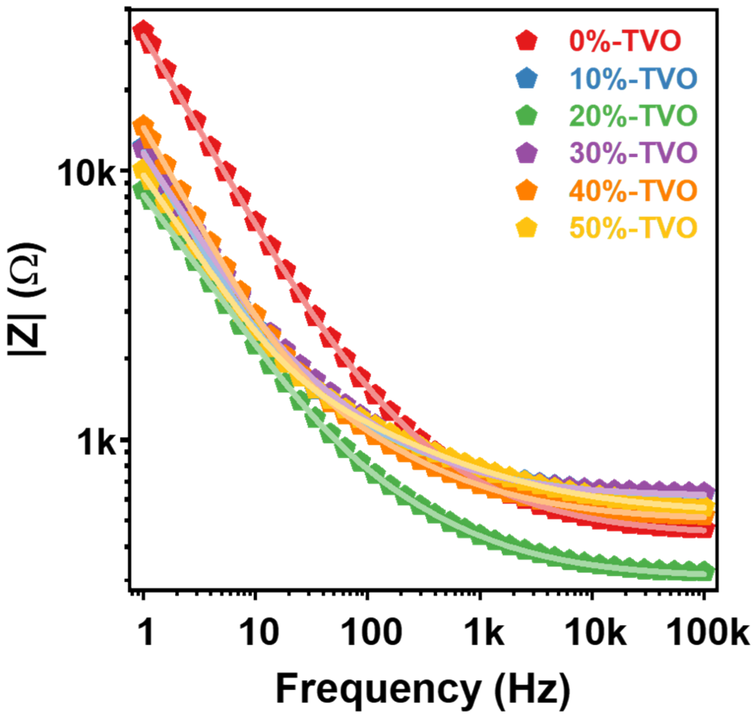
SI Figure 4 X-ray photoelectron spectroscopy analysis. (a-c) V 2p3/2, (d-f) O 1s, (g-i) Ti 2p for 10, 30, and 40%-TVO electrodes.



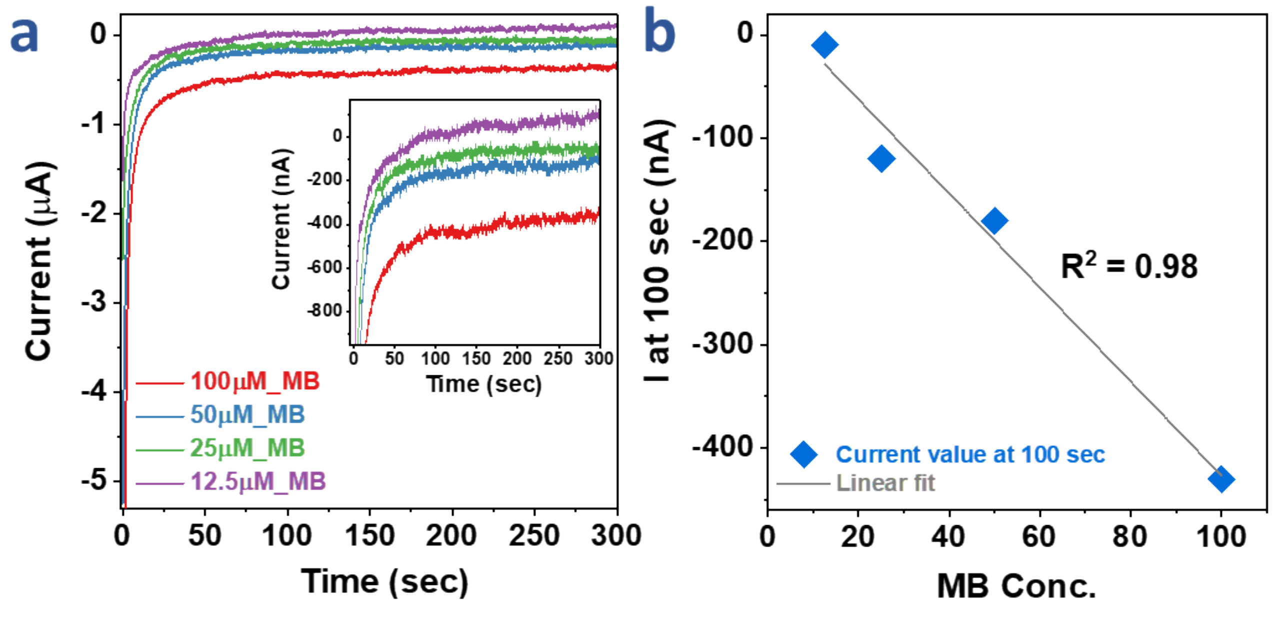
SI Figure 5 FE-SEM micrographs of 10%, 30%, and 40% -TVO, respectively.



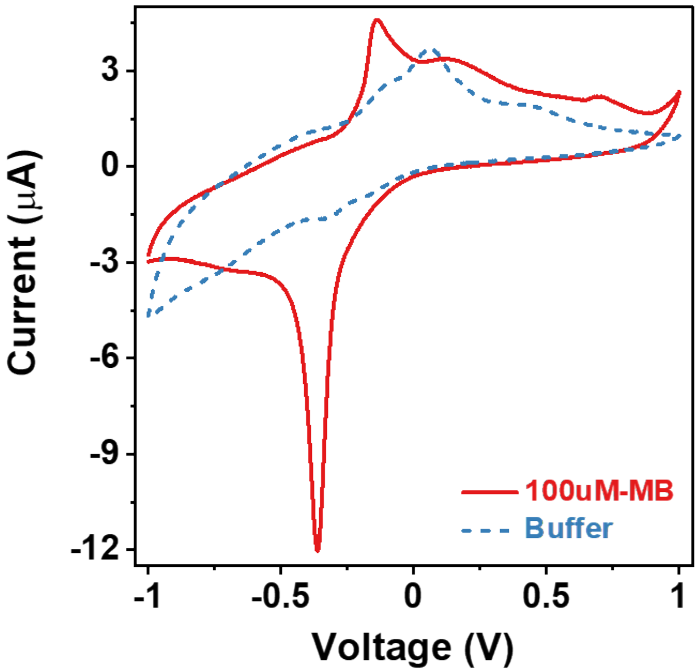
SI Figure 6 Measured thickness profiles of 0 to 50%- TVO layers.



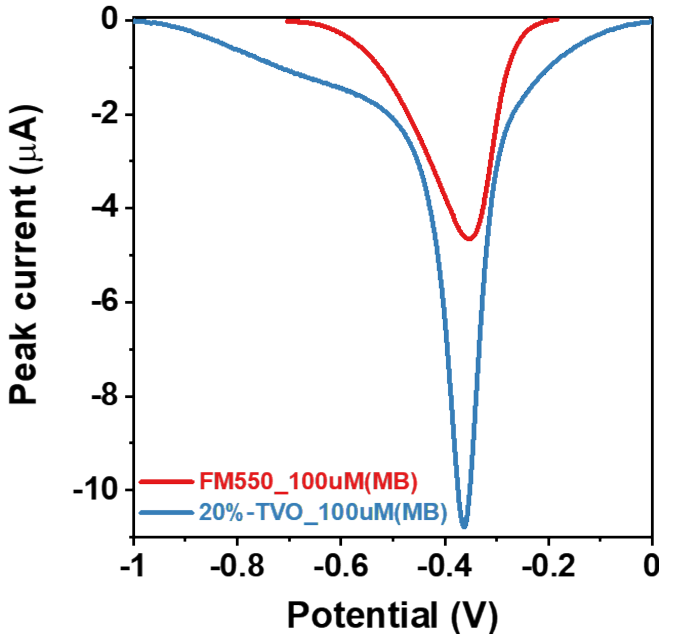
SI Figure 7 Bode plot for 0 to 50%-TVO electrodes with 100 μM MB.



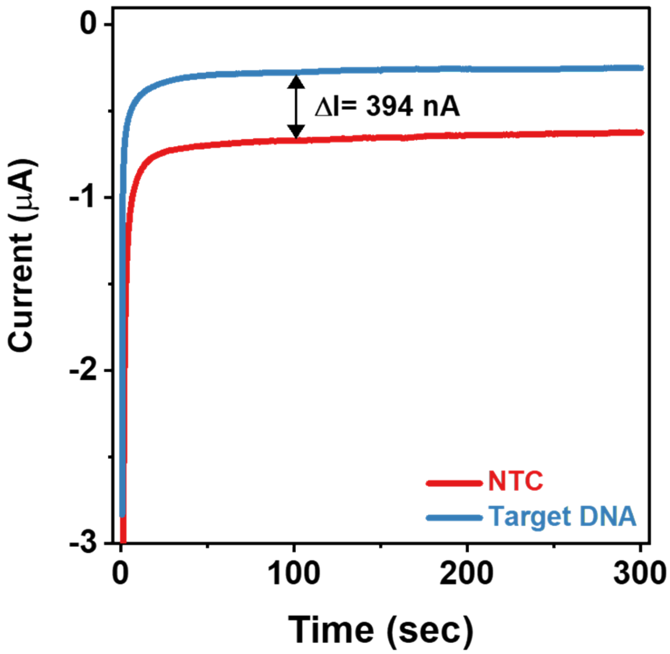
SI Figure 8 Calibration curve for concentrations (100-12.5 μM) of methylene blue (MB) in 10 mM tris-HCl buffer using chronoamperometry. (a) Chronoamperometry measurements recorded on 20%-TVO electrode using MB solutions. (Inset: magnified view of the data in nA current range). (b) Calibration curve for MB detection constructed from the measurements presented in panel (a) where the current measured after 100 s was plotted as a function of MB concentration.



SI Figure 9 I-V characteristics of 20%-TVO collected for 100μM MB and buffer alone.



SI Figure 10 Current signal comparison of 20%-TVO electrode and MnO_2 (FM550) electrode for 100μM-MB solution (the data presented is an average of n=5 cycles).



SI Figure 11 Chronoamperometry of electrochemical LAMP experiment on NTC and plasmid DNA with 10^3 initial target copies.

Reference:

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3 V. D. Mote, Y. Purushotham and B. N. Dole, *Williamson-Hall analysis in estimation of lattice strain in nanometer-sized ZnO particles*, 2012.