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Improved electrochemical performance of metal doped Zirconia nanoparticles for detection of Ochratoxin-A

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Abstract

Here, aluminum (Al) doped Zirconia nanoparticles (ZrO_2 NPs) were proposed as a novel material for the fabrication of an efficient electrochemical immunosensor. X-ray diffraction (XRD) analysis and high resolution–transmission electron microscopy (HR-TEM) images visualized phase stabilization and generation of oxygen deficiency in the ZrO_2 NPs due to doping of Al ions (Al^{3+}) in ZrO_2 lattice. On the increase in Al^{3+} concentration, a sequential decrease in crystallite size of ZrO_2NPs describes the Zener pinning effect. Further increase in Al^{3+}concentration (beyond 11 mol%) terminated crystallinity of ZrO_2 NPs. The generated oxygen deficiency due to Al^{3+} doping increased the surface charge and hydrophilicity of ZrO_2 NPs as observed by zeta potential and contact angle measurements, respectively. Moreover, oxygen deficiency was the main reason for the remarkable enhancement in the electrochemical behavior of Al^{3+} doped ZrO_2 NPs, and maximum was observed for 7 mol% Al^{3+} doped ZrO_2 NPs. Thus, 7 mol% Al^{3+} doped ZrO_2 NPs based Al^{3+}-ZrO_2/ITO electrodes were fabricated*via* electrophoretic deposition and further functionalized with antibodies specific to Ochratoxin A (anti-OTA) and bovine serum albumin (BSA). Fabricated BSA/anti-OTA/Al^{3+}-ZrO_2/ITO immunoelectrode showed improved sensitivity of 34.07 μA (log ng mL^{-1})$^{-1}$ and LOD of 0.14 ng mL^{-1} in the detection range of 1–10 ng mL^{-1} as compared to BSA/anti-OTA/ZrO_2/ITO immunoelectrode for the detection of OTA. Moreover, recovery of OTA from the spiked sample was observed in the range of 93.3–99.2 % with maximum RSD of 4.86.

Keywords: Zirconia Nanoparticles, Metal doped, Electrochemical,Ochratoxin-A, Immunosensor