$Ti_3C_2T_x$ MXene-ink modified gold screen-printed electrodes as an efficient transducer for (bio)sensing applications

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Abstract:

Sensors containing screen-printed electrodes often have low sensitivity due to limited electron transport and need modifications. Herein, we report $Ti_3C_2T_x$-MXene modified gold screen-printed electrodes (AuSPEs/MXene) as an effective signal transducer for biosensing applications. MXene was etched via HF+HCl etching approach and delaminated using lithium fluoride (LiF) to obtain a stable colloidal suspension. Etching and the subsequent delamination were investigated by X-ray diffraction (XRD), scanning electron microscopy (SEM), and energy-dispersive X-ray spectroscopy (EDXS). Cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) were performed to elucidate the electrochemical performance of AuSPEs/MXene. The disappearance of the XRD peak at $2\theta \approx 38.9°$ indicates the removal of interleaved Aluminum. Also, the usual broadening and downshifting of (002) peak to a lower angle ($2\theta \approx 6°$) corresponds to large c-spacing and indicates the successful exfoliation and subsequent delamination (Figure-a). For electrochemical measurements, AuSPEs were modified by drop-casting 2µl of $3 mg{\cdot}ml^{-1}$ MXene ink onto the working electrode and dried at ambient conditions. CV measurements show that the AuSPE/MXene has significant peak currents compared to the bare electrode, which can be attributed to MXene's high conductivity and large redox-active surface area (Figure-b). EIS Nyquist plots of AuSPE show a semicircle and charge transfer resistance (R_{ct}) was calculated to be 972 Ω. The R_{ct} was reduced significantly after MXene modification (AuSPE/MXene) and was found to be 132 Ω, indicating improved electron transfer and mass transfer performance (Figure-c). These results suggest that MXene-modified AuSPEs can serve as a rapid, sensitive, and cost-effective real-time clinical and environmental monitoring platform.

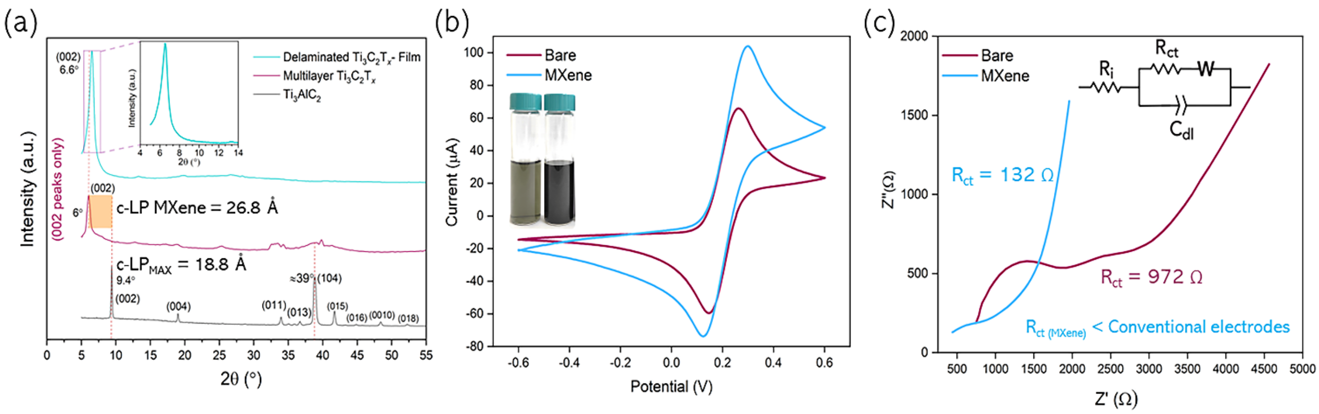

Figure: (a) XRD patterns of Ti_3AlC_2 MAX, Ti_3C_2 multilayers (ML) powder, and delaminated single layer (SL) MXene film shows successful etching and delamination. (b) CV experiments of bare and MXene-modified AuSPE performed in 40 mM $Fe(CN)_6^{3-}/Fe(CN)_6^{4-}$ in 0.1M PBS as a redox probe. (c) EIS plots of bare and MXene-modified AuSPE in the frequency range 0.5–10,000 Hz. The measurements were fitted according to Randles' circuit (as shown in inset) and showed an enhanced conductivity (reducing the R_{ct}) after MXene modification.