Ti3C2-MXene based fluorescent biosensor for rapid detection of lung cancer biomarker

Over the last decade, zero-dimensional (0D) and two-dimensional (2D) nanomaterials such as nanostructured metals, and graphene derivatives delivered an extraordinary impact as fluorescence quenchers or energy acceptors in developing fluorescent biosensors. However, these OD/2D materials have a tendency to agglomerate/restack, forming larger clusters that might influence the quenching efficiency and biosensing characteristics. These challenges could be addressed by creating a 0D-2D nanohybrid in which the decorated 0D nanomaterials can generate the interlayer spacing thereby inhibiting the inherent stacking of 2D nanosheets. However, it has been reported that the decoration of 0D materials can occur only on the defect sites or edge of graphene-based traditional 2D nanomaterials. Moreover, graphene-based 2D materials involve the use of an additional reducing agent for decorating the 0D material. Furthermore, these materials have difficulties in functionalization, insufficient surface terminated groups, and low-hydrophilicity all of which may have an impact on the fluorescent biosensing applications.

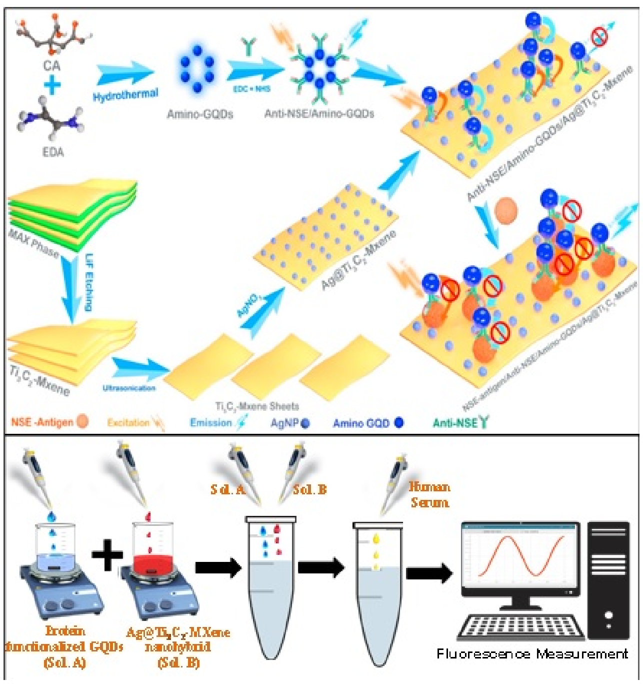

Fig. 1. Schematic representation of Ag@Ti3C2-MXene nanohybrid based fluorescent biosensor for Neuron Specific Enolase detection.

In light of the aforementioned, another 2D nanomaterial known as MXene has gained recent research interest in the development of various biosensing platforms. MXene is a new class of emerging 2D nitride, carbide, or carbonitride materials having the atomic arrangement of $M^{n+1}X_nT_x$, in which the T_x denotes the surface functionalization, X might be N and/or C, and M represents an early transition metal). Unlike classic 2D material i.e. graphene, Ti_3C_2-MXene provides superior biocompatibility, surface terminated functionality, and aqueous solubility. In addition, the Ti_3C_2-MXene's self-reducing ability eliminates the need for an extra reducing agent in order to prepare the MXene based 0D-2D nanohybrid materials.

The researchers utilized a one-pot direct reduction method to decorate the silver nanoparticles onto the Ti_3C_2-MXene nanosheets in which the 2D nanosheets of Ti_3C_2-MXene served both as the support matrix and reducing agent in preparing the 0D-2D (Ag@Ti_3C_2-MXene) nanohybrid material. The prepared Ag@Ti_3C_2-MXene nanohybrid was utilized as a dual-energy acceptor that exhibited superior energy transfer efficiency and biosensing performance compared to other platforms such as bare Ti_3C_2-MXene, graphene, and metal nanoparticles.

Further, a potential fluorescent biosensor consisting of NSE specific antibodies (anti-NSE) attached graphene quantum dots (anti-NSE/amino-GQDs) and Ag@Ti_3C_2-MXene nanohybrid as donor-acceptor pair is developed for NSE detection. The research team observed that the Ag@Ti_3C_2-MXene MXene nanohybrid quench the blue fluorescence of anti-NSE/amino-GQDs conjugate. However, the addition of specific NSE antigen initiates the recovery of quenched fluorescence. It was observed that the addition of NSE has a linear relationship with the recovery of fluorescence intensity. The developed biosensor was found to be rapid, highly sensitive, and selective to existing ones that upon exposure to NSE exhibited remarkable biosensing parameters including a wider linear detection range (0.0001–1500 ng mL^{-1}), and a faster detection time (12 min). The developed biosensor was able to detect NSE selectively even in the presence of other interfering cancer biomarkers. Thus, Ti_3C_2-MXene nanohybrid-based fluorescent biosensor can help in early and rapid diagnose of small cell lung cancer (SCLC) by detecting the concentrations of Neuron-specific enolase (NSE) in serum samples.

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