Recent Advances in Quantum Dots-Based Sensors for the Detection of Tuberculosis: A Review

Tuberculosis (TB) remains a major global infectious disease, especially in developing countries where diagnostic limitations contribute to late or incorrect detection and continued transmission. Conventional diagnostic methods, such as sputum smear microscopy and culture-based assays, suffer from low sensitivity, limited specificity, and long processing times, underscoring the need for rapid, accurate, and affordable alternatives. Biosensors have emerged as promising tools for point-of-care (POC) TB detection, employing biorecognition elements to identify *Mycobacterium tuberculosis* (Mtb) biomarkers with high sensitivity. Recent advances incorporate nanoparticles (NPs)—particularly quantum dots (QDs)—to enhance biosensor performance through strong signal amplification and ultrasensitive detection of TB-specific targets. Owing to their high photostability, broad absorption spectra, and size-tunable fluorescence, QDs are well suited for fluorescence-based biosensors, POC devices, and molecular imaging. QD-based platforms also show potential cost-effectiveness in portable electrochemical and colorimetric assays for resource-limited settings. However, commercialization remains limited due to concerns regarding toxicity, biocompatibility, and the complexity and cost of QD synthesis. Current research focuses on developing safer QDs, improving surface modification strategies, and advancing portable detection technologies. Overcoming these challenges through material innovation, reduced fabrication costs, and extensive clinical validation may enable QD-based biosensors to become practical POC diagnostic tools for TB and other infectious diseases.