

Abstract:

The Continuous IL-6 Sensor Module is a hot-swappable cytokine-sensing unit for the TraceLoop-MX closed-loop ICU system. It continuously monitors interstitial interleukin-6 (IL-6) levels via a microneedle-array electrochemical aptamer sensor, enabling real-time detection of inflammatory surges. The module employs a reversible aptamer-based field-effect electrochemical transducer, tuned to IL-6's rapid kinetics and low interstitial-fluid (ISF) concentrations. A 1 cm² dissolvable microneedle patch serves as the wear interface (24 hour single-use), painlessly sampling dermal ISF from the deltoid. The multi-layer construction – including a flexible substrate, gold microelectrodes with IL-6-specific aptamer functionalization, a swellable hydrogel anti-fouling layer, and a biocompatible adhesive – ensures stable in vivo operation. On-board memory stores calibration factors and enforces a 24 h wear limit. Redundant sensor channels with self-diagnostics provide drift compensation and fault tolerance. The module communicates IL-6 data to the TraceLoop controller at 1 min⁻¹ intervals, triggering immunomodulatory infusions (e.g. tocilizumab) when IL-6 breaches critical thresholds. Safety interlocks (firmware wear-timers, impedance watchdogs, and loop gating logic) guarantee fail-safe integration into the closed-loop network.