Modern Whole Blood Analyzers for Critical Care Measurements: The Key Advances in Electrochemical Sensor Technology that Enabled Instrument Development

Mark E. Meyerhoff
Department of Chemistry
University of Michigan
Ann Arbor, MI 48109-1055

Miniaturized potentiometric and amperometric chemical sensors for ions (K^+, Ca^{++}, Na^+, Mg^{++}, Cl^-, H^+), gases (O_2 and CO_2), nutrients/metabolites (glucose, lactate, creatinine, urea) and biomarkers (troponin, BNP, etc. via electrochemical immunoassay) have revolutionized the practice of critical care and emergency medicine by providing tools to measure an array of physiologically important species, in small volumes of undiluted whole blood. Indeed, a wide variety of modern whole blood analyzers used in hospitals worldwide now employ such sensors as either single-use or multi-use devices for near-patient testing, especially in emergency rooms, operating rooms, intensive care units, etc. Further, nearly all glucometers now use electrochemical measurement principles to provide accurate blood glucose concentrations for millions of diabetic patients, both in the hospital and at home. Given the widespread use of these various electrochemical sensor-based products, it is safe to say that electroanalytical devices are saving lives each and every day.

In this presentation, a historical perspective regarding the key advances in electrochemical sensor technology that led to this revolution in point-of-care instrument design and whole blood measurement capability will be provided. Critical contributions over the past 60 years by pioneering researchers in the areas of blood-gas sensors, enzyme electrodes, ionophore-based membrane electrodes for electrolyte, and pH measurements, new generation gas sensor designs, and electrochemical detection for whole blood immunoassays will be summarized. The challenges that remain with regard to expanding the analyte menu and ongoing electroanalytical research aimed in this direction will also be briefly summarized.