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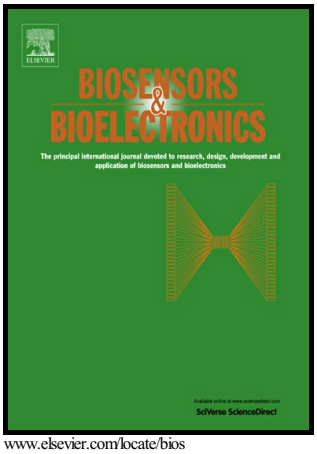

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Determining Mean Corpuscular Volume and Red Blood Cell Count Using Electrochemical Collision Events

Thy L. T. Ho[a,1], Nhung T. T. Hoang[a,1], Jungeun Lee[a], Jun Hui Park[b,*], Byung-Kwon Kim[a,*]

[a]Sookmyung Women's University, Department of Chemistry, Seoul, 04310, South Korea

[b]Chungbuk National University, Department of Chemistry, Chungju, 28644, South Korea

ABSTRACT:

Blood tests (e.g., red blood cell (RBC) count) are crucial for detecting, diagnosing, and monitoring the progression of blood disorders. Here, we report the development of a new and rapid method for electrochemically detecting RBCs using single-particle collision events. The principle of this method relies on the electrochemical oxidation of an electroactive redox species (potassium ferrocyanide) hindered by an RBC attached to an electrode surface. A decrease in staircase current, caused by the collision of RBCs on the electrode, was observed. The magnitude of this current decrease could provide quantitative information on the size and concentration of RBCs, which could be converted into the mean corpuscular volume (MCV) and used for diagnosis. Anemia-related diseases caused by abnormal count of RBCs (e.g., erythrocytosis, pernicious anemia) or abnormal RBC size (e.g. megaloblastic anemia, microcytic anemia) could be detected easily and quickly using this electrochemical collision method, potentially leading to extensive applications in hematology and point-of-care blood testing devices.

Keywords: red blood cell • electrochemical collision method •ultramicroelectrode • mean corpuscular volume (MCV) • anemia sensing

1. Introduction

Red blood cells (RBCs) are the most common cells in the blood; they contain hemoglobin (Hb) and play an important role as the transporter of oxygen to body tissues (Kasper et al., 2015). Diseases related to the abnormal size and amount of blood cells (including RBCs) are called anemia (Kasper et al., 2015). Anemia can be caused by massive bleeding, radiation exposure, iron deficiency, vitamin deficiency, cancer, anticancer drug administration, diabetes, and bone marrow abnormalities (Handin et al., 2002; Kasper et al., 2015; Provan et al., 2015). Anemia not only causes serious health problems by itself, but also causes complicating diseases. Most anemia-related diseases are difficult to detect early. Therefore, anemia is often detected only after the disease progresses past its treatable stage. Early detection and timely treatment can substantially decrease the risk of future diseases. Blood tests can help in disease prevention by providing valuable information for clinical diagnosis and monitoring disease progression and changes in patient health during treatment. Today, in hospitals, blood analysis is performed using a device called a hematology analyzer (Shu et al., 2013). This test provides the complete blood count (CBC), which reveals important information about the blood (Kasper et al., 2015). For instance, CBC can reveal the RBC count, hematocrit (Hct) level, Hb level, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) level, and mean corpuscular hemoglobin concentration (MCHC). Among them, RBC count, Hct, and Hb can be directly obtained through measurement, while MCV, MCH, and MCHC can be calculated from RBC count, Hct, and Hb (Kasper et al., 2015). This information can be used as a primary indicator for specific anemia and other RBC-related diseases. Currently, the equipment used for CBC determination in hospitals is bulky and expensive, and only skilled experts can handle it. In addition, a large amount of blood (~10 mL) is required for the analysis. Obtaining this amount of