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ARTICLES

A Colorimetric Sensor Based on a Polymethacrylate Matrix with Immobilized 1-(2-Pyridylazo)-2-Naphthol for the Determination of Cobalt

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Abstract—A colorimetric sensor is proposed for the determination of cobalt. It is prepared by immobilizing 1-(2-pyridylazo)-2-naphthol (PAN) in an optically transparent polymethacrylate matrix. The conditions for determining cobalt by the proposed colorimetric sensor are found in the study of the complexation of cobalt with a PAN-modified polymethacrylate matrix. The determination is based on the interaction of the sensor with a cobalt solution at pH 4 for 5 min, followed by the measurement of absorbance at 620 nm. The sensor ensures the determination of 0.05–0.50 mg/L of cobalt with the detection limit 0.03 mg/L. It is demonstrated that the sensor can be used for the determination of cobalt in the Cyanocobalamin medical preparation and potable water.

Keywords: cobalt, immobilized reagent, polymethacrylate matrix, colorimetric sensor, solid-phase spectrophotometry

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Cobalt is a vital trace element with potential toxicity; the strict control of its concentration in the environment is required. Cobalt is a part of vitamin B_{12} (cyanocobalamin), which is very important for human health. Cobalt is involved in hematopoiesis, functions of the nervous system and the liver, and enzymatic reactions. In large doses, cobalt can inhibit tissue respiration, violate the carbohydrate and lipid metabolism, and damage the cardiovascular system. Consequently, the problem of simple and sensitive method for the determination of cobalt in food, pharmaceuticals, and water without use of expensive and complicated equipment is important.

A promising direction in the development of methods for the control of metal concentrations in various objects is the creation of optical sensors [1–4]. Among their advantages are low cost, miniaturization, and automation of control. Among optical sensors, colorimetric sensors are of particular interest. Their action is based on the change of color in the detection of analytes, which results in a visually observed and easily measured analytical signal [5, 6]. For the measurement of the analytical signal, both conventional spectrophotometric equipment and portable fiber optic spectrometer connected to a laptop or a mobile phone or a PDA can be used. Typically, the colorimetric sensor is a solid substrate with the immobilized reagent. Cellulose, silica gels, and polymer materials are most common used as solid substrates. In particular, optical sensors based on cellulose acetate membrane [7, 8], XAD-7 resin [9], chitosan [10, 11], and triacetylcellulose membrane [12] are developed for the determination of cobalt. We have proposed to use a transparent polymethacrylate matrix for the immobilization of reagents without losing their ability to participate in analytical reaction with the analyte, accompanied by an optical effect with without losing the transparency of substrate [13].

Reagents from different classes are used for the determination of cobalt. One of the most sensitive and available organic reagents, useful for the detection of small amounts of cobalt, is 1-(2-pyridylazo)-2-naphthol [14]. The methods for the determination of cobalt in the solid phase using PAN immobilized in acetate cellulose membrane and silica gel are reported [7, 15–17]. It is shown that PAN keeps its chemical and analytical properties after immobilization in a polymethacrylate matrix; therefore, it can be used for determining metals [18].

In this work, we present the results of the study of the interaction of cobalt with PAN immobilized in a polymethacrylate matrix, aimed to the creation of a colorimetric sensor.