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Original Article

9-(2,4-dihydroxyphenyl)-2,3,7-trihydroxyl-6-fluorone as analytical reagent for spectrophotometric determination of molybdenum in plant tissues

Li Zaijun[a,*], Yang Yuling[b], Tang Jian[a], Pan Jiaomai[c]

[a] *School of Chemical and Materials Engineering, Southern Yangtze University[1], Huihe Road 170, Wuxi 214036, PR China*
[b] *Department of Food Science and Engineering, Nanjing Economy University, Nanjing 210003, PR China*
[c] *Department of Chemistry, East China Normal University, Shanghai 200062, PR China*

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Abstract

A highly sensitive and selective spectrophotometric method is proposed for direct determination of trace molybdenum in plant tissues. The method is based on the reaction of molybdenum (VI) with a new analytical reagent 9-(2,4-dihydroxyphenyl)-2,3,7-trihydroxyl-6-fluorone (DHPTHF). Under optimum reaction conditions, DHPTHF reacts with molybdenum (VI) and forms a red complex with the maximum absorption peak at 523 nm. The color reaction is rapidly completed and the absorbance remains stable for at least a week at room temperature. The apparent molar absorption coefficient, the limit of quantification and the limit of detection were $1.4 \times 10^5\,L\,mol^{-1}\,cm^{-1}$, $6.6\,ng\,mL^{-1}$ and $2.0\,ng\,mL^{-1}$, respectively. A linear absorbance was obtained for 0–6 μg of molybdenum (VI) in 10 mL solution. The effect of various substances on the determination of molybdenum was also investigated in detail. Results indicated that most of the studied co-existing substances can be tolerated in considerable amounts, e.g. 150 mg of Ca (II), 100 mg of Mg (II), 5.0 mg of Fe (III) and 50 mg of Zn (II), and do not interfere with the determination of molybdenum. The proposed method offered the advantages of sensitivity, rapidity, selectivity and simplicity without any prior separation or extraction. Moreover, the synthesis and physical and chemical properties of the reagents were also studied.

Keywords: Spectrophotometry; Molybdenum; 9-(2,4-dihydroxyphenyl)-2,3,7-trihydroxyl-6-fluorone; Plant tissues

*Corresponding author. Tel.: +86-510-581-1863; fax: +86-510-586-5424.
E-mail address: zaijunli@263.net (L. Zaijun).

[1] Its former name was known as Wuxi University of Light Industry.

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1. Introduction

Molybdenum is an essential nutrient element for plants, especially leguminous plants. Lack of molybdenum may result in accumulation of nitrate and decrease of amino acids and levels of vitamin metabolism in plant tissues, hence reducing crop growth and yield and can even result in death depending on the severity of the deficiency. The above harms can be avoided easily by using a fertilizer containing molybdenum when required (Wang, 1991). For this reason, the routine analysis of molybdenum in plant tissues is strongly advocated. As molybdenum occurs at low levels, its determination by conventional analytical techniques such as classical spectrophotometry and flame atomic absorption spectrometry is difficult. Although some new techniques such as graphite furnace atomic absorption (Ferreira et al., 2003), liquid chromatography (Bagur et al., 1995), electrochemical method with special selective electrodes (Hagedoorn et al., 2001), atomic emission spectrometry with inductively coupled plasma (Dos Santos et al., 2001) and inductively coupled plasma mass spectrometry (Minoia et al., 2002) are reported to determine trace molybdenum, they are complex to use and require some type of pre-concentration steps; therefore, only well-equipped laboratories can accomplish the determination of molybdenum accurately. Modern spectrophotometry is most commonly used for analysis of molybdenum, especially in developing countries. In the literature, reagents for spectrophotometric determination of molybdenum have 3,3′,5,5′-tetramethylbezidine (Di and Tu, 2001), bromopyrogallol red (Hoshi et al., 1997), alizarin Red S (Alkan et al., 2003), phenylfluorone (Nakatsuka et al., 1995), thiocyanate (de Andrade et al., 1998; Tunceli and Turker, 2004), 1,2-dihydroxybenzene-3,5-disulfate (Lis and But, 2000) and thiazolylazo compounds (Amin, 1999). Although each chromogenic system has its advantages and disadvantages with respect to sensitivity, selectivity, water solubility and rapidity due to different reagents, most of them require a previous separation or pre-concentration procedure to increase the sensitivity or selectivity. In recent years, many catalytic spectrophotometric methods for the determination of molybdenum have been reported in the literature. These are based on the catalytic effect of molybdenum (VI) on oxidation reactions (Kawakubo et al., 1997; Mousavi and Karami, 2000); although they are very sensitive, poor selectivity appears to be their main limitation as other ions have similar catalytic properties. In this work, a new chromogenic reagent, 9-(2,4-dihydroxyphenyl)-2,3,7-trihydroxyl-6-fluorone (DHPTHF), whose structural formula is shown in Fig. 1, was synthesized and studied for spectrophotometric determination of trace molybdenum in plant tissues.

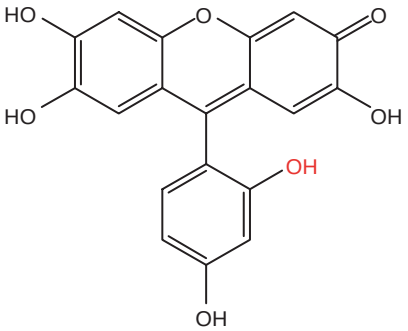

Fig. 1. The structural formula of 9-(2,4-dihydroxyphenyl)-2,3,7-trihydroxyl-6-fluorone.