INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH AND ANALYSIS

ISSN(print): 2643-9840, ISSN(online): 2643-9875

Volume 06 Issue 11 November 2023

DOI: 10.47191/ijmra/v6-i11-39, Impact Factor: 7.022

Page No. 5311-5314

Identification of Calcium and Magnesium in Medicine Using Plasma Laser Spectroscopy

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ABSTRACT: The identification of magnesium (Mg) in pharmaceutical products was carried out using LIPS (Laser-Induced Plasma Spectroscopy). The lasers used in the research were Nd: YAG laser and CO2 laser. The sample used was a supplement tablet. The laser beam is directed and focused by a convex lens on the sample. The plasma beam is induced on the sample surface. The sharp and high-intensity emission spectrum detected using the Nd: YAG laser indicates the presence of Calcium (Ca) and Magnesium (Mg) in the sample. The results obtained were then compared with sample testing using a CO2 laser. The results of the Mg spectrum intensity were much higher using a CO2 laser.

KEYWORDS: LIPS, Nd: YAG, Magnesium, Calsium

I. INTRODUCTION

Identification of macro elements in pharmaceutical products is very necessary because of the importance of the elements for the human body. Macroelements include calcium, magnesium, zinc, potassium, and sodium, which are highly beneficial to human health [1]. Therefore, regular checks on the quality of pharmaceutical products containing macro elements are very important.

Several methods have been used for drug analysis. The Inductively Coupled Plasma Mass Spectrometry (ICP-MS) method has been used to identify macro elements (Ca, K, Mg, and Na), microelements (Cu, Ni, Fe, Mn, and Zn), and trace elements (Al, Co, Cd, Ti, Rb, and Sr) in fifteen samples of American ginseng herbal medicine [2]. Another method has also been used to identify the element content in the Indian ginseng herbal medicine, namely the Atomic Absorption Spectroscopy (AAS) method. In this study, it was explained that ginseng herbal medicine contains macro elements (K, Ca, and Na), microelements (Zn, Fe, Cu, Ni, and Mn), and trace elements (Al, Co, Cd and Cr) [3]. Both of these methods have high sensitivity and can identify macro and micro elements at low concentrations. However, both methods are quite complicated, the equipment is expensive, can only be used for liquid samples, and requires a long sample preparation time and quite a large number of samples [4].

Another method that is more effective and can be applied easily to identify elements in samples is laser plasma spectroscopy or Laser Induced Breakdown Spectroscopy (LIBS). The laser plasma spectroscopy method can identify various types of samples such as liquid, solid, and gas [5]. Apart from that, the advantage of the LIBS method is that it has quite good sensitivity, more affordable device prices, and fast implementation time so results can be obtained at that time for further data analysis [6].

Laser-induced plasma spectroscopy (LIPS) commonly called laser-induced breakdown spectroscopy (LIBS) is a new method in analytical spectroscopy. In LIBS, it is common to use laser pulses to induce plasma flare [7-8]. The resulting plasma is captured by a spectrum analyzer in the form of an OMA (optical multichannel analyzer) to obtain an emission spectrum. Compared to other conventional methods, LIBS allows one to perform elemental analysis quickly and without pre-treatment [9-10]. In addition, LIBS systems are much cheaper than other spectrochemical equipment such as ICP and x-ray fluorescence spectroscopy.

Some researchers have used LIBS to detect elements in pharmaceutical products [11]. However, in this study, an Nd: YAG pulse laser was used. In the research, a comparative study was also carried out on LIBS studies to detect macro elements in pharmaceutical products using an Nd: YAG pulse laser and a CO2 laser. It was found that the emission spectrum of Cad and Mg elements in supplement drugs was much better when a CO2 laser was used, namely the emission intensity was much higher when compared to the Nd: YAG laser.

II. METHODS

The equipment set-up used in the research (figure 1a) consists of a laser (Nd: YAG laser (1,064 µm, 60 mJ, 10 ns,) and CO2 laser (10.64 µm, 1500 mJ, 200 ns,)), lens to focus the laser beam, the chamber as a space for samples and producing plasma, a pulse generator as a power supply, an OMA which functions as a spectrum capture and analyzer, and a computer to display spectrum results and process spectrum data. The laser is irradiated and focused onto the sample surface using a quartz lens, as illustrated in Figure 1 b, to induce plasma flare. The plasma diameter on the sample surface produced with the Nd: YAG laser is 0.1 mm, while for the CO2 laser, it is 2 mm.

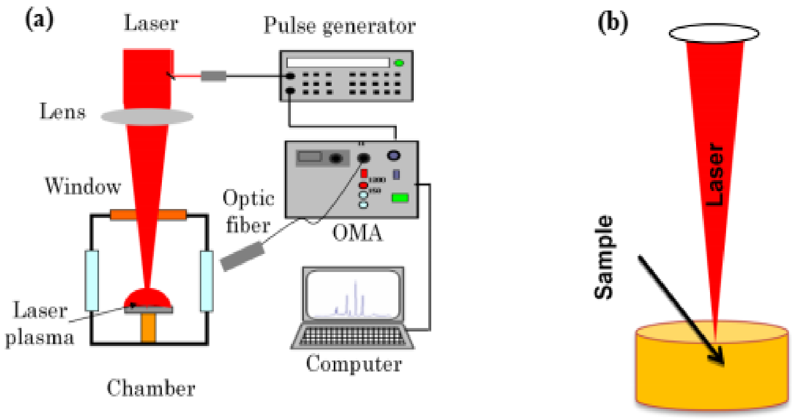

Figure 1. (a) Tool set-up, (b) illustration of shooting a sample target

The samples used in this study were supplement drugs containing around 2.5% and 1% Ca. Mg. The sample was put into a container placed in the chamber (12 cm x 12 cm x 12 cm). Plasma is produced at an air pressure of 1 atm. To obtain spectral emissions, the plasma emissions obtained from the sample are sent to a spectrograph system in the form of an OMA via optical fiber.

III. RESULTS AND DISCUSSION

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Figures 2 and 3 are the results of detecting calcium and magnesium content in supplement drugs using the Nd: YAG laser and CO2 laser. The resulting emission spectrum lines are compared to the standard spectrum database at NIST (National Institute of Standards and Technology). The spectrum results detected by OMA show that there are several calcium emission lines, namely Ca II 393.3 nm, Ca II 396.8 nm, and Ca II 422.6 nm. Ca II 393.3 nm has an ionization energy of 3.2 eV at the Ek level and the lowest energy at the Ei level of 0 eV. The emission spectrum produced by the CO2 laser looks sharper with a higher intensity than the emission spectrum of the Nd: YAG laser.

The CO2 laser ionization energy level is higher, resulting in a higher emission intensity. The lower intensity of the neutral Ca lines in the CO2 laser also proves that the higher temperature in the plasma is caused by CO2 TEA. The plasma produced at high temperatures causes an effective atomic ionization process to occur and produces optimal emission intensity [12].

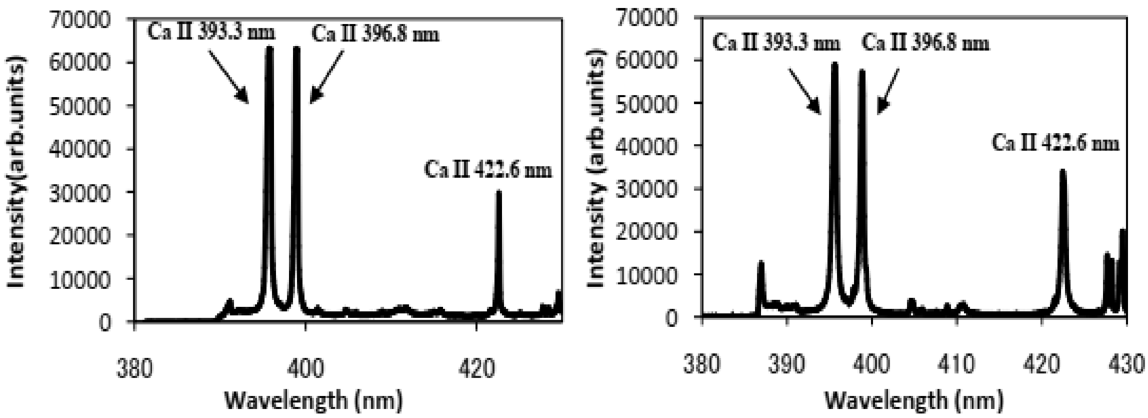

Figure 2. Ca emission spectrum, (a) TEA CO2 laser, and (b) Nd: YAG laser.

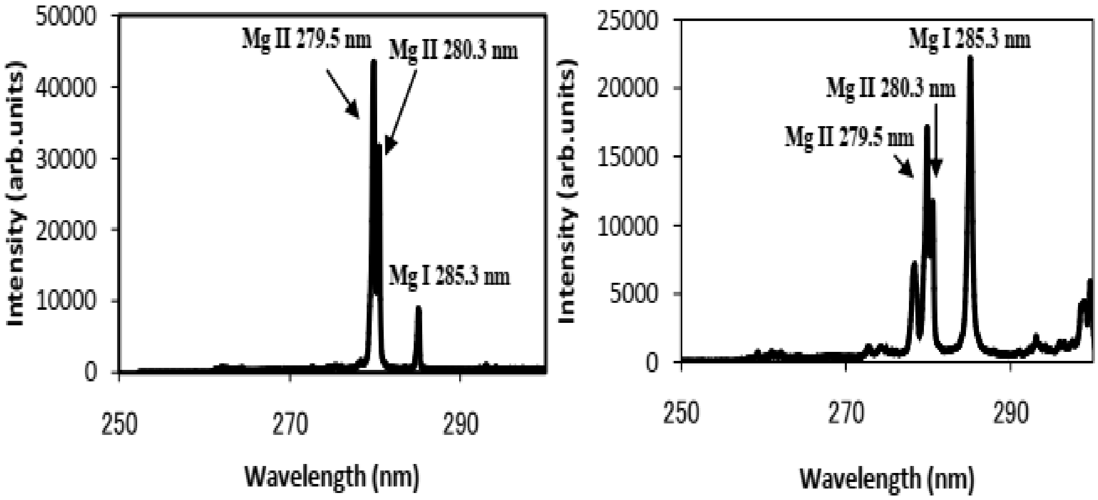

Figure 3. Mg emission spectrum, (a) with the TEA CO2 laser, and (b) using the Nd: YAG laser

Spectrum emission lines with high intensity are visible at wavelengths of 279.5 nm (Mg II) and 280.3 nm (Mg II) using the TEA CO2 laser. Meanwhile, with the Nd: YAG laser, the highest peaks can be seen at the 280.5 nm (Mg II) and 285.3 nm (Mg I) lines. The excitation energy of Mg II at the 279.5 nm and 280.3 nm emission lines is 4.4 eV from the ground state ionic level. The intensity of the emission spectrum produced by the TEA CO2 laser looks higher when compared to the Nd: YAG laser. Meanwhile, for Mg I, the spectrum line produced by the TEA CO2 laser looks lower with an energy of 7.6 eV. Based on the level of ionization energy, the Mg ionization process is more effective using a TEA CO2 laser because the resulting plasma has a high temperature, resulting in a high emission intensity.

IV. CONCLUSION

LIPS can be used as a method for identifying elements from solid materials. This result is proven by the emission spectrum lines produced. The Ca and Mg emission spectra obtained using a CO2 laser have much higher intensities than using a Nd: YAG laser. Plasma temperature makes a significant contribution to the emission spectrum. That is, the higher the plasma temperature, the higher the intensity of the observed spectrum.

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