Detection of sodium aerosol using laser induced breakdown spectroscopy

Z Alhamid and A Khumaeni

1Master Program of Physics, Department of Physics, Faculty of Science and Mathematics, Diponegoro University, Tembalang, Semarang 50275, Indonesia
2Department of Physics, Faculty of Science and Mathematics, Diponegoro University Jl. Prof. Soedharto, SH, Tembalang, Semarang 50275, Indonesia
E-mail: khumaeni@fisika.undip.ac.id

Abstract. Analysis of sodium aerosol is very important in various field including nuclear power station, electronic industry, and medical field. In medical field, aerosol detection can be employed to earlier detection of disease based on liquid in human being. In this present work, aerosol sodium detection has been performed using laser-induced breakdown spectroscopy (LIBS) utilizing pulse Nd:YAG laser. In the study, sodium aerosol made of sodium chloride (NaCl) liquid was deposited on a copper (Cu) metal plate. The Cu plate functions as a metal subtarget to initiate a plasma emission and to improve the emission intensity of sodium line. Experimentally, a pulse laser Nd YAG (1064 nm, 7 ns, dan 45 mJ) was focused on a sodium aerosol to induce a luminous plasma. The plasma was then sent into the spectrometer to obtain the emission spectrum of sodium. The observed sodium aerosol samples were made in five variations based on their various molarities (concentrations). Variations are made, ranging from 1 molar to 3 molar with the difference of each sample of 0.5 molar. Sharp Na lines at 588.9 nm and 589.3 nm, which overlap due to low resolution of spectrometer were clearly detected. The other lines coming from Cu subtarget occurs at 324.7 nm and 327.4 nm. Detail study of sodium analysis using laser induced breakdown spectroscopy will be presented.

1. Introduction

Sodium is one of the most useful ingredients in everyday life. In aerosol form, sodium is applied to nuclear, electronic industries, and medical fields. In the medical field, aerosol sodium detection can be used for early detection of diseases based on fluids in humans. Because there are many ingredients in sodium aerosols found in the human body. Several methods have been used to regulate health in humans including LIBS [2]. LIBS is a direct and fast method of analysis in detecting an element. The popularity of this method is shown by a large number of papers published in this method in many journals (more than 1500 papers in the last 5 years) [6-10]. The elements detected by LIBS are solids, liquids or gases. In medical detection that is widely used is liquid. When LIBS is used to analyze fluids, there are technical problems that interfere with the accuracy of the analysis performance. Among them are, shock waves that accompany plasma formation cause sparks, waves, bubbles, and aerosols. Various approaches are described in the literature that address this issue. So that aerosols are chosen as a substitute for fluids to increase the accuracy of the target to be analyzed. To shoot a metal-targeted aerosol is needed as a container before being shot. By depositing aerosols on the sub target metal detection can be performed [1].
2. Material and Methods
In this research, we used a pulse Nd: YAG laser as the radiation source. The laser wavelength, energy, repetition rate and pulse width were 1064 nm, 45 mJ, 10 Hz, and 7 ns respectively. Experimentally, a pulse laser Nd YAG was focused on a sodium aerosol to induce a luminous plasma as illustrated in Fig. 1. The plasma was then sent into the spectrometer to obtain the emission spectrum of sodium. In the process of plasma induction of sodium aerosol there is warming caused by the focused laser energy. Because of the heat then there is evaporation. The observed sodium aerosol samples were made in five variations based on their various molarities (concentrations). Variations are made, ranging from 1 molar to 3 molar with the difference of each sample of 0.5 molar.

![Experimental setup and emission spectra](image)

**Figure 1** (a) Experimental setup used in this work and emission spectrum of ionic Ca obtained from the human blood using the present setup. (b) shows emission spectrum of Na line obtained from the sodium aerosol. Sharp Na lines at 588.9 nm and 589.3 nm, which overlap due to low resolution of spectrometer were clearly detected. The other lines coming from Cu subtarget occurs at 324.7 nm and 327.4 nm.

3. Result and Discussion
A high-power narrow pulse laser beam on a solid target surface will cause the target to experience ablation, evaporating atoms emitting out experiencing excitation and ionization and forming plasma, which is characterized by continuous emissions as well as emission of atomic and ionic lines [4].
Figure 2 Formed Plasma in high-pressure atmospheric of the order of 1 atmosphere from target natrium and sub target Cu (cooper)

When plasma generation is carried out in a high-pressure atmospheric or gas atmosphere of the order of 1 atmosphere, the formed plasma is spherical-shaped with a millimeter-order radius and has a high density due to high surrounding gas pressure and emits a strong continuous emission spectrum characterized by a very white color bright with atomic and ionic emissions. Continuous emissions take place in a very short period of time. Continus emission is caused by recombination process and inverse bremsstrahlung. [5]

Figure 3 Formed Plasma in low-pressure atmospheric of about 1 plasma torr from target natrium and Sub Target Cu (Cooper)

At a low pressure of about 1 plasma torr that occurs consisting of two different regions [3, 5] namely the primary plasma area and the secondary plasma. The first area called primary plasam is a narrow area located right in the bright white laser-target interaction area because it emits a continuous emission spectrum in a short time. The second area is called secondary plasma located outside the primary plasma due to the primary plasma membrane to the surrounding area. A secondary spherical plasma that emits sharp atomic and ionic emission spectral lines. The secondary plasma radius is a function of gas buffer pressure, wavelength, and pulse width of laser and laser pulse energy. Figure 3 showed Plasma in low-pressure atmospheric of about 1 plasma torr from target natrium and sub
target Cu (Cooper). Colour green showed material cooper. Whereas for the detection of sodium is shown by the graph of the wavelength and intensity obtained from the detection by OMA of the light that appears. The following are the results of detection by OMA from the light that appears. For 1 molar sodium aerosols, an intensity of 501 was detected.

Figure 4 shows emission spectrum of Na line obtained from the sodium aerosol. Sharp Na lines at

![Emission Spectrum of Na Line](image)

Figure 4 588.9 nm and 589.3 nm, which overlap due to low resolution of spectrometer were clearly detected. The other lines coming from Cu subtarget occurs at 324.7 nm and 327.4 nm.

For sodium aerosol 1.5 molar the intensity of 1978 was detected

![Emission Spectrum of Na Line](image)

Figure 5 shows emission spectrum of Na line obtained from the sodium aerosol. Sharp Na lines at 588.9 nm and 589.3 nm, which overlap due to low resolution of spectrometer were clearly detected. The other lines coming from Cu subtarget occurs at 324.7 nm and 327.4 nm.

For sodium aerosol 2 molar. The intensity of 2608 was detected
Figure 6 shows emission spectrum of Na line obtained from the sodium aerosol. Sharp Na lines at 588.9 nm and 589.3 nm, which overlap due to low resolution of spectrometer were clearly detected. The other lines coming from Cu subtarget occurs at 324.7 nm and 327.4 nm.

For sodium aerosol 2.5 molar the intensity of 2832 was detected

Figure 7 shows emission spectrum of Na line obtained from the sodium aerosol. Sharp Na lines at 588.9 nm and 589.3 nm, which overlap due to low resolution of spectrometer were clearly detected. The other lines coming from Cu subtarget occurs at 324.7 nm and 327.4 nm.

For sodium aerosol 3 molar the intensity of 2880 was detected
Figure 8 shows emission spectrum of Na line obtained from the sodium aerosol. Sharp Na lines at 588.9 nm and 589.3 nm, which overlap due to low resolution of spectrometer were clearly detected.

The other lines coming from Cu subtarget occurs at 324.7 nm and 327.4 nm.

From the detection results of sodium aerosols obtained can be made the ratio as follows

![Intensity vs Wave Length](image)

Figure 9 shows ratio from emission spectrum of Na line obtained from the sodium aerosol.

From the ratio graph shown can be concluded the greater the molarity of sodium aerosols, the likelihood of the intensity detection results will be even greater.

4. Conclusion
Detection of sodium aerosol has been successfully performed using LIBS method with laser Nd: YAG. This detection is indicated by the detected wavelength and the emission color emitted. Thus, the LIBS method can be used to detect aerosol-shaped elements by using Cu-shaped solids as sub-targets.

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