Utilizing Laser-Induced Breakdown Spectroscopy Method to recognize chemical composition of low-carbon steel in NH₃(NO)₄ material

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Abstract. A standoff laser Induced Break down Spectroscopy (L.I.B.S) technique has been used to characterization the organic materials such as NH₃(NO)₄, a Q-switched Nd:YAG laser (1064 nm wavelength, 9 ns pulse width and 1 Hz repetition rate, 300 mJ) is focused to the targets to generate plasma. HR 4000 CG-UV-NIR spectrum analyzer was used to collect the generated plasma emissions, specific signature of each targets material can be obtained by analysis the plasma emission spectrum. Peak ratio analysis technique is used for the identification of energetic materials.

Key words: Laser-Induced-Breakdown Spectroscopy, LIBS, plasma, low-carbon steel.

1. Introduction:
LIBS (Laser-Induced Breakdown Spectroscopy) is a diagnostic emission spectroscopic method, where a high energy pulsed laser concentrate onto a material that creates a passing high-density plasma as the laser ferocity overtakes the material breakdown threshold (~1-10 MW/cm²)[1]. Orienting the analytic breakdown to be ions and free electrons that make the plasma be recognized by atomic emission [2]. The Ultraviolet and apparent emission from the plasma is likely be spectrally determined for qualitative and quantitative analysis of the samples composition. This paper presents LIBS technique of the organic materials analysis through the analysis of their plasma spectral lines and measure their intensities and the conforming line with the basic components. This technique owns a lot of benefits as it is considered as an analytical technique which needs no sample planning, The analysis procedure is rapid and does not use to any other samples (conducting and non-conducting), disregard to their physical status. LIBS can also be used to analyze hard materials that have the difficulty of being digested or dissolved. This technique is able to simulate multi-element determination and used successfully even in difficult environmental conditions [3], [4]. So it is considered as a suitable technique for detecting and identifying the atmospheric environment performance [5].

2. Experiment
A graphic diagram of the experimental plan is displayed in Fig.1 in our experiments, energy source was a Q-switched Nd:YAG pulsed laser operative at the main wave-length (1064 nm), having pulse duration of 9 ns and 1Hz repetition rate. The energy per pulse at the target surface was fixed at a level of 300 mJ. The laser beam was focused on the targets by a lens of focal length (10 cm). The targets were a pure sample on a glass supstrate[6,7],

The laser spot was measured at the target surface using an optical microscope and gives a circle of area 5x10⁻² cm² and hence laser intensity of the order of 6.628 GW/cm² was calculated. Plasma emission spectroscopy was performed with an Ocean optics (HR 4000 CG-UV-NIR) spectrum
analyzer having resolution in (320-740 nm) wavelength interval. An optical fiber was positioned at (3 cm) distance from the targets surface (to capture as much as possible of emission spectrum).

![Experimental setup](image)

**Figure 1.** Experimental setup

3. Results and discussion

In depending on the elements spectral lines of dung sample that was analyzed by the LIBS, Figure 2 demonstrates exemplary LIBS spectrum in various wavelength reach for the tested sample [8], in table 1, elements that have been recognized in manure sample can be shown. In addition, other impurities were identified in small percentage, like (Al, Fe, H, N, and O) [9].

The absorbed emission lines were situated on a noisy spectral background basically because of the technicality that involves free electrons (inverse bremsstrahlung, radiative recombination and photoionization) [10]. These peaks were assigned using (NIST) database [11].

| NIST element | NIST λ (nm) | [Intensity] | λ (wavelength) (nm) | Marker Number |
|--------------|-------------|-------------|---------------------|---------------|
| H I          | 373.4       | 0.005629    | 373.3673            | 1             |
| Fe I         | 383.925     | 0.076838    | 383.9247            | 2             |
| O I          | 393.2152    | 0.510173    | 393.2152            | 3             |
| SII          | 397.02      | 0.282957    | 397.0158            | 4             |
| Al II        | 422.787     | 0.179054    | 422.7759            | 5             |
| Mg II        | 518.638     | 0.100376    | 518.637             | 6             |
| FeII         | 558.859     | 0.122383    | 558.7551            | 7             |
| N II         | 589.9       | 0.580938    | 589.5827            | 8             |
| N I          | 616.18      | 0.153727    | 616.1873            | 9             |
| OI           | 657.11      | 0.119813    | 656.7277            | 10            |
Figure 2. shown typical LIBS spectrum for the tested sample

4. Conclusions

Evaluating the performance of LIBS for identification of the material composition was done. LIBS spectra were recorded using a spectrometer analyzer. An emission spectra test was enough to identify between many materials. LIBS was a low-cost and high-quality system for analyzing in comparing with all other analysis technologies. LIBS displayed high sensitivity to identify some elements like: (H, N, O, and other elements). LIBS is a fast way to analyze the material, non-destructive and no sample preparation is required to gain beneficial results.

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