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Spectroscopic Detection of Main Elements (C, H, O, N and S) of Crude Oil Sample from Melut Oilfield in Sudan Using Laser Induced Breakdown Spectroscopy

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Abstract:- Laser Induced Breakdown Spectroscopy (LIBS) technique used to detection of the basic elements in crude oil sample collecting from Melut oilfield in Sudan. The irradiation of the sample was done by using Q-Switched ND-YAG Laser 1064 nm set with pulse energy 150, 170, 190 mJ. Such plasma emission spectrum was collected using wide band fused-silica optical fiber of one-meter length connected to a portable Ocean Optics USB 2000+ spectrometer of range (200 nm to 1100 nm). Crude oil can vary with the location and age of the field in addition to any variations that occur with the depth of the individual well. Two adjacent wells may even produce oil with very different characteristics. The sample was irradiated by pulse laser energy 150, 170, 190 mJ, the main elements in crude oil samples (C, H, O, N and S) were found in all samples by using LIBS technique. The spectra of the samples showed different amounts of main elements of crude oil with different ionization stages. The peaks were identified with help of NIST-ASD and Origin Pro 9 software. LIBS technique proved to be a good, fast, accurate, technique in the detection of main elements in crude oil sample.

Keywords:- *Laser-Induced Breakdown Spectroscopy, Main Element-Crude Oil, Melut Oilfield.*

I. INTRODUCTION

The basis of optical emission spectroscopy (OES) analysis of materials is the fact that in plasma, the light emitted by excited atoms and ions is unique for each chemical element. The characteristic emission spectra can be used to identify and quantify the elements of which a substance consists. There exist several possible plasma excitation methods. The most common ones are the electrode spark and the inductively coupled plasma (ICP). With the development of the laser in the 1960s a new plasma source became available. In laser-induced breakdown spectroscopy (LIBS) intense laser pulses are used for material ablation and excitation [1, 3]. The use of laser pulses for material ablation and plasma ignition in LIBS has many advantages in comparison to conventional techniques. The ability to perform LIBS measurements in-line, remotely and fast can allow monitoring of industrial processes and the analysis of materials in hazardous conditions. The material to be analyzed can be solid, liquid or gaseous. Another advantage of LIBS is that only a very small amount of material is required for measurements, which makes it almost non-destructive [4].

Understanding the plasma physics of LIBS is essential to provide an optimized setting for LIBS measurements. The plasma, induced by the interaction pulsed laser-sample, emits light which consists of discrete lines, bands, and an overlying continuum. These discrete lines, which characterize the material, have three main features; wavelength, intensity, and shape. These parameters depend on both the structure of the emitting atoms and their environment. Each kind of atom has some different energy levels which determine the wavelength of the line.

A LIB is an atomic emission spectroscopy technique which uses highly energetic laser pulses to stimulate optical sample excitation. The interaction between focused laser pulses and the sample creates plasma composed of ionized matter. Plasma light emissions can affect “spectral signatures” of chemical composition of many different kinds of materials in solid, liquid, or gas state [7].

II. EXPERIMENTAL PART

LIBS setup is employed for measurements of crude oil sample taken from Melut oilfield in Sudan. The sample material was laser ablated by focusing the pulsed radiation of a Q-Switched ND-YAG of wavelength 1064 nm, pulse energy 150, 170, 190 mJ, repetition rate 2 Hz, pulse duration 10ns.

LIBS spectra were measured with an Ocean optics USB2000+ spectrometer of detector range (200 to 1100) nm. The optical emission was collected by direct coupling to a fiber optic. The LIBS emission spectra are recorded at a 90˚ angle to the direction of incident laser pulse. Software built in the spectrometer reads the data from the chip and

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reconstructs the spectrum. For evaluation of the spectra, the peaks were identified with help of National Institute Standard and Technology (NIST)-Atomic Spectral Database (ASD) and Origin Pro 9 software.

III. RESULTS AND DISCUSSION

The sample was irradiated by pulse laser energy 150, 170, 190 mJ, and the spectra of the sample were recorded as shown in fig (1 to 3), the recorded spectra were analyzed and the identifications of main elements in crude oil spectral lines were listed in table (1 to 3).

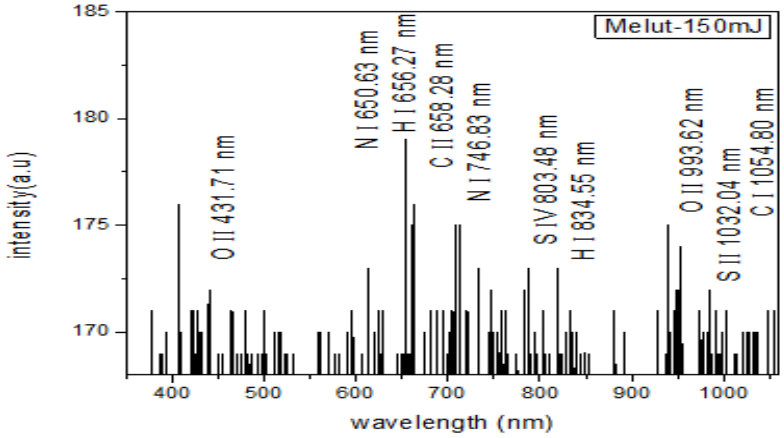

Fig 1:- Typical LIBS emission spectra of Melut oilfield sample irradiated by 150mJ.

Wavelength (nm)	Intensity (a.u)	Element
431.71	169.048901	O II
476.83	172.049232	N I
606.2	169.059476	C I
648.5	169.07399	O II
650.63	169.07399	N I
656.27	169.103017	H I
658.28	169.059476	C II
659.58	175.058338	N I
702.23	170.022197	C I
705.16	171.057474	S IV
753.83	170.03671	N I
783.94	172.049232	O III
788.17	169.03045	S IV
802.82	171.028458	C I
803.48	171.033295	S IV
823.33	169.064314	O I
834.55	168.807911	H I
946.06	170.060899	N I

Table 1:-LIBS main elements of Melut oilfield when irradiated by 150mJ.

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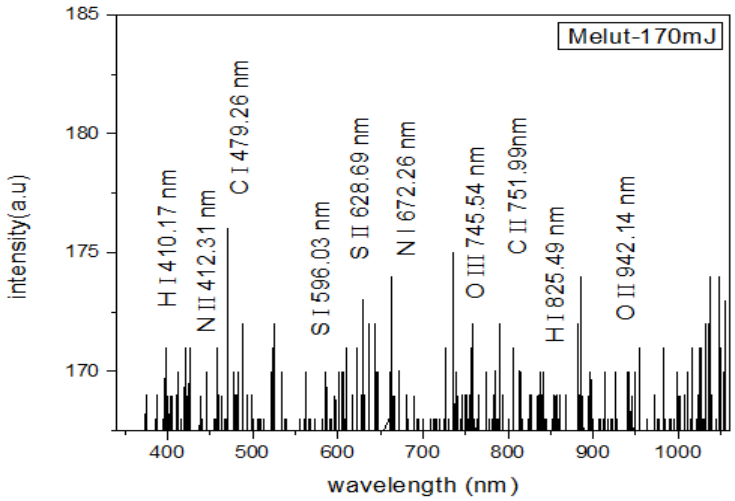

Fig 2:- Typical LIBS spectra of Melut oilfield sample irradiated by 170mJ

Wavelength (nm)	Intensity (a.u)	Element
374.66	169.04	O V
388.9	169.08	H I
406.67	169.02	C I
410.17	169.02	H I
412.31	170.09	N II
415.26	168.16	S I
421.71	169.1	S II
434.04	167.03	H I
445.99	168.61	N II
479.26	169.12	C I
480.86	169.07	C I
493.02	169.09	O V
600.84	170.07	N I
596.03	169.1	S I
28.69	171.72	S II
660.57	170.06	C I
672.26	170.07	N I
745.54	169.03	O III
758.64	168.61	C III
765.67	168.99	O II
792.88	169.08	S I
795.13	169.08	C I
824.99	168.96	H I
825.22	169.05	H I
825.49	169.1	H I
839.74	170.06	C III
854.53	169.05	H I
857.7	169.05	C I
837.44	170.02	H I
942.14	170.06	O II

Table 2:- LIBS main elements of Melut oilfield when irradiated by 170mJ

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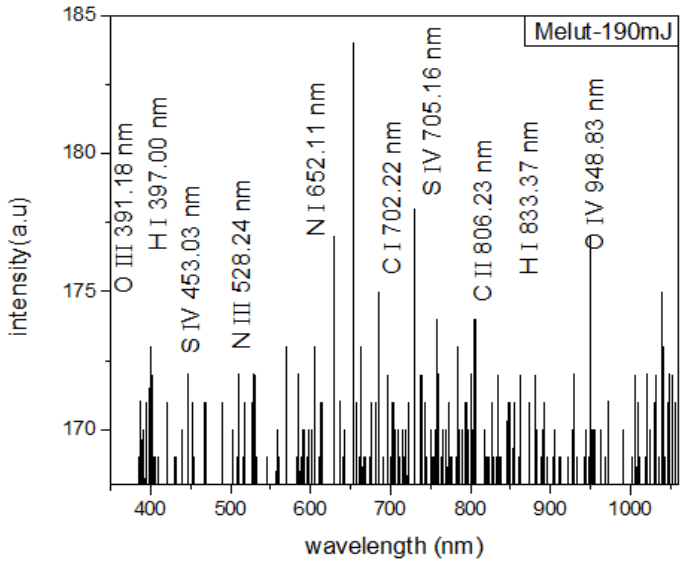

Fig 3:- Typical LIBS spectra of crude Melut oilfield sample irradiated by 190 mJ

Wavelength (nm)	Intensity (a.u)	Element
388.9	170.250802	H I
391.18	170.038133	O III
453.03	171.08082	S IV
397.01	168.715993	H I
397	168.619237	H I
410.17	169.098179	H I
528.24	172.112123	N III
589.43	170.024474	S I
597.25	170.060899	C I
652.11	183.998293	N I
658.76	171.076266	C I
656.28	171.076266	H I
702.22	171.035287	C I
705.16	171.035287	S IV
736.61	171.58054	N I
806.23	169.341491	C II
891.86	171.035287	C I
948.83	171.085373	O IV
1038.21	175.042117	C I

Table 3:- LIBS main elements of Melut oilfield when irradiated by 190 mJ

The spectra of the sample showed different amounts of main elements (C, H, O, N and S) of Sudan crude oil with different ionization stages, the main elements in crude oil were found in all samples by used LIBS technique.

It's clear from table (1) the essential elements like Carbon ions C I and C II were appeared because the irradiated pulse energy was sufficient to excite this elements. Also oxygen O II, O III was found and Nitrogen element in first ionization stage NI and definitely hydrogen ions H I.

When the pulse energy was increased Carbon and oxygen appeared with higher order of ionized C III, O III. And the same thing for S II and N II as illustrated in table (2).

In table (3) H I, N III, O IV, S IV were appeared with higher order of ionization stages due to increase in energy pulse. Hydrogen ion was appeared (as expected) in all different energy pulses because its ratio in any crude oil sample is 14%.`

IV. CONCLUSION

In this work the analysis of crude oil sample by using LIBS technique with Q-Switched ND-YAG laser is presented. The analysis of the spectra with help of NIST-ASD shows five basic elements (C, H, O, N and S) in crude oil sample with different ionization stages due to the increased in energy pulse.

LIBS technique proved to be a good, fast, portable, accurate, technique in the detection of main elements in crude oil samples.

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