Study and Analysis the Wisdom Tooth structural and Optical Characteristic by Using LIBS, SEM and EDS

Asmaa N. Ahmeda, Ashraf M. Alattara,b, Ruaa A. Mohammada
aAlhussien University College –Karbala'a- Iraq
bSchool of Material Science and Engineering
Georgia Institute of Technology, Atlanta, GA 3003, USA
Author E-mail: dr.ashrafiibrahim@huciraq.edu.iq , ashraf_alattar2000@yahoo.com

Abstract
This work shows some of samples Wisdom tooth, by using LIBS method selected specimens were analyzed for their racial components using the atomic transition lines. Elements detected in a wisdom tooth sample: ca, ph, mg, Fe, Pb and Na. Many changes in ratio of Ca, K, Mg, Na and Sr between women’s teeth these contents were found. Also Sr and Mg content increase with oldness in teeth samples was noticed. Using SEM and EDS in order to support the interpretation of the results. Through the SEM micrographs in images are show different network structure and a spongy porous structure that confirming with low porosity of the Wisdom tooth for selected interesting samples.

1. Introduction
Since last decades the study of and emission spectroscopy technique get more attention. Light emitting plasmas have been studied in earnest since the 1920s, and laser induced plasmas (LIBS) since 1960 [1]. high density photons and matter between of them there is interaction, basically can say the LIBS method is an emission spectroscopy, primarily formed ions and atoms in their excited state and it is as a result of material samples and tightly focused of beam laser interaction. The interaction between matter and high-density photons generates plasma plume, which grows with time and may eventually acquire thermodynamic equilibrium [2]. LIBS has become of interest to many researchers owing to its unique properties such as minimal time period of preparing the sample, low cost capability of being used in all three states of materials, and its nondestructive nature [3].

Also, its need for more information about the bones and fossils. It is also used to detect backgrounds characteristic similar age and statues of bodies [4]. Notice the modification and caries of a tooth used this technique in density. Spectral analysis plasma spark made by pulse laser can be used safely and accurately to monitor the occurrence of cancer [5-7]. Due to increases laser uses in practice of clinical dental probably, LIBS it can possible be achieved to create concentration maps of one-dimensional or two-dimensional as a function of depth or location which will permits studying of elements distribution. Also, Scanning Electron Microscopy (SEM) attached with Energy Dispersive Spectroscopy (EDS) are two analysis methods that are usually used to study all types of solid samples, from inorganic to biological. They have been used to determine morphological characteristics features of interest exactly at the level micron and sub-micron to detect the samples chemical structure in the terms of the amount for each element present. Therefore, the SEM/EDS techniques useful to human dental samples when irradiated with a laser Er:YAG to avoid caries[ 8].

2. Experimental Part
Samples of wisdom teeth were summation by the dental clinics in Yarmouk Hospital Baghdad, Iraq. In order to eliminate pollution from the outer surface, washed done in sodium hypochlorite diluted with distilled water for up to 15 minutes, and then dried at room temperature, using formalin solution to preserve, using LIBS experimental system shown in Fig. 1 the optical emission spectra for plasma ablated near teeth samples surfaces were noted. It consists of pulse
Nd: YAG laser of 10 ns duration, 10 Hz pulse repetition frequency, using wavelength of 1064 nm, with energy (400 mJ). Sample which is found at focal length of a converging lens (f = 10 cm) laser beam was shows intensive on the surface of the sample. Optical fiber regulated at 45° with beams directed at 5 cm space from the specimen where plasma was generated. Spectroscopic datum was gotten it from the laser induced targets plasma spectra in air, under atmospheric pressure.

Therefore, the samples were examined through scanning electron microscopy (SEM) FEI Company- Nether lands Inspect S50- Model. Energy Dispersive X-ray Spectroscopy Bruker company-Germany X Flash 6110- model.

3. Results and Discussion

Wisdom teeth are the final teeth to evolved. Most of us in each corner of our mouth have four wisdom teeth. They usually emerge during our late teens or early twenties [9]. Simply, in the jawbone the wisdom tooth become trapped and impacted, often times fail to erupt, development of localized tooth decay, gum disease or infection it causes by shift of other teeth or crowding. Stop erupting in a normal way of wisdom teeth in the jawbone are set impacted in unusual position, sometimes horizontally. The results obtained from wisdom teeth for women exhibited statistically significant differences for Ca, K, Na, Zn, Mg and Sr. Concentrations of Ca, K and Na were higher in females age group less than 30 year, while the intensities A.L intensities of these components decreased at age group above 30 year.

Figure (2and 3) shows LIBS spectra of wisdom teeth for women’s in spectral range 150-1000 nm at energy of 400 mJ respectively.

Also, these elements Ca, K, Na, Mg, Zn and Sr were detected in the wisdom teeth for women’s at age group 40 year and above. Variations of the elements prorate composition of teeth are various with age group. Figures (4and 5) show the LIBS spectra of wisdom teeth for women’s at age groups 40 year and (above 40) respectively. It can be seen that the relative of the intensity elements Ca, K, Na and Zn are higher in women’s age group 40 year than in women’s age group above 40 year. Also a high content of Sr and Magnesium was detected in the wisdom teeth.

In our results the porous structure of all Wisdom tooth samples was observed by scanning electron microscope (SEM). Through the SEM micrographs in images are show different network structure and a spongy porous structure that confirming with low porosity of the Wisdom tooth for selected interesting samples. These images were selected according to their age values, which revealed essential variant LIBS spectra test, in order to examine their structures shapes.

These images offer different networks stricture related to their ages environment. SEM image for tooth sample at (21year) is shown in figure (6). The image reflects narrow pore size distribution, where the measured pore size of tooth is ranging from (6.6-9 nm). Also, the core of aerogel is open cellular foam and can be called Low-Density Microcellular Materials (LDMMs). Researchers at LLNL proposed a nomenclature for open cellular foam structures called Low-Density Microcellular Materials (LDMMs) [12].

The Wisdom tooth samples has different pores size, which can range from mesoporous. SEM Image in figure (7) presents the tooth core morphology for (38 year) which can be classified as fractal structure type.

SEM image for the tooth sample at (25 year) is illustrated in figure (8). It can be monostuctural, characterized by a repetition of elongated microstructural features that have maximum dimensions in the 100s of mm range).

Figure (9.a) displayed microstructure image for tooth sample at (48 year) which have open-cell foam and can be denoted as reticulate foam. Reticulate foam is open-cell foam with a strut like structure [12], as well as, the image shows narrow pore size distribution.

The same scenario was repeated for (49 year) sample as show in figure (9.b).
Also through EDS it found very high magnifications, especially under high beam currents, wisdom tooth core displays the compositional contrast in the sample. The EDS image confirm the existence W(catalyst) and carbon (organic components, SILICA ,,,,,, Sample in the figure (10,a,b,c,d and e) illustrates the ratio of the elements that existed and show the (W) existing in the map with minimum ratio. While each of O, Si and C it shows up the ratio in the map. Although the coating gets rid of most of the liquid inside the bulk sample but the map spectrum showing there is little amount of the liquid that represent by the (o) and (c) that used during preparation.

Figure (11) shows the relative statistics of calcium concentration in wisdom teeth according to age groups. The maximum calcium concentration belongs to young women’s age group (less 30 year) compare with other groups.

Finally the plasma parameters can be used to determine electrons temperature and electron density according to Boltzmann equation and Saha-Boltzmann equation, respectively [10, 11].

\[
\ln \frac{I_{j_i}}{I_{j_f}} = -\frac{E_j}{kT_{\text{ex}}} + \ln\left(\frac{h c n_e}{4 \pi T}\right)
\]

(1)

Where \( I_{j_i} \) is the intensity of the spectral line of the transition from level \( j \) to \( i \). Thus, a plot of \( \ln \left(\frac{I_{j_i}}{I_{j_f}}\right) \) versus the energy of the upper level \( E_j \) yields a straight line called Boltzmann plot, its slope is equals to \(- (kT_{\text{ex}}) -1\).

According to the Saha-Boltzmann equation electron density can be deduced from the intensity relation of two lines matching to different ionization stages [10, 11].

\[
n_e = \frac{2(2\pi m_e kT)^{3/2}}{h^3} \frac{l_{mn}^l A_{l_k}^j}{l_{nm}^l A_{l_m}^j} e^{-\left(E_{\text{ion}} + E_{l} - E_{\text{ion}} - E_{l}\right)/kT}
\]

(2)

Where \( E_m \) and \( E_j \) are the upper level energies of neutral and single ionized transitions, \( E_{\text{ion}} \) is the ionization energy and \( n_e \) is the electron density.

The Debye length is the measure of the penetration depth of the external electrostatic fields, i.e. of the boundary charge sheath thickness. The applied electrical potential will therefore develop mostly near surface, over a distance \( \lambda_D \), called the Debye length and defined by [13].

\[
\lambda_D = \left(\frac{\varepsilon_0 kT_e}{n_e e^2}\right)^{1/2}
\]

(3)

Where \( \varepsilon_0 \) is permittivity of free space, \( k_B \) the Boltzmann constant and \( e^2 \) electron charge. It can be exhibited that the Debye length is a function of electron temperature \( T_e \), and plasma density \( n_e \). The plasma frequency of electron \( (\omega_p) \) can be calculated by [13].

\[
\omega_p = \left(\frac{n_e e^2}{\varepsilon_0 m_e}\right)^{1/2}
\]

(4)

Table 1 show the plasma parameters calculation from wisdom teeth samples.

4. Conclusions

The present work results show potential use of the LIBS system for discriminating between wisdom teeth tissue of women. The concentration matrix elements (Ca and Na) and non-matrix elements (other elements) increase in women’s age group less than 30 year. Exploiting the variations in concentration ratios between the matrix elements (Ca and Na) and non-matrix elements (K, Zn, Mg and Sr), represented by the relation changes in the line intensities as seen in the LIBS spectra, of different ages. The concentration of some atomic elements in wisdom teeth samples decrease with age. Negative correlation for Ca and Na content in wisdom teeth specimens with age noticed. The Ca concentration increases in young women’s compare with old women. Additional developments could present LIBS allowing to monitoring and to control the troubles of teeth during laser drilling of tooth. Also through the SEM micrographs in images are show different network structure and a spongy porous structure that confirming with low porosity of the Wisdom tooth for selected interesting samples.
Acknowledgements

We would like to acknowledge the National Science Foundation Nanostructured Materials for Energy Storage and Conversion (NESAC) IGERT program for traineeship support under Award Number 1069138. In addition, we thank the Iraqi Ministry of Higher Education and Scientific Research for their generous support and AL-hussien University College. The 2018 IDMP theme is "medical Physics for Patient Benefit"

References

[1] L. Radziemski, and D. Cremers, “A brief history of laser induced breakdown spectroscopy” Spectrochim. Acta, Vol. 87, pp.3–10, 2013.
[2] K. Song, Y. Lee, and J. Sneddon, “Applications of laser induced breakdown spectrometry;” Applied Spectroscopy Reviews, Vol. 32, No. 3, pp. 183–235, 1997.
[3] D. Cremers and L. Radziemski, “Handbook of Laser Induced Breakdown Spectroscopy”, John Wiley & Sons, Ltd. ISBN: 0-470-09299-8, 2006.
[4] M. Martin, N. Labbe, N. Andre et al., “High resolution applications of laser-induced breakdown spectroscopy for environmental and forensic applications,” Spectrochimica Acta Part B, vol. 62, no. 12, pp. 1426–1432, 2007.
[5] O. Samek, D. Beddows, H. Telle, G. Morris, M. Liska, and J. Kaiser, “Quantitative analysis of trace metal accumulation in teeth using laser-induced breakdown spectroscopy,” Applied Physics A, vol. 69, no. 1, supplement, pp. 179–182, 1999.
[6] O. Samek, H. Telle, and D. Beddows, “Laser-induced breakdown spectroscopy: a tool for real-time, in vitro and in vivo identification of carious teeth,” BMC Oral Health, vol. 1, no.1, article 1, 2001.
[7] A. Kumar, F. Yueh, J. P. Singh, and S. Burgess, “Characterization of malignant tissue cells by laser-induced breakdown spectroscopy,” Applied Optics, vol. 43, no. 28, pp. 5399–5403, 2004.
[8] O. Olea-Mejia1, R. Contreras-Bulnes2, C.M. Zamudio-Ortega2, R. A. Morales-Luckie1, O. Olea-Cardoso3 and R. López-Castañares3 “Scanning Electron Microscopy and Energy Dispersive Spectroscopy microanalysis applied to human dental specimens under laser irradiation for caries prevention” Microscopy: advances in scientific research and education, 2014.
[9] P.F. Gonçalves, E.A. Sallum, A.W. Sallum, M.Z. Casati, S. Toledo and F.H.N. Junior, “Dental cementum reviewed: development, structure, composition, regeneration and potential functions”, Braz. J. Oral Sci., Vol.4, no.12. pp.651-658, 2005.
[10] Tognoni E. et al., “A numerical study of expected accuracy and precision in calibration-free Laser-induced Breakdown Spectroscopy in the assumption of ideal analytical plasma”. Spectrochimica Acta Part B, Vol. 62, no.12, pp 1287-1302, 2007.
[11] S. Z. Mortazavi, P. Parvin, M. R. Mousavi Pour, A. Reyhani, A. Moosakhani, and S. Moradkhani, “Time-resolved evolution of metal plasma induced by Q –switched Nd:YAG and ArF-excimer lasers,” Optics & Laser Technology, vol. 62, pp. 32–39, 2014.
[12] J.D. Le May, R.W. Hopper, L.W. Hrubesh and R.W. Pekala, Low-Density Microcellular Materials, MRS bulletin, 1990 - Cambridge Univ Press.
[13] T. J. M. Boyd, J. J. Sanderson “The Physics of Plasmas” Cambridge University Press, ISBN: 0521459125, 9780521459129, 2003”. 
Fig. (1) The conventional LIBS system configuration

Fig.(2) LIBS spectra of wisdom tooth for women’s age group less than 30 year at 400mJ
Fig. (3) LIBS spectra of wisdom tooth for women’s age group above 30 year at 400mJ

Fig. (4) LIBS spectra of wisdom tooth for women age group 40 year at 400mJ
Fig.(5) LIBS spectra of wisdom tooth for women’s age group above 40 year at 400mJ

Fig.(6) SEM image for male tooth sample at (21year)

Fig.(7) SEM image for women tooth sample at (38year)
Fig.(8) SEM image for women tooth sample at (25year)

Fig.(9.a) SEM image for male tooth sample at (48year)

Fig.(9.b) SEM image for women tooth sample at (49year)
Fig.(10.a) EDX image for male tooth sample at (21year)

Fig.(10.b) EDX image for women tooth sample at (25year)
Fig.(10.c) EDX image for women tooth sample at (38 years)

Fig.(10.d) EDX image for male tooth sample at (48 years)
Fig. (10.e) EDX image for women tooth sample at (49year)

Fig. (11) Concentration of Ca in wisdom teeth at different age groups
Table 1. Some qualitative analysis of plasma parameters for Ca in wisdom teeth

| parameters        | Age  | Women’s |
|-------------------|------|---------|
| \( T_e \) (eV)    | < 30 | 1.580   |
|                   | > 30 | 1.530   |
|                   | 40   | 1.510   |
|                   | > 40 | 1.430   |
| \( n_e \times 10^{17} \) (cm\(^{-3} \)) | < 30 | 6.180   |
|                   | > 30 | 5.170   |
|                   | 40   | 5.110   |
|                   | > 40 | 5.013   |
| \( \lambda_D \) (nm) | < 30 | 473     |
|                   | > 30 | 453     |
|                   | 40   | 432     |
|                   | > 40 | 410     |
| \( f_p \) (Hz) \times 10^{11} | < 30 | 2.243   |
|                   | > 30 | 2.042   |
|                   | 40   | 2.031   |
|                   | > 40 | 1.930   |
| \( N_D \)         | < 30 | 133.060 |
|                   | > 30 | 143.075 |
|                   | 40   | 148.225 |
|                   | > 40 | 179.682 |