Analysis of human blood serum using double pulse laser induced breakdown spectroscopy in He gas

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Human blood serum

- The red blood cells carry the oxygen, nutrients, waste products and carbon dioxide. The white blood cells fight off infections and help heal wounds. The blood platelets help the blood to clot.

- The elemental analysis of human blood is significant in the routine clinical practice as well as in medical research.

The elemental concentration levels of blood serum may indicate certain diseases; therefore, their determination is useful for establishing diagnosis.
General methods for liquid serum analysis

ICP MS
ICP AES

High Frequency Plasma

Liquid sample

Serum sample

✓ Delicate sample preparation
✓ Labor intensive
✓ Expensive in experimental instrumentation
✓ Not mobile system

✓ Rapid analysis
✓ Without/less sample preparation

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Atomic Emission Spectroscopy

Laser-Induced Breakdown Spectroscopy (LIBS)

Experimental setup

The main advantage:
- Direct analysis without pretreatment (*in-situ* analysis).
- Micro-area analysis.
- Low cost compared to other analytical tools.

Pulsed Nd:YAG laser is usually used

**HIGH PRESSURE**

- Strong continuous plasma emits
- 2-3 mm

**LOW PRESSURE**

- Background emission is very low
- 15-20 mm

**GAS PLASMA**

- To realize in-situ analysis, 1 atm is required
- 10-15 mm

Cremers & Radziemski’s Group, 1981

Kagawa & Kurniawan’s Group

Mars mission

http://www.utopiales.org
Laser-induced breakdown spectroscopy (LIBS) system
Mechanism of laser plasma generation

Nd:YAG laser
Wavelength: 1.06 um
Pulse: 8-10 ns
Power density is approximately 10-100 GW/cm²

Absorption
Atoms are ablated
Primary plasma
Shock wave plasma

Damage on sample surface

1. Laser
2. Heating
3. Vapor
4. Plasma
5. Emission
6. Decay
7. Crater
Experimental setup

Nd:YAG laser beam
Luminous plasma
Blood serum film
Metal subtarget

Target plasma
He gas plasma
Optical fiber
Sample
Optical fiber
Rotating motor
3 cm
f= 15 cm
f= 20 cm
355 nm laser
1064 nm laser

Experimental setup diagram with Nd:YAG laser beam, luminous plasma, blood serum film, and metal subtarget.
Emission spectrum of blood serum using single pulse LIBS in air

Experimental setup

Pulsed Nd:YAG laser is usually used
Emission spectrum of blood serum using single pulse LIBS in He
Emission spectrum of blood serum using double pulse LIBS-He meta stable atoms
Energy dependence and Emission stability of element intensities in blood serum using single pulse

[S/N ratio vs. Laser energy (mJ)]

[S/N ratio vs. Number of laser shots]

- C I 247.8 nm
- Ca II 393.3 nm
- O I 777.7 nm
- H I 656.3 nm
Emission intensity and LoD of elements in blood serum using single and double pulse LIBS-He

<table>
<thead>
<tr>
<th>Elements</th>
<th>Standard LIBS Intensity (Au)</th>
<th>Standard LIBS LoD (ppm)</th>
<th>double pulse LIBS Intensity (Au)</th>
<th>double pulse LIBS LoD (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca I 422.6 nm</td>
<td>6100</td>
<td>1.25</td>
<td>17400</td>
<td>0.39</td>
</tr>
<tr>
<td>Mg I 285.2 nm</td>
<td>650</td>
<td>3.55</td>
<td>3280</td>
<td>0.69</td>
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<tr>
<td>K I 766.5 nm</td>
<td>920</td>
<td>14.8</td>
<td>4200</td>
<td>3.25</td>
</tr>
<tr>
<td>Na I 588.9 nm</td>
<td>16000</td>
<td>14.66</td>
<td>60000</td>
<td>3.91</td>
</tr>
<tr>
<td>Fe I 371.9 nm</td>
<td>1329</td>
<td>10.53</td>
<td>2000</td>
<td>7.35</td>
</tr>
</tbody>
</table>
Conclusion

- Analysis of elements in human blood serum has been made using double pulse laser-induced breakdown spectroscopy (LIBS) in He gas.
- Identification of C, C-N, H, Na, Ca, Mg, K, Fe, and N from the human blood serum can rapidly be carried out by using the present technique.
- Good emission stability of analyte intensity was obtained using the present technique.
- Enhancement of emission intensity happens of around 4-6 times for the case of double pulse LIBS compared to standard single pulse LIBS.
- The LoD of analyte is much better for double pulse LIBS compared to single pulse LIBS.
- This present technique is very potential to be applied for diagnose of human disease such as tuberculosis.
Thank You