Non-Invasive Estimation of Blood Parameters from Composite Signal From Optode Array Using Near Infrared Spectroscopy Coupled With Independent Component Analysis

by

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***Abstract*— This Paper provides an approach of estimating the concentration of Individual blood components from a composite signal due to multiple parameters as sensed by the optode array.The optode array is used to estimate the blood parameters non invasively using the notion of near infrared spectroscopy. Using an optode array of suitable wavelengths, the composite signal is resolved into components using Independent Component Analysis . Using this approach a mixture of four blood components vi Bilirubin, Albumin, Lipemia and Hemoglobin have been successfully separated into individual estimate.Error in Theoretical estimation as compared to pathological lab results is as low as 2.0683%**

I. VIBRATIONAL SPECTROSCOPY

A. Vibrational Spectroscopy

$$E_{vib} = hc\vartheta(n+\frac{1}{2}) - hc\chi\vartheta(n+\frac{1}{2})^2 + ... \quad (1)$$

$$\vartheta_n = n\vartheta_f + (n+n^2)\vartheta_f\chi \quad (2)$$

where $n = 1, 2, 3...$ and ϑ is the vibrational frequency in wavenumbers cm^{-1} and in [2] ϑ_n is the wavenumber of overtones and ϑ_f is the fundamental frequency in wavenumber .χ is the anharmonicity constant .[8].Based on calculated Anharmonicity values, we can get vibrational energies, fundamental frequency and overtones of all compounds, hence can find suitable NIR sensors of the characteristic waelength of the molecule.

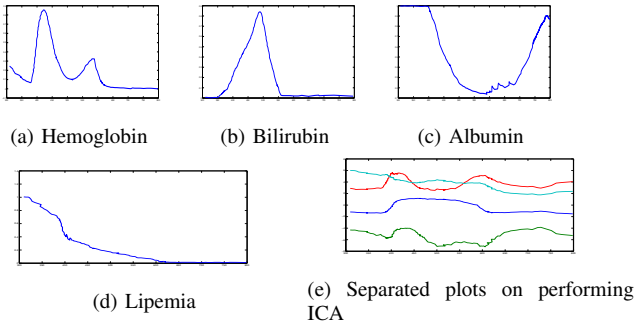
Bond	DE(Kcal/mol)	DE(cm^{-1})	M1	M2	K	χ
CH	80.9	0.231301	12	1	516	0.042
H_2	104.206	0.29793641	1	1	516	0.035
OH	101.76	0.29094303	16	1	512	0.0265
NH_2	107.6	0.3076402	15	1	512	0.0251
HCHO	88.144	0.2520133	29	1	512	0.030
CO	85.5	0.2444539	12	16	512	0.0116

TABLE I: Anharmonicity Constant

II. IDENTIFICATION AND SEPARATION OF COMPOUNDS

A. Results On Applying Independent Component Analysis

From the figure 1(e) we can make out that the light blue plot is continually decreasing hence indicates Lipemia , while the red one clearly has 2 peaks at 400 and 600 nanometers , hence indicate Hemoglobin .The deep blue plot , also has a significant peak at around 500 nanometers hence is Bilirubin , while the green one has high absorbance at 350 nanometers and then has a trough at around 550 nm,therefore is Albumin .



(a) Hemoglobin (b) Bilirubin (c) Albumin

(d) Lipemia (e) Separated plots on performing ICA

Fig. 1: Lipemia,Albumin, Bilirubin and Hemoglobin Plotted in Matlab with 154 points .

III. ANALYSIS AND CONCLUSION

On analysis and comparison , we understand that certain compounds have strong absorptivity at some wavelength while weak absorptivity at some other wavelength .First order derivative of the plot(slope of the plot) and second order derivative (nature of the curve) helps in understanding and differentiating between two compounds having same absorptivity at a particular wavelength of infrared or near infrared sensors.Further work can be done on how to estimate the quantity of each compound in blood .On separating the compounds, we could estimate the quantity of each compound which would be a very good value addition . As of now , we can just identify the compounds , not estimate the quantity of the compounds.This factor is being looked into

REFERENCES

[1] Chemical Principles of Near Infrared Technology by Charles E Miller
[2] Independent Component Analysis: Algorithms and Applications by Aapo Hyvrinen and Erkki Oja