Detection of Albumin and Urea in Kidney Failure Patients by Optical Biosensor

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Abstract
The major function of the kidney is the filtration and secretion of the final products of metabolism and the excess of electrolytes. Permanent failure of the kidney to accomplish its functions is called chronic kidney disease (CKD) and failure to sustain life, is called end stage renal disease [1]. Kidney failure is the stage of CKD at which a patient needs treatment with either dialysis or a kidney transplant to maintain life. Kidney failure occurs when glomerular filtration rate is less than 15 (CKD stage 5) [2]. Albumin is the major protein found in the

1. Introduction

The major function of the kidney is the filtration and secretion of the final products of metabolism and the excess of electrolytes. Permanent failure of the kidney to accomplish its functions is called chronic kidney disease (CKD) and failure to sustain life, is called end stage renal disease [1]. Kidney failure is the stage of CKD at which a patient needs treatment with either dialysis or a kidney transplant to maintain life. Kidney failure occurs when glomerular filtration rate is less than 15 (CKD stage 5) [2]. Albumin is the major protein found in the

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blood. A healthy kidney does not let albumin pass into the urine. A injury kidney lets some albumin pass into the urine. Albumin in the urine is a sign of kidney damage [3]. Urea a waste product found in the blood that comes from the normal breakdown of protein in the body. It is normally removed from the blood by the kidneys and excreted in the urine. Urea builds up in the blood of people with severe kidney disease. High levels are associated with many adverse effects [4].

The field of optical biosensor reflect as multidisciplinary region of research that bonds the basic sciences principles (biology, physics and chemistry,) with essentials of medical application, nano-technology and its application in electronics. The history of biosensors demonstrated that the first ‘true’ biosensor was established by Leland C. Clark in 1956 [5] to detect oxygen and establish the first bubble oxygenator for tradition in cardiac surgery in 1962, he is identified as the ‘biosensors father ‘and the origination of the oxygen electrode bearings his name [6]. Kamil and Abu Baker 2015, designated a new type of biosensor expenses tapered type of single mode fiber with molecules bio recognition type to intelligence directed molecule of proteins. The interface of the evanescent waves with the outside average adjoining the area which is tapered products an interferometry-patterned spectrum, which changes similarly to variations of refractive index (RI) in the exterior medium [7].

1.1. The objectives of this study are:
1- Finding optical method alternative to traditional methods as indication to concentration of biomarkers.
2- Detection the effect of (Albumin and urea) optically by optical fiber sensor.

2. Materials and Methods
The present work include the investigation of samples of biomarkers Albumin and Urea in age ranged from (40-72) years ,females were (62%) and males were (38%). blood samples were admitted to Al- Kadhimiya and Medical City / Baghdad hospital complaining from Kidney Failure diseases.

2.1 Spectral Absorbance Measurement
The absorption spectra were measured using UV-spectrophotometer (SHIMADZU-UV-2401PC), and spectra for all albumin and urea. Albumin has exhibited good absorption at 532 nm. Hence for further study 532 nm Nd: YAG (green) laser was used, but urea has exhibited good absorption at 452 nm Hence for further study 452 nm (blue) laser was used as a source [8].

3. Results and Discussion
3.1 Detection of the intensity of Albumin
The intensity of Albumin of all samples and standard are measured using single mode, multimode biosensors as seen in the table (1).

Table 1- The measurement of intensity of Albumin using biosensors.

| Sequence of Albumin Samples from higher to lower concentration | Intensity au Single mode Biosensor | Intensity au Multimode biosensor |
|---------------------------------------------------------------|-----------------------------------|----------------------------------|
| Reference                                                     | 3227                              | 3592                             |
| Standard                                                      | 2316                              | 2531                             |
| 4.1                                                          | 2421                              | 2683                             |
| 4                                                            | 2431                              | 2737                             |
| 3.7                                                          | 2560                              | 2924                             |
The initial intensity (reference) for single mode biosensor are 3227 au, for multimode are 3592 au. The highest intensity of Albumin in single mode is 3342 au and the lowest intensity are 2421 au. In multimode biosensor the highest intensity is 3520 au and the lowest intensity are 2683 au. The laser biosensors in (1cm) length and 531nm wavelength are used to measure the intensity spectra of Albumin. The intensity spectra of Albumin standard and the highest concentration of all Albumin sample in 2 types of biosensor (SM and MM) fibers are shown in figures (1) and (2), respectively.

**SM Albumin**

![Intensity Spectra SM Albumin](image)

*Figure 1*-The intensity spectra of standard and different concentration (con.) of all samples for albumin in (SM) biosensor.
Figure 2-The intensity spectra of standard and different concentration (con.) of all samples for albumin in (MM) biosensor.

3.2 Testing coincidence of Intensity among Studied Parameters:
Analysis of variance has shown significant differences ** (P<0.01) between Effect of Albumin concentration in mm and sm Intensity. Also, LSD value (173.49 **) shows highly significant differences between mm Intensity and samples concentration, LSD value (216.74 **) shows highly significant differences between sm Intensity and samples concentration and shows highly significant differences between mm and sm Intensity for each sample.

Table 2-Effect of Albumin concentration in mm and sm Intensity

| Albumin concentration | Intensity mm | Intensity sm | LSD value  |
|-----------------------|-------------|--------------|------------|
| 4.1                   | 2737        | 1873         | 128.05 **  |
| 4                     | 2683        | 2019         | 152.36 **  |
| 3.7                   | 2928        | 2308         | 141.88 **  |
| 3.6                   | 3009        | 2392         | 207.34 **  |
| 3.5                   | 3151        | 2525         | 163.27 **  |
| 3.4                   | 3251        | 2667         | 154.93 **  |
| 3.3                   | 3307        | 2760         | 136.71 **  |
A calibration curve between the albumin concentration and mm intensity is shown in figure (3). Figure (3) shows the intensity spectra at different concentration of albumin which leads to different refractive index RI values at (1cm) single mode fiber length. The reduction in intensity is noticed when RI increased.

A calibration curve between the albumin concentration and sm intensity is shown in figure (4).

(Sensitivity = 5193.93 ABS/RIU).  
(Sensitivity = 5447.06 ABS/RIU).

3.3 Detection the intensity of Urea

The intensity of Urea of all samples and standard are measured using single mode, multimode biosensors as seen in table (3).

| Sequence of Urea Samples from higher to lower concentration | Intensity au multi mode biosensor | Intensity au single mode biosensor |
|-------------------------------------------------------------|----------------------------------|----------------------------------|
| Reference                                                   | 2753                             | 3354                             |
| Standard                                                    | 1983                             | 2775                             |
| 277                                                         | 1114                             | 1384                             |

** (P<0.01).
The initial intensity (reference) for single mode biosensor is 3354 au, for multimode are 2753 au. The highest intensity of Urea in single mode are 2534 au and the lowest intensity are 1384 au. In multimode biosensor the highest intensity are 1945 au and the lowest intensity is 1114 au. The laser biosensors in (1cm) length and 532nm wavelength are used to measure the intensity spectra of Urea. The intensity spectra of Urea standard and the highest and lowest concentration of all Urea sample in 2 types of biosensor (SM and MM) fibers are shown in figures (5) and (6), respectively.

| 226 | 1176 | 1520 |
| 206 | 1200 | 1586 |
| 195 | 1280 | 1642 |
| 192 | 1318 | 1649 |
| 168 | 1411 | 1737 |
| 107 | 1476 | 1861 |
| 106 | 1490 | 1891 |
| 94  | 1580 | 2034 |
| 86  | 1602 | 2068 |
| 83  | 1602 | 2119 |
| 80  | 1736 | 2194 |
| 77  | 1749 | 2321 |
| 65  | 1804 | 2375 |
| 54  | 1870 | 2475 |
| 52  | 1934 | 2492 |
| 51  | 1865 | 2501 |
| 36  | 1945 | 2534 |
Figure 5- The intensity spectra at different concentration (con.) of urea of all samples at (1cm) single mode length.

Figure 6- The intensity spectra at different number of urea concentration (con.) in all samples at (1cm) multi-mode fiber length.

Highly significant effects ** (P<0.01) of sampling Urea concentration in mm and sm Intensity were found in analysis of variance of these values. However, LSD test gave a value indicating that most of these values were differed significantly from each other.
### Table 4 - Effect of Urea concentration in mm and sm Intensity

| Urea concentration | Intensity mm | Intensity sm | LSD value |
|--------------------|--------------|--------------|-----------|
| 277                | 1114         | 1384         | 85.32 **  |
| 226                | 1176         | 1520         | 96.04 **  |
| 206                | 1200         | 1586         | 87.14 **  |
| 195                | 1280         | 1642         | 103.46 ** |
| 192                | 1318         | 1649         | 81.93 **  |
| 168                | 1411         | 1737         | 79.74 **  |
| 107                | 1476         | 1861         | 112.36 ** |
| 106                | 1490         | 1891         | 98.07 **  |
| 94                 | 1580         | 2034         | 109.35 ** |
| 86                 | 1602         | 2068         | 114.29 ** |
| 83                 | 1602         | 2119         | 120.86 ** |
| 80                 | 1736         | 2194         | 91.35 **  |
| 77                 | 1749         | 2321         | 95.03 **  |
| 65                 | 1804         | 2375         | 86.27 **  |
| 54                 | 1870         | 2475         | 116.42 ** |
| 52                 | 1934         | 2492         | 85.62 **  |
| 51                 | 1865         | 2501         | 91.44 **  |
| 36                 | 1945         | 2534         | 88.74 **  |
| LSD value          | 95.68 **     | 128.53 **    | ---       |

** (P<0.01).

A calibration curve between the urea concentration and mm intensity is shown in figure (7). A calibration curve between the urea concentration and sm intensity is shown in figure (8).
(Sensitivity = 1998.44 ABS/RIU). (Sensitivity = 2623.14 ABS/RIU).

Analysis of variance of these results reveals highly significant ** (P<0.01) impacts of both Correlation coefficient between mm and sm on Albumin and Urea. Furthermore, Correlation coefficient -r shows clear and significant differences between these data.

Table 5 - Correlation coefficient between multi mode and single mode

| Parameters | Intensity | Correlation coefficient -r | P-value |
|------------|-----------|-----------------------------|---------|
| Albumin    | Mm and Sm | 0.98 **                     | 0.0001  |
| Urea       | Mm and Sm | 0.99 **                     | 0.0001  |

** (P<0.01).

The current study in table (6) was designed to SM more Sensitivity than MM for all Biomarkers was recorded for Albumin 5447.06, 5193.93 in sm and mm respectively and Urea sample 2623.14, 1998.44 in sm and mm respectively.

Table 6 - Compare coefficient between Sensitivity of multi mode and single mode, sm more Sensitivity than mm for Albumin and Urea

| Biomarkers | Sensitivity (ABS/RIU) of SM | Sensitivity (ABS/RIU) of MM |
|------------|-----------------------------|-----------------------------|
| Albumin    | 5447.06                     | 5193.93                     |
| Urea       | 2623.14                     | 1998.44                     |

Typical biosensor is sensitive device that converts the biological change into a noticeable sign, later is then converted into a numerical signal consequence. The absorbance can be observed by directing a beam of radiation at the sample and noticing the intensity of emission that originates across it [9].

The obtaining results demonstrated that the absorption of laser light by highly concentrated samples are higher and inversely proportional to the intensity of light, means the intensity of light is high when the concentration of samples are low. This phenomenon could be explained as, the higher absorption of light by samples (Biomarkers) due to the selection of suitable laser which depends on the absorption of the samples to the wavelength of the laser. The
refractive index regulates how much the route of light is resolved, or refracted, when arriving a material [10].

From the findings of the present study, The constructed biosensor are fastest response, stable, more accurate, fair sensitivity and inexpensive when used in the measurement of the concentration of biomarkers, single mode (SM) optical fiber sensor to sense the biomarkers and a high sensitivity to the concentration of the biomarkers has been observed, because the mode patterns passing through that fiber are compatible with the energy transmission levels of the biomarkers, also single mode which have limitation number of modes due to their basic, while SM fiber selected for any wavelength benefit, SM few losses than MM.

The present study highlights the following conclusions, which includes: the Albumin sensing in wavelength 531.16 nm MM and sensing in wavelength 531.62 nm in SM setup. The Urea sensing in wavelength 453.88 nm MM and sensing in wavelength 452.04 nm in SM setup.

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