ISSN: 0067-2904

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

Marwa .S. Alani*, Ithar Kamil Al-Mayaly
Department of Biology, Collage of Science, University of Baghdad, Baghdad, Iraq

Received: 6/12/2020 Accepted: 28/2/2021

Abstract

The major function of the kidney is the filtration and secretion of the final products of metabolism and the excess of electrolytes. The term kidney failure denotes inability of the kidneys to perform excretory function leading to retention of nitrogenous waste products from the blood. Biosensor are most accurate, with a rapid diagnosis ,more costly method than the traditional method to avoid any biological changes in blood sample that lead to changes optical characteristic (refractive index and absorption) of blood sample. The current study was designed to single mode more Sensitivity than multi mode for Biomarkers were recorded for Albumin 5447.06, 5193.93 and Urea sample 2623.14, 1998.44 in sm and mm respectively .

Keywords: kidney failure, Biomarkers, Biosensor.

الكشف عن الألبومين واليوريا في مرضى الفشل الكلوي بوساطة جهاز الاستشعار البيولوجي البصري

مروة صباح العاني*, ايثار كامل الميالي
قسم علوم الحياة ، كلية العلوم ، جامعة بغداد ، بغداد ، العراق

الخلاصة

تتمثل الوظيفة الرئيسية للكلى في ترشيح وإفراز المنتجات النهائية لعملية التمثيل الغذائي وزيادة الإلكتروليتات. يشير مصطلح الفشل الكلوي إلى عدم قدرة الكلى على أداء وظيفة الإخراج مما يؤدي إلى الاحتفاظ بالنواتج النيتروجينية من الدم. المستشعر الحيوي هو الأكثر دقة ، مع تشخيص سريع ، وطريقة اقل تكلفة من الطريقة التقليدية لتجنب أي تغيرات بيولوجية في عينة الدم التي تؤدي إلى تغيرات بصرية طفيفة (معامل الانكسار والامتصاص) لعينة الدم. صممت الدراسة الحالية لفايبراحادي النمط أكثر حساسية من فايبر ثنائي النمط لجميع المؤشرات الحيوية حيث تم تسجيلها للألبومين 5447.06 ، 5193.93 وعينة اليوريا 2623.14 ، 1998.44 للفايبر احادي النمط وثنائي النمط على التوالي.

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

Email:ms_90_mbio@yahoo.com

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 in1962, 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 includes 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**

3.6	**2648**	**3011**
3.5	**2728**	**3160**
3.4	**2927**	**3247**
3.3	**2985**	**3308**
3.2	**3055**	**3395**
2.9	**3154**	**3420**
2.6	**3342**	**3520**

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.

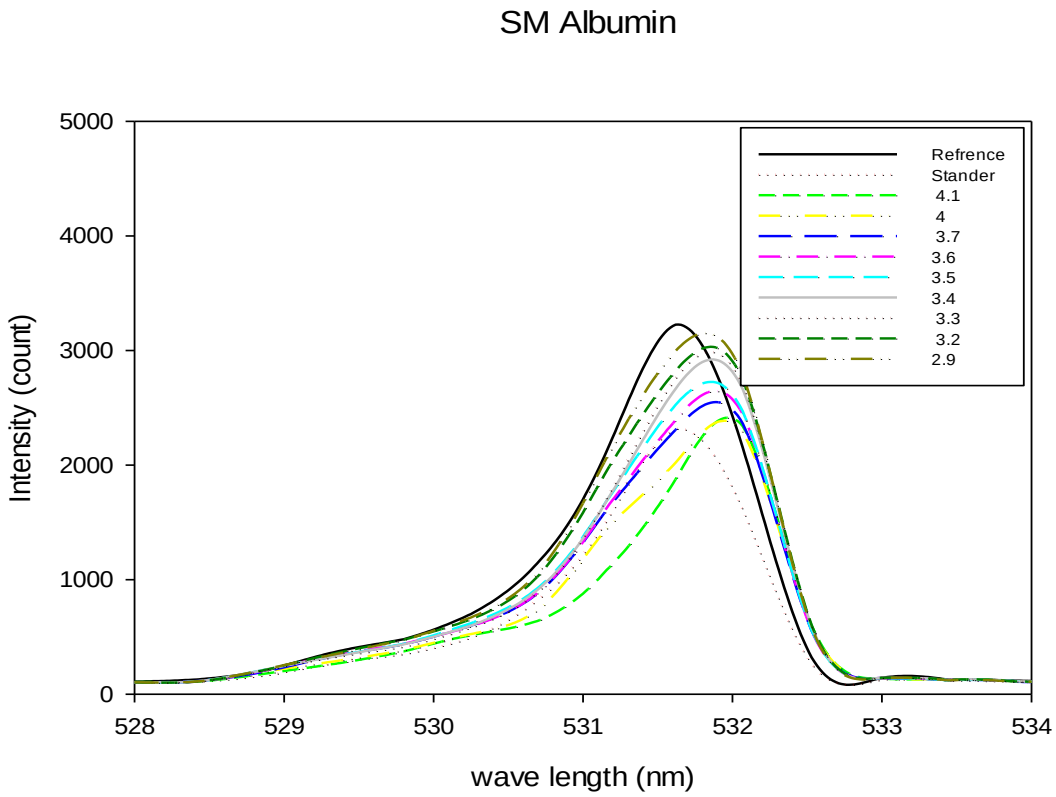

Figure 1-The intensity spectra of standard and different concentration (con.) of all samples for albumin in (SM) biosensor.

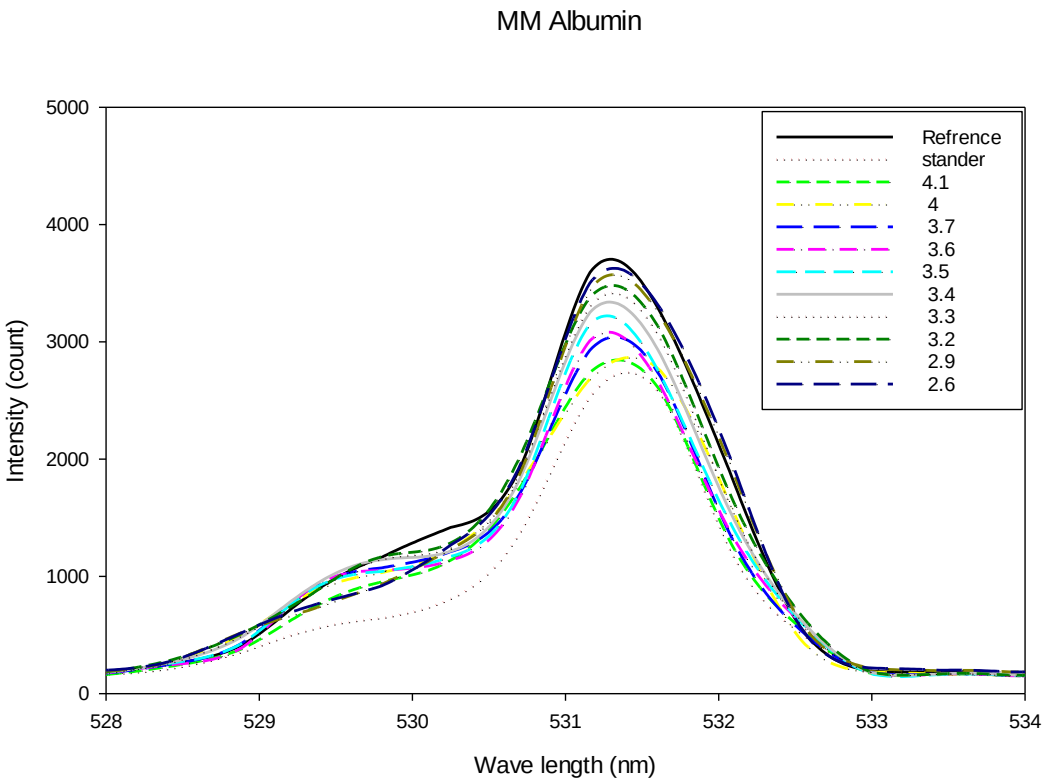

Figure 2-The intensity spectra of standard and different concentration (con.) of all samples for albumin in (MM) biosensor.

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 **

3.2	3378	2821	127.37 **
2.9	3446	2996	122.64 **
2.6	3501	3087	138.57 **
LSD value	173.49 **	216.74 **	---
** (P<0.01).			

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).

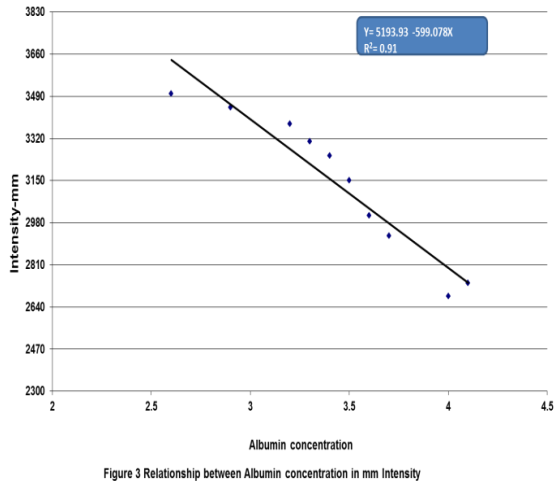

Figure 3 Relationship between Albumin concentration in mm Intensity

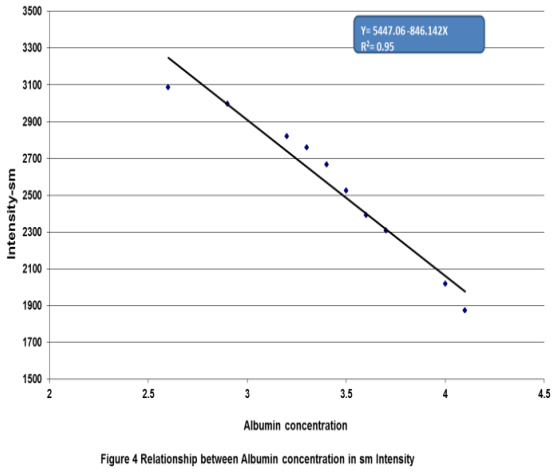

Figure 4 Relationship between Albumin concentration in sm Intensity

(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).

Table 3-The measurement of intensity of Urea by using biosensors

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

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

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.

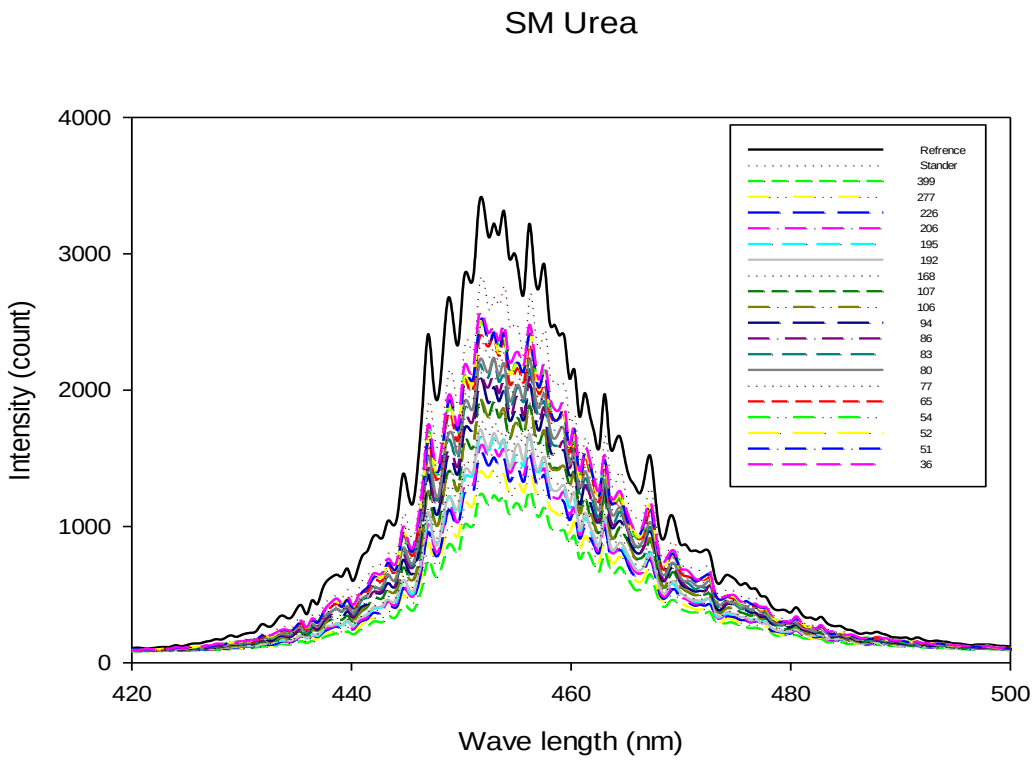

Figure 5-The intensity spectra at different concentration (con.) of urea of all samples at (1cm) single mode length.

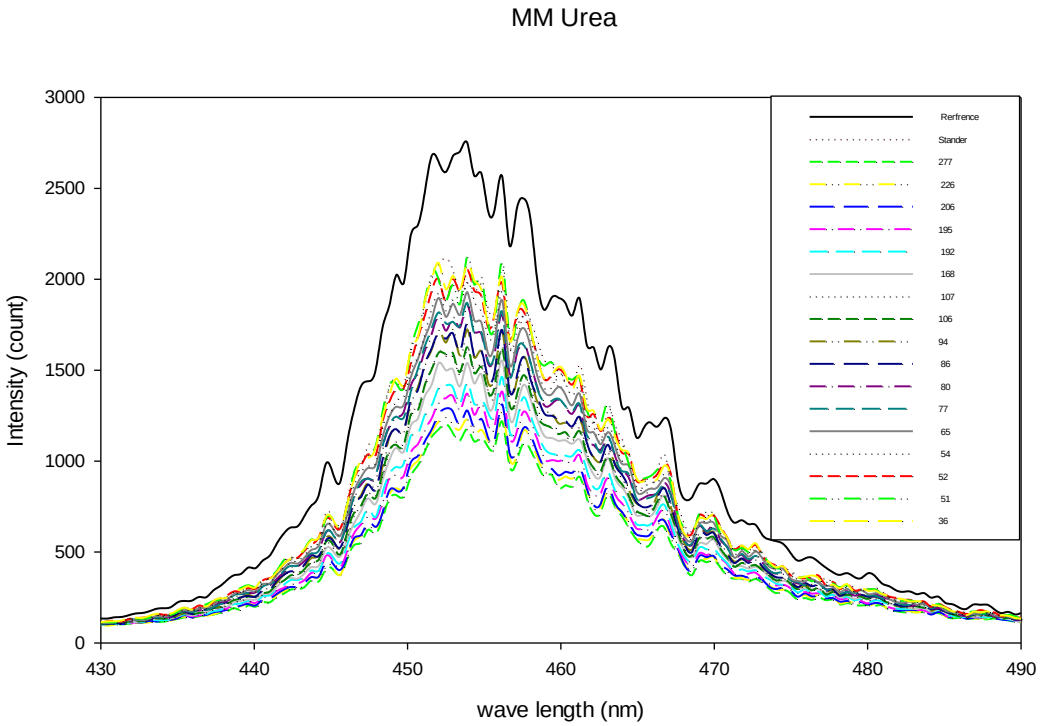

Figure 6-The intensity spectra at different number of urea concentration (con.) in all samples at (1cm) multi-mode fiber length.

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).

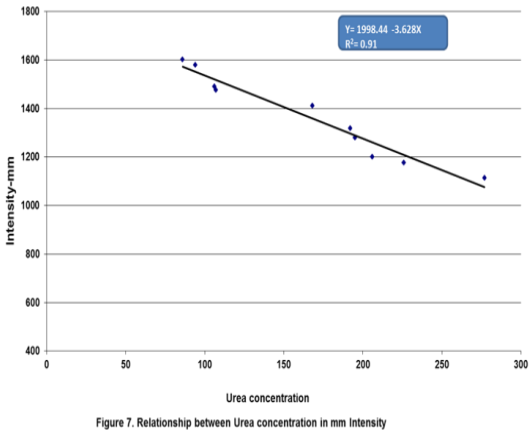

Figure 7. Relationship between Urea concentration in mm Intensity

(Sensitivity = 1998.44 ABS/RIU).

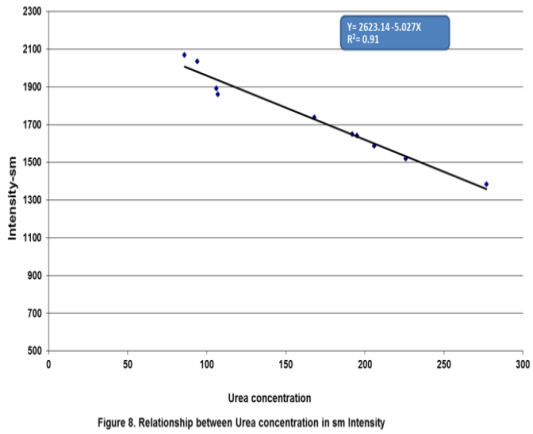

Figure 8. Relationship between Urea concentration in sm Intensity

(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.

4. Referance

[1] N. Thomas, "Renal Nursing. University Studio Press, Thessaloniki," 2003. Available: https://www.hsj.gr/medicine/causes-and-complications-of-chronic-kidney-disease-in-patients-on-dialysis.php?aid=2656#1.

[2] I. Vlahogiannis, "Clinical nephrology and hypertension," Ed., Paschalidis, Athens, 2009. Available: https://www.hsj.gr/medicine/causes-and-complications-of-chronic-kidney-disease-in-patients-on-dialysis.php?aid=2656.

[3] D. J. Rowe, H. Bagga and P.B. Betts, "Normal variations in rate of albumin excretion and albumin to creatinine ratios in overnight and daytime urine collections in non-diabetic children," Br Med J (Clin Res Ed) 291, pp. 693–694, 2009.

[4] L. A. Stevens, J. Coresh, T. Greene and A.S. Levey, "Assessing kidney function: Measured and estimated glomerular filtration rate," New Eng J Med. 354, pp.2473-2483, 2006.

[5] J. W. Severinghaus and P.B. Astrup, "History of blood gas analysis. IV. Leland Clark's oxygen electrode," Journal of Clinical Monitoring, vol. 2, no. 2, p. 125, 1986.

[6] B. Nikhil, P. Jolly, N. Formisano and P. Estrela, "Introduction to biosensors Essays in Biochemistry," vol. 60, no.1, pp.1-8 , June, 2016.

[7] Y. M. Kamil and M. H. Abu Bakar, "Sensitive and Specific Protein Sensing Using Single-Mode Tapered Fiber Immobilized With Biorecognition Molecules IEEE Photonics Journal," vol. 7, no. 6, pp.1-1, December, 2015.

[8] A. N. Dhinaa and P.K. Palanisamy, " Z-Scan technique: To measure the total protein and albumin in blood," J. Biomedical Science and Engineering, vol. 3, pp. 285-290, 2010.

[9] C. R. Lowe, "Biosensors. Trends in Biotechnology," vol. 2, no.3, pp.59–65, 1984.

[10] D. Bergstrom, A. Kaplan and J. Powell, "Laser Absorption Measurements in Opaque Solids," Presented at the 10th Nordic Laser Materials Processing (NOLAMP) Conference, Piteå, Sweden, August, p. 17-19, ed: A. Kaplan, published by Luleå TU, Sweden, 2005.