Fiber Optic Adaptive Probe as a Cuvette Substitution for UV-Vis Spectrophotometer (Genesis 10S)

Fredy Kurniawan[1] and Edi Suharmanto[1]

***Abstract*—Fiber optic adaptive probe UV-Vis for Genesis 10S has been fabricated to substitute cuvette for real time analysis. Most of standard spectrophotometers UV-Vis (the common type) use cuvette to place sample which is being analyzed. The light pass through the sample in the cuvette to detector then the intensity of the absorption of the solution is measured. Most of the cuvette system requires to transferring sample solution to cuvette from its original vessel, so the real time analysis cannot be conducted. The probe with special design using fiber optic cable FT-Au tonics 420-10 has been made to substitute the cuvette system. The light from the source moved inside fiber optic cable, which has been cut in the middle of the cable (the sample can passes through at this gap), to the detector. The end (entrance and exit) of the fiber optic was designed so that it fit to the compartment of the Genesis 10S spectrophotometer without any modification from the standard instrument condition. The spectrum results from the probe in varies gap, in the range 0.2 – 1 cm, was observed. The gap in the middle of the fiber optic was equal to the length of the pathway in the cuvette system. Rhoda mine B was used as the sample with variation concentration 4.175 × 10^{-5} M, 3.34 × 10^{-5} M, 2.5 × 10^{-5} M, and 1.67 × 10^{-5} M. The spectrum result of adaptive fiber optic probe was compared to the spectrum of standard cuvette system. The optimum result was provided using 0.2 cm gap. The maximum wavelength absorbance of adaptive fiber optic probe was at 533 nm which similar to the cuvette system.**

Keywords—**spectrophotometer probe, real time analysis, fiber optic, Rhoda mine B, in-situ**

Abstrak*—*Telah dibuat probe fiber optik adaptif untuk spektrofotometer Genesys 10S menggantikan kuvet, digunakan pada analisis real time. Hampir semua spektrofotometer UV-Vis standar (jenis yang umum) memanfaatkan kuvet untuk meletakkan sampel yang akan dianalisis. Berkas sinar menembus sampel yang berada di dalam kuvet menuju detektor. Intensitas yang dihasilkan diamati. Pada sistem kuvet, larutan sampel perlu dipindahkan dari wadah asli ke kuvet sehingga analisis "real time" tidak mungkin untuk dilakukan . Probe dengan desain khusus, memanfaatkan kabel fiber optik FT-Autonics 420-10 dibuat untuk menggantikan sistem kuvet. Berkas cahaya dari sumber bergerak melalui kabel fiber optik, yang telah dipotong dibagian tengah (larutan uji dapat melewati celah potongan kabel ini) ke detektor. Ujung (masuk dan keluar) dari fiber optik di desain sedemikian rupa sehingga sesuai dengan kompartemen dari spektrofotometer Genesys 10S tanpa adanya modifikasi apapun. Hasil spektrum probe ini pada berbagai variasi celah (antara 0,2 – 1 cm) diamati. Celah ditengah kabel fiber optik sama dengan panjang lintasan di dalam sistem kuvet. Rhomine B digunakan sebagai larutan uji dengan variasi konsentrasi 4,175 × 10-5 M; 3,34 × 10-5 M; 2,5 × 10-5 M; dan 1,67 × 10-5 M. Hasil spektrum probe fiber optik adaptif dibandingkan dengan spektrum yang diperoleh dari sistem kuvet. Celah optimum yang diperoleh adalah 0,2 cm. Absorbansi maksimum dari probe fiber optik adaptif terjadi pada panjang gelombang 533 nm, sama dengan yang diperoleh pada sistem kuvet.

Keywords—***probe spektrofotometer,analysis real time, fiber optik, rhodamine B, in-situ***

I. INTRODUCTION

Spectrophotometry is a technique of chemical analysis which based on interaction of electromagnetic radiation with a matter. Most of the instruments used for analysis in spectrophotometry technique are called spectrophotometer. One the most common spectrophotometer which can be found in every laboratory is UV-Vis Spectrophotometer that can be used to analyse a compound quantitatively and qualitatively [1]. The absorption or reflectance in the visible range affects directly the perceived colour of the chemicals observed. In this region, molecule undergoes electronic transitions when it absorbs the electromagnetic spectrum. In general the samples which will be measured is placed in the cuvette (Figure. 1) if the sample in the liquid form. The cuvette can be made from quartz, glass, or plastic depend on the need of the measurement which will be performed. For example, it will require quarts cuvette if the measurement is performed in ultra violet wavelength because normal glass or plastic will absorb electromagnetic radiation at ultra violet wavelength [2-3].

Briefly, the light from the source in UV-Vis spectrophotometer passes through the samples which are placed in the cuvette. This method is called by in-vitro which an original sample must be taken from its original place, transfer it in the cuvette then measured it in UV-Vis spectrophotometer [4-5]. In some cases the in-vitro analysis cannot be performed for some reason, so that we should analysed sample directly on the original place. For example if we want to observe changing of the reaction process during synthesis gold nanoparticles in Turkevic method [6-7]. Beside the reaction temperature is quite high, i.e. 100^{o}C, the reaction rate is also relatively fast to be observed, so that is almost impossible to using cuvette or even if we use special flow cuvette to observe the experiment. The most probable to observe this kind of the experiment, we should use a tool which can measure directly in the solution during the reaction process [8].

Special UV-Vis spectrophotometer using fiber optic probes was already exist on the market, but sold in one package with the spectrophotometer itself. The probe is probably using mirror for reflect the light from the light

[1]Fredy Kurniawan and Edi Suharmanto are with Department of Chemistry, Sepuluh Nopember Institute of Technology, Surabaya, Indonesia. E-mail: fredy@chem.its.ac.id, edi09@mhs.chem.its.ac.id.

source to the detector [9]. Until this time no company sell the fiber optic probe separately that match with the existing spectrophotometers which are not equipped with the fiber optic probe such as Genesis 10s from Thermo Scientific. So many agencies which have spectrophotometer need to analyze using in-situ method or real time analysis. To overcome this problem, we can make simple modification on existing spectrophotometer to meet this demand which does not require a huge cost compared to buy a new one. In this paper, we would like to present handmade fiber optic probe that can be used universally for all spectrophotometer to fulfill this demand without using mirror reflector.

II. METHOD

A. Materials and Equipment

Genesis 10s UV-Vis spectrophotometer was used for modification in the experiment. The UV-Vis spectrophotometer was equipped with normal cuvette holder which has dimension 1 x 1 x 4 cm. Fiber optic kit tools from Ripley Miller was used during all preparation of the fiber optic cable. The body of the probe was prepared by other workshop in Institut Teknologi Sepuluh Nopember (ITS). Fiber optic cable FT-420- 10 was purchased from Autonics. Acrylic sheet was bought from the market. Rhodamine B was obtained from Merck. Aquadest was used for cleaning and dilution.

B. Experimental

This research was conducted in four steps, namely the preparation of materials, the preparation of adaptive fiber optic probe, and performance test of fiber optic adaptive probe UV-Vis spectrophotometer for in situ analysis using rhodamine B solution.

1. Preparation of adaptive fiber optic probe.

All materials were cleaned before used. The fiber optic adaptive probe UV-Vis Spectrophotometer consist two important parts, i.e.

a. Main body of fiber optic adaptive probe UV-Vis spectrophotometer

Main body of fiber optic adaptive probe UV-Vis spectrophotometer is important part which will be immersed to sample solution. This part consists of two fiber optic cables which were set up in straight line. There is a gap between two cables which the sample solution can pass through. The gap length in can be adjusted using screws at left and right of the body. This gap has function like a cuvette in normal UV-Vis spectrophotometer technique. The design of the main body of fiber optic adaptive probe UV-Vis spectrophotometer is shown in Figure 1.

b. Connector of fiber optic adaptive probe UV-Vis Spectrophotometer

Connector of fiber optic adaptive probe UV-Vis Spectrophotometer has function to link between UV-Spectrophotometer and the main body of the adaptive probe. The light from spectrophotometer lamp should go right on one of the fiber optic cable in the main body of adaptive probe. Then the light will continue moving to the second fiber optic cable after passing through the sample solution at the gap. At the end of the second fiber optic cable, the light also must be directed right on the detector to get the signals. The connector of fiber optic adaptive probe UV-Vis Spectrophotometer was made from acrylic. The design of the connector of fiber optic adaptive probe UV-Vis is shown in Figure 2.

2. Preparation of materials.

Primary solution of rhodamine B (Mr = 479,02; pa = 99%) was prepared by weight 0.02 grams of solid rhodamine B, transfer to volumetric flask and dissolve with aquadest until the line mark to obtains rhodamine B solution with concentration of 1.67 x 10^{-4} M. Other variations concentration of rhodamine B solution, i.e. 4.175 × 10^{-5} M, 3.34 × 10^{-5} M, 2.5 × 10^{-5} M, and 1.67 × 10^{-5} M. was prepared by dilution of primary solution. All this solution will be used in step 3 (performance test of fiber optic adaptive probe UV-Vis Spectrophotometer).

3. Performance test of the adaptive fiber optic probe

Performance of the adaptive fiber optic probe was performed by comparing the measurement of the rhodamine B solution using cuvette and adaptive fiber optic probe with spectrophotometer Genesis 10s.

a. Rhodamine B analysis using cuvette.

All variation concentration rhodamine B, i.e. 4.175 × 10^{-5} M, 3.34 × 10^{-5} M, 2.5 × 10^{-5} M, and 1.67 × 10^{-5} M, was measured using UV-Vis Spectrophotometer with standard cuvette system. The absorbance and the maximum wave length absorbance were obtained from the spectrum from this experiment was compared to the spectrum which was obtained from adaptive fiber optic probe measurement system.

b. Rhodamine B analysis using adaptive fiber optic probe.

All analysis in this part was performed equal to analysis using cuvette. The only difference, the cuvette which was used in section 3a, replaced by adaptive fiber optic probe that was prepared in the preparation of adaptive fiber optic probe steps. As a consequence of using adaptive fiber optic probe, all measurement was conducted in situ (no more transfer sample solution to other place).

c. Influence of the gap width on the measurement.

As described above, the absorption of the electromagnetic radiation process will be held in the gap when the light passing through the sample solution. So the gap width will play important role in signal produced. The adaptive fiber optic probe, which was made in experimental section 2, has been adapted to this experiment. The gap width can be adjusted easily by rotate the screw next to the body of main body of fiber optic adaptive probe (Figure 1). The measurement have been done for several variation gap width (i.e. 0.2 cm, 0.4 cm, 0.6 cm, 0.8 cm, and 1 cm) for all concentration of rhodamine B which also have been measured using cuvette system.

III. RESULT AND DISCUSSION

A. Main body fiber optic probe

In this experimental we used material which can be found easily in the market. Autonics FT-420-10 has been selected for the fiber optic cable because both ends will equipped with the special connector so that it can be easily adjusted. The body was made from stainless steel because it is cheap and easy to set up, but in the future it can be replaced by other materials which lighter and resistant to chemicals. All material was set up like Figure

1. The gap between cables can be adjusted to find the optimum condition of the measurement.

B. Connector of fiber optic adaptive probe UV-Vis Spectrophotometer

Connector of fiber optic adaptive probe UV-Vis Spectrophotometer has been made in such away the light from lamp of the UV-Vis spectrophotometer go exactly into fiber optic cable, and also the light out from fiber optic cable came to the detector of UV-Vis spectrophotometer. In this experiment acrylic sheet was selected because it is cheap, easy to find in the market and easy to be shaped.

C. Performance test adaptive fiber optic probe

a. Rhodamine B analysis using cuvette

Measurement rhodamine B using cuvette was shown in Figure. 3. All measurement was repeated 5 times for each concentration (i.e.4.175 × 10^{-5} M, 3.34 × 10^{-5} M, 2.5 × 10^{-5} M, and 1.67 × 10^{-5} M). As the expected result, more concentrated solution will have higher absorbance. The all maximum wavelength for all concentration measured remain at 551 nm which can be found in other publication [8]. Then this result will be compared with the measurement using adaptive fiber optic probe.

b. Rhodamine B analysis using adaptive fiber optic probe and the influence of the gap width on the measurement

All rhodamine B with variation concentration which was measured using cuvette also measured using adaptive fiber optic probe for 0.2 cm, 0.4 cm, 0.6 cm, 0.8 cm, and 1.0 cm gap width respectively. The result for every gap was discussed below:

i. 0.2 cm gap width

The result spectrums were shown in the Figure 4. The spectrum had only one maximum peak. The maximum wavelength absorbance was at 550 nm which it was almost similar with the measurement using cuvette. The absorbance of the measurement was 3 times lower than measurement using cuvette. The thickness of the cuvette was 5 times wider than the gap width of the adaptive fiber optic probe, so that the performance of the adaptive fiber optic probe is better than cuvette.

ii. 0.4 cm gap width

The result spectrums were shown in the Figure 5. The spectrum also has only one maximum peak. The maximum wavelength remains at 550 nm which it was similar with the measurement using 0.2 gap width before. The absorbance of the measurement was almost the similar with the 0.2 gap width. This is not as the expected result that longer gap (longer pathway of the light) will give higher absorbance. In this case, probably more width will give more light lost (more light does not enter the second fiber optic cable)

iii. 0.6 cm gap width

The result spectrums were shown in the Figure 6. The spectrum began to appear two maximum peaks. The maximum wavelength which appears in 0.4 gap widths also remains not constant; it spread between 445 - 550 nm for different concentration of rhodamine B solution. The second peak appears between 625 – 650 nm. The absorbance of the measurement was also lower comparing to 0.2 and 0.4 gap width. From this spectrums, we are more convinced that more width will give more light lost.

iv. 0.8 cm gap width

The result spectrums for 0.8 cm gap width were shown in the Figure 7. The spectrum also remains appear two peaks. The maximum wavelength which appeared in 0.6 gaps also appeared in this experiment. The maximum wavelength that was between 445 - 550 nm become lower and the maximum wavelength that was between 625 – 650 nm become higher. The increasing absorbance at 625 – 650 nm is almost probably because of the reflectance of the light with longer wavelength when the light is entering the second fiber optic cable.

v. 1.0 cm gap width

The result spectrums were shown in the Figure 8. The spectrum becomes worse because so many peaks appear and the absorbance at 550 was getting lower than other gap width.

Significant tests, t-student and F test, are applied to data in 0.2 cm gap width. The result is no significant different the measurement using cuvette and adaptive fiber optic probe using 95% confidence level.

III. CONCLUSION

In this study, it has been shown that adaptive fiber optic probe can be made and replaced the cuvette to conduct real time analysis using UV-Vis spectrophotometer Genesis 10s. The most optimum gap width for the measurement was 0.2 cm which gave maximum absorbance value. Gap width more than 0.4 cm will give more peaks because of the reflectance of the light when entering the second fiber optic cable. The maximum wavelength value for rhodamine B at the optimum gap width using adaptive fiber optic probe was 550 nm, so that it was similar with the value which was got from the measurement using cuvette. Using significant tests (t-student and F test) was obtained that no significant different for the measurement using cuvette and adaptive fiber optic probe at 95% confidence level.

REFERENCES

[1] M.H. Mulja, and Suharman, *Analisis Instrumental,* Airlangga University Press, Surabaya, 1995.

[2] A. Didit, *Pembuatan Probe Sensor* Serat *Optik Untuk Mengukur Derajat Keasaman (pH) Menggunakan Violet Sebagai Dye Indikator*. Jurusan Fisika Institut Pertanian Bogor, Bogor, 2006.

[3] T.Y. Hidayat, *Penggunaan Serat Optik Pada Spektrofotometer UV-Vis untuk Penentuan Cuplikan Secara In-Situ.*Jurusan Fisika-FMIPA, Institut Teknologi Sepuluh Nopember, Kampus ITS Sukolilo, Surabaya, 2013.

[4] C.W. Brown, dan J. Lin, *Interfacing a serat-optik probe to adiode array UV-visible spectrophotometer for drug dissolution tests*, Appl. Spectroscopy. Wenheim, Jerman, 1993, 615-618.

[5] Y. H. Pramono, dan AY. Rohedi, *Aplikasi Directional Coupler* Serat *Optik sebagai Sensor Pergeseran,* Jurusan Fisika-FMIPA, Institut Teknologi Sepuluh Nopember, Kampus ITS Sukolilo, Surabaya, 2008.

[6] M.J. Snare, F. E. Treloar, K. P. Ghiggino, and P. J. Thistlethwaite, *The Photophysics of Rhodamine B.* Physical Chemistry Department, Melbourne University, Australia, 1981.

[7] P. Wilhelm, dan D. Stephan, Photodegradation of rhodamine B in aqueous solution via $SiO_2{\cdot}TiO_2$nano-spheres. Technische Universitat Munchen, Garching, Germany, 2007.

[8] S. Bakkialakshmi, P. Selvarani, S. Chenthamarai, *Fluorescence quenching of Rhodamine B base by two amines,* Department of Physics, Annamalai University, Annamalainagar 608 002, Tamil Nadu, India, 2013.

[9] J. Alarcon, *Fiber Optic Devince For Sensing Analysis and Metode Of Making Same,* GooglePatent US 7787923 B2, 2010.

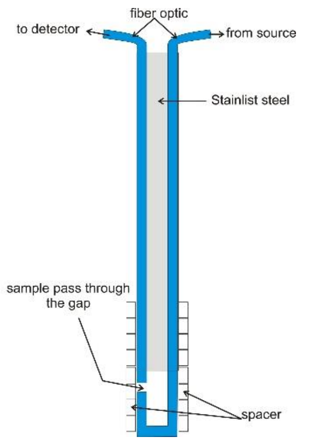

Figure 1. Fiber optic probe desing

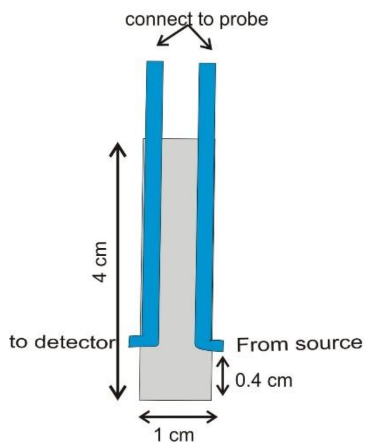

Figure 2. Holder design of fiber optic probe

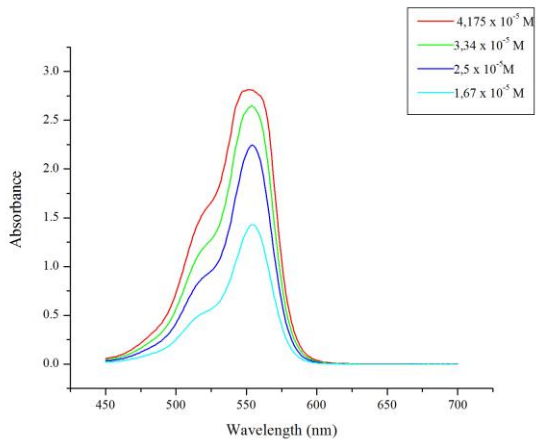

Figure 3. Spectra UV-Vis Rhodamine B with various variation of concentration with cuvette

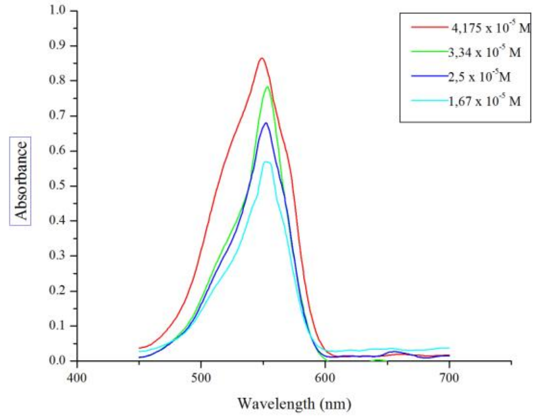

Figure 4. UV-Vis rhodamine B spectrum at various concentrations with 0.2 cm gap

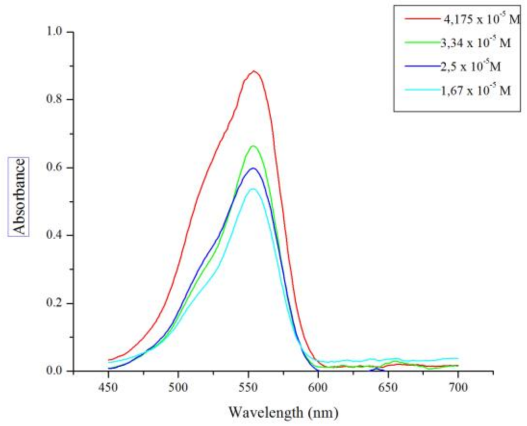

Figure 5. UV-Vis rhodamine B spectrum at various concentrations with 0.4 cm gap

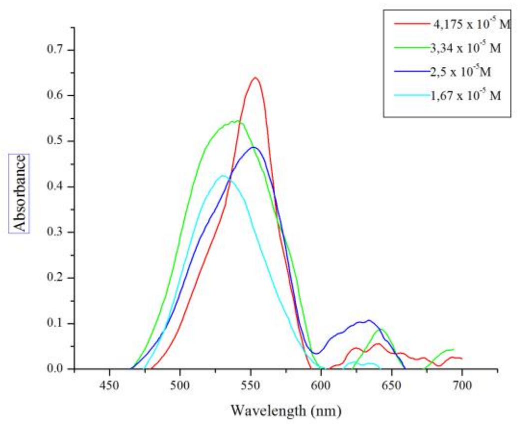

Figure 6. UV-Vis rhodamine B spectrum at various concentrations with 0.6 cm gap

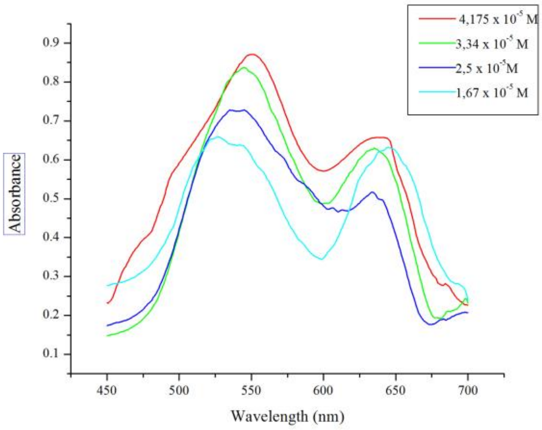

Figure 7. UV-Vis rhodamine B spectrum at various concentrations with 0.8 cm kap

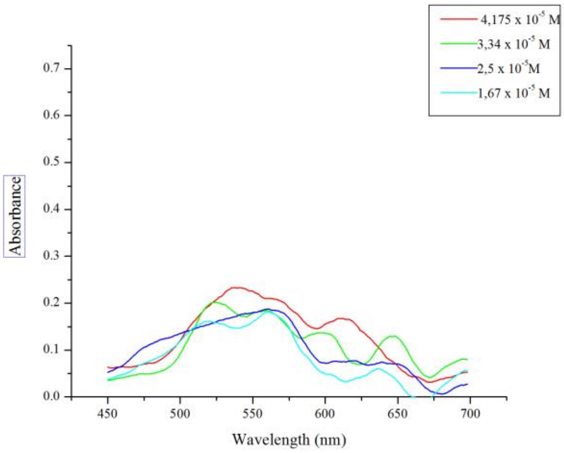

Figure 8. UV-Vis rhodamine B spectrum at various concentrations with 1.0 cm gap