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Sensors and Mini Photocatalytic Reactor as a Tool for Measure CO_2 Gas from the Degradation of the Detergent Active Compound

Yeyen Maryani[1*], Yayat Ruhiat[2], Yuvita Oktarisa[2]

(1) University of Sultan Ageng Tirtayasa, Dept. of Chemical Engineering, Engineering Faculty, Jakarta Street km. 4, Serang – Banten, Indonesia
(2) University of Sultan Ageng Tirtayasa, Dept. of Physic Education, Teachers' Training and Education Faculty, Jakarta street km. 4, Serang – Banten, Indonesia

*Corresponding Author Email: yeyen.maryani@untirta.ac.id

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ABSTRACT

This study aims to test the performance and feasibility of new tools and methods for analysis of detergent based on the photocatalytic degradation of LAS (Linear Alkylbenzene Sulfonate) and ABS (Branched Alkylbenzene Sulfonate) , which is a detergent active compound. Testing is done by measuring the CO_2 gas formed from the degradation at every one-hour for five hours of reaction. The results of the determination of analytical parameters are as follows, sensitivity: 0.394 to 0.460, the limit of detection: 0.16 mg/L, accuracy: 0.94% to 12.88% and punctilio: 0.12% to 0.14%, the range of linearity: 0.4 mg/L to 2 mg/L. Results of calibration using standard solutions obtained regression equation y = 1.033 x - 77.713 with R^2 = 0.988, indicating that the instrument has been calibrated and fit for use for the analysis of LAS and ABS with concentrations above or equal to 25 mg/L. The test results showed that the developed method is practical, effective and efficient.

Keywords: *Calibration, CO_2 sensors, Parameter analysis, Photocatalytic. LAS and ABS*

1. INTRODUCTION

Linear alkylbenzenesulphonate (LAS) and alkyl benzene sulphonate (ABS) is an anionic detergent active compounds. Detergent wastes generated from industrial waste waters and waste from households in which both use detergent for washing / cleaning (Doan and Saidi, 2008).

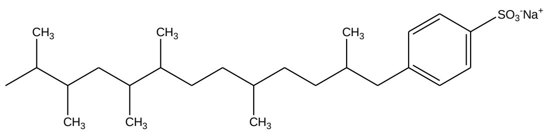

Fig. 1. Cemical structures of Alkyl Benzene Sulfonate (ABS) (Reiser et al., 1997)

With the replacement of ABS with LAS, sewage problems caused by detergent, it is not a problem anymore, because a change in the structure of the carbon chain branched ABS (Fig.1) become straight carbon chain LAS (Fig.2), while its sulphonate group is to remain unchanged. Straight carbon chain structure in LAS, can be digested by microbes (Reiser et al., 1997).

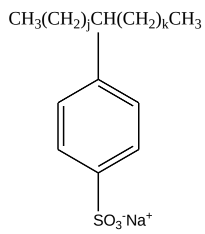

Fig. 2. Chemical Structure of (LAS)$C_nH_{2n-1}O_3SNa$ (n = 16-20) (Reiser et al., 1997)

Method of waste water treatment containing detergent can be done using a variety of techniques, for example in biological waste water treatment, coagulation-flocculation-flotation, activated carbon adsorption, activated sludge, chlorination and other representative techniques depending on the effectiveness and efficiency of financial needs.

1.1. Method of Photocatalytic

Processing method is suggested through advanced oxidation process AOPs (advanced oxidation processes). One method is photokatalitis UV/TiO_2 major ones (Doan and Saidi, 2008). By using a photocatalytic process, LAS and ABS is converted into carbon dioxide (CO_2) and H_2O (Horváth and Huszánk, 2003; Hidaka et al., 2004).

So, the photo excitation process will generate electrons in the conduction band and holes in the valence band. Among the types of semiconductor material, generally TiO_2 is a semiconductor material that is most effective, because it has a high photocatalytic activity and more chemically inert under any circumstances.

Photocatalytic process with TiO_2 as catalyst have the ability to initiate chemical reactions. In aqueous media, most organic compounds can be oxidized to carbon dioxide and water, meaning the process can clean the water of organic pollutants (Gunlazuardi et al., 2002). Reaction is as follows:

$$C_cH_hO_o + [(h-2O)/4+n]O_2 \xrightarrow{TiO_2,\, hv} cCO_2 + H_2O \qquad (1)$$

Semiconductor titanium dioxide (TiO_2) is widely used as a photocatalyst which serves to accelerate the process of degradation of LAS compounds into CO_2 and H_2O and intermediate compounds that are more environmentally friendly (Herman, 1999).

Carbon dioxide (CO_2) produced , in general, can be measured by means of non- dispersive infra- red (NDIR) absorption spectrometry, thermal conductivity, or determined volumetric titration, gravimetric, conductometric and various methods of ion chromatography , after its CO_2 absorbed into the solution acid or base (Gunlazuardi et al., 2002).In order to be determined directly, in this study the CO_2 is measured using CO_2 sensors . The sensor is something that is used to detect any changes in the physical or chemical environment. At this time , the sensor have been made with very small size to the order of nanometers. Very small size is very convenient use and save energy . General specifications are expected to researchers from these sensors is as follows (Dong et al., 1999).

The gas will be censored is CO_2 and CO_2 sensors already on the market with a variety of shapes and materials. In this study, the selected sensor is the electrode coating material containing Li_2CO_3, this material is often used as an n-type oxide materials that are sensitive to reducing gas molecules. Layers of material sensor is sensitive layer that interacts directly with the gas, which undergo electrochemical reactions at the surface. The dimensions of this layer (which represents the number of molecules of Li_2CO_3) will determine the measurement range of the sensor (Dong et al., 1999).

During this time, the determination of detergent concentration results were analyzed based on the content of LAS degradation as the active compound using a chromatographic or spectrophotometric, this procedure is felt less effective and efficient because it requires many reagents, long time and should be done in the laboratory (EPA, 1983; Jurado et al., 2006; Hu et al., 2006; Akyuz and Roberts, 2002).

LAS is a compound that is unstable and easily degraded in waters ranging from the first day until day 20 (Leon et al., 2006). For the purposes of analysis, LAS can be stored up to 3 days and cooled at 4°C ± 2°C. To meet the above requirements, this research will develop a tool and a method of analysis of detergent Test Kit, which is a blend of photocatalytic process and the results of degradation was measured using CO_2 sensors.

These new tools and methods must be tested in order to obtain the performance and feasibility of a new method that Standard and Valid, to analyze the levels of Aklilbenzen Linear Sulfonate (LAS) and Alkyl Benzene Sulfonate (ABS) as a detergent active compounds, and can be used for routine analysis and monitoring of waste detergent in the water environment (Caulcutt and Boddy, 1983).

This study has been conducted testing of the analytical parameters of the photocatalytic reactor and calibration of the CO_2 sensor to determine the feasibility of tools and methods. And after it was made the equation that describes the relationship between the concentration of CO_2 with the concentrations of LAS and ABS are decomposed.

1.2. Determination of Parameter Analysis.

A new method is developed, it must be calibrated and validated through testing and procurement of evidence of the object being analyzed so that the method is feasible and appropriate for the intended use. In this study, the validation is done by determining the analytical parameters which include:

1). Sensitivity (S), is determined by the price of the slope of the standard calibration curve of the analyte (Massart et al., 1980). **2) . The detection limit,** is the lowest concentration of analyte that can still be detected by the methods specified confidence level (Caulcutt and Boddy, 1983), whereas according to Miller and Miller (2000), the detection limit is the lowest concentration of analyte that can still be measured and give a signal of the blank signal (yB) plus three times the standard deviation (SD). **3). The accuracy and precision** of analytical procedures based on standard measurements repeated with a certain concentration. The precision is expressed as the difference between the average value of measurements to the true value divided by the true value. The accuracy is the percent relative error (% e), while the accuracy is expressed as the standard deviation of the average value of the measurement results in percentage, known as the coefficient of variation (CV) (Caulcutt and Boddy, 1983; Skoog et al., 1996). **4). Range of linearity,** according to Massart et al. (1980) the range of linearity of the calibration curve is determined by the lower limit indicated by the detection limit, while the upper limit is indicated by the largest concentration of analyte sensitivity changes by 3%, while according to (Caulcutt and Boddy, 1983), linearity range can determined by t test at a certain confidence level, assuming $t_{test} > t_{table}$ (α;db) that the measurement results differ significantly.

2. METHODS

2.1. Stage Research

Methods of research conducted with a solution of LAS and ABS degrade in the photocatalytic reactor and degradation results in the form of CO_2 directly measured with CO_2 sensors and analytical parameters determined. Flowchart of the implementation of the study are presented in Figure 3.

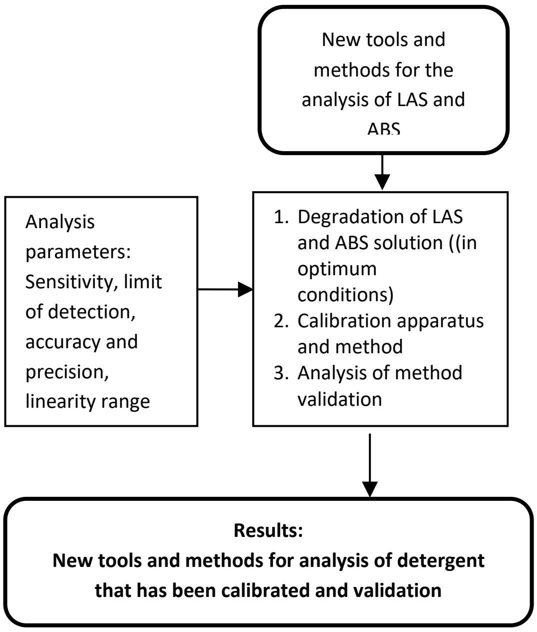

Fig. 3. Flowchart of study

2.2. Materials and Laboratory Equipments.

Materials.

The chemicals used were TiO_2 powder (Merck Lab.), TiO_2 Degussa P25, distilled water, 0.45µm membrane filter, chloroform ($CHCl_3$) (l), anhydrous sodium sulfate (Na_2SO_4), sodium dodecylbenzene sulphonate (LAS)(s) ($C_{18}H_{29}NaO_3S$), dodecylsulfate sodium salt ($C_{12}H_{25}NaO_4S$), alkyl benzene sulphonat (ABS) (l), phenolftalein (s), sodium hydroxide (NaOH), sulfuric acid (H_2SO_4) acid, methylene blue reagent, granular sodium phosphate hydrate ($Na_3(PO_4)_2$(s), sodium hydrogen phosphate hydrate ($NaH_2PO_4.H_2O$)(s), methanol (CH_3OH), hydrogen peroxide (H_2O_2) 30%, glass wool, D_2O(l), ACETONITRIL (ACN) (l), aquabides (l), ethyl acetate(l), ethanol (C_6H_5OH)(l), hydrochloric acid (HCl)(l), nitrogen gas (N_2), sodium chloride (NaCl) (s), sodium bicarbonate ($NaHCO_3$) (s), dihidroksida barium (Ba $(OH)_2$ (s), CO_2 gas.

Laboratory equipments.

Equipment used for the analysis of LAS compounds with MBAS (Methylene Blue Active Substances) method is UV -Visible spectrophotometer Shimadzu , flowmeter , 500 mL separating funnel , photocatalytic reactors , analytical balance , and a set of other glassware used in the laboratory.

The sensors have electrodes that are sensitive to CO_2. The increase in CO_2 concentration can be monitored by the increase in the value of electromotive force (EMF) . The instrument specifications are dimensions 10 mm x 25 mm , operating temperature 25 ° C - 300 ° C , power 3W Working heater and measurement range : 350 ~ 1000 ppm . Variable output from the sensor is converted into electrical quantities by means of a transducer , then the programmable electrical quantities and converted into the form of units of concentration .

Specifications reactor used is a kind of slurry photocatalytic reactor working in batch made from pyrex glass tube shape with a height of 40 cm and a diameter of 9 cm . The reactor is equipped with a UV - A lamp types Merck Pilip Blacklight 125 watt bulbs are placed at the top . As used alumimium foil reflector mounted on the walls , roof and base . Photoreactor is also equipped with a magnetic stirrer , a cooling fan PD120S Meck CE - 220 V models with a stirring speed is set between 500 to 1000 rpm and the distance between the sample with UV light was 6.5 cm .

2.3. Procedure

1. For sensor calibration, performed by measuring the pure gas of known concentration. The procedure begins with a pure stream of CO_2 gas through Mass Flowmeter brands KOFLOC of Kojima Instruments Inc., ie the gas flow measuring device for the benefit of calibration (Calibration reference) equipped with a computer, and arranged so that the concentration of the gas in the container vessel is 500 ppm.

2. Standard solution with a concentration of 100 mg / L as much as 1000 ml inserted into the reactor tube and then added 1 g activated TiO_2 catalysts. Reactor run for 5 hours, and the interval is done taking the standard solution once every 1 hour except when the process runs in the first 1 hour, sampling is done once every ½ hour. CO_2 gas is formed, flowed for quantitatively analyzed using CO_2 sensors, the next is the determination of the analytical parameters that include: sensitivity, detection limit, precision and accuracy of measurement the average value and the range of linearity.

3. To determine the relationship between the concentration of CO_2 is formed by the concentration of LAS and ABS are decomposed, then the analysis is done on a certain concentration range. If the analysis were obtained directly proportional to the amount of analyte and the sample, then the relationship is said to be linear. In this study the concentration of LAS and ABS were made, namely, 5.0, 10, 25, 50 and 100 mg / L.

3. RESULT AND DISCUSSION

3.1. Calibration Results and Methods

Standard of 500 ppm CO_2 gas in the container calibration, measured by the sensor 5 times with measurable results for: 447, 462, 455, 449 and 458. The results obtained are averaged and obtained imprecision in the range of 8-12%. Implementation of the calibration is done periodically at LIPI, Jl. Cisitu – Bandung, Indonesia. CO_2 concentration measurement results (ppm) flowed at an initial concentration of LAS and ABS. Curves that can be obtained can be seen in Figure 4.

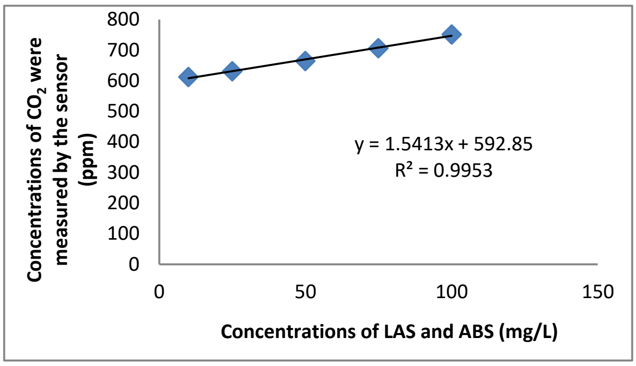

Fig. 4. Curve of Calibration

Result calculated using equation y = bx + a, for the calibration curve obtained the regression equation y = 1.5413x + 592.85 with R^2 = 0.9953. From the regression equation, the value of the intercept is large, namely 592.85, because the values used are the maximum values of each concentration measurement, and the value of the maximum CO_2 concentration for each concentration of LAS and ABS are degraded is above 600 ppm. Lowest value of CO_2 concentration is at a concentration of LAS and ABS 10 mg / L is 612 ± 4.7 ppm, so that when a line drawn to the point 0 concentration, CO_2 concentration will be obtained at 592.85 ppm.

Based on the linearity test , the range of confidence b , with a level of confidence 95 % was obtained slope value between 1.538 to 1.544 , and range of confidence a, gained 584.35 to 601.75. Because of range of confidence value a does not pass through zero point, so the equation used is fix. This suggests that this method of analysis, is not the same as the method of MBAS , which meets the Lambert Beer's Law (A = abC). However this equation can still be used since the beginning of the experiment (LAS and ABS concentration value = 0), the sensor has been read CO_2 concentration of 350 ppm, so when there is extra CO_2 from the degradation of LAS and ABS then the sensor reading will increase as well. And the value of CO_2 concentration measurement results, will be taken maximum value, so the value of the intercept of 584.35 is not a problem, because the measurement of CO_2 concentrations LAS and ABS in the concentration range of 10 to 100 mg / L gives a larger value of CO_2 concentration, so that when the value is inserted into the regression equation obtained, will give the value of the concentration of sample LAS and ABS are correct.

Regression equation obtained has a value of R^2 = 0.9953, this indicates that a linear relationship between the concentration of LAS and ABS as ordinate, the value of CO_2 concentration as abscissa. The calibration line can be used to determine the concentration of LAS and ABS solution, which is not known from the same material, after the measurement of CO_2 concentration. In this study the concentration of LAS and ABS which is unknown can be determined by measuring the levels of CO_2 concentration values, using the equation y = 1.5413 x + 592.85.

Furthermore, to prove the above statement, the resulting regression equation was tested with two concentrations degrade LAS and ABS is 65 mg / L and 40 mg / L and the concentration of CO_2 produced was measured with a sensor that reads the CO_2 concentration is 685 ± 4 ppm and 649 ± 4 ppm, these values are then entered into the regression equation above and the obtained concentrations of LAS and ABS is 60.9 mg and 36.4 mg with an accuracy value of 6 to 9%, then persamaam can be used.

3.2. Result of Analytical Parameter Calculation

Determine the sensitivity

Sensitivity is calculated based on the value of Δy, divided by the value of Δx (from experiments 2 and 3) and ± Sb values, is as follows:

$$S = (\Delta y) / (\Delta x) \qquad (2)$$

$$= (706-665) / (75-50) = 1.64 \pm 0.06 = 1.664 \pm 0.06 \text{ ppm / mg / L}$$

Then the sensitivity value is in the range of 1.58 to 1.72, it can be said that the sensitivity of the sensor is used to determine the concentration of LAS and ABS based on the measured CO_2 value is 1.58 ppm to 1.72 ppm.

Determine the limit of detection

The limit of detection was calculated by the formula

$$y = yB + 3SB \qquad (3)$$

where: y = 1.5413 x + 592.85
yB = a = 592.85
sB = sy / x

$$sy/x = \sqrt{\frac{(y_{i-y})^2}{n-2}} = \sqrt{\frac{12722}{5-2}} = 65$$

$$y = yB + 3\ sB$$

$$1.5413\ x + 592.85 = 592.85 + 3\ (65)$$
$$x = (195) / 1.5413 = 126.5 \text{ ppm}$$

The limit of detection photocatalytic - CO_2 sensor method = 126.5 ppm

Determine the limit of quantitation

The limit of quantitation is calculated by the formula
y = yB + 10SB
where: y = 1.5413 x + 592.85
yB = a = 592.85
SB = sy / x

$$sy/x = \sqrt{\frac{(y_{i-}y)^2}{n-2}} = \sqrt{\frac{12722}{5-2}} = 65$$

y = yB + 10 SB
1.5413 x + 592.85 = 592.85 + 10 (65)
x = (650) / 1.5413 = 421.72 ppm
The limit of quantitation Photocatalytic - CO_2 sensor method = 421.72 ppm

This shows that the smallest amount of CO_2 concentrations of degradation LAS and ABS which can be detected and still provide a significant response compared with the blank is 125 mg / L. While the smallest quantity of CO_2 concentration limit degradation of LAS and ABS results are still able to provide accurate and precise criteria is 421 mg / L. While the specification of the sensor is known that the detection limit is 350 ppm, so that the value of the above is acceptable because the detection limit specification, there is between the limit of detection and quantitation limits of measurement.

Determine Precision and Accuracy

The results of calculations over a range of concentrations of LAS and ABS, 10 to 100 mg/L has a precision of 3.4% to 38.5%. This suggests that the degree of closeness between the results of the analysis of LAS and ABS sample, with levels of LAS and ABS is actually a 3.4% to 38.5%.

Good accuracy value is equal to or less than 5%, but this value may change depending on the concentration of the sample, since the concentration of LAS and ABS were in the range of 10 to 100 mg / L, the value is still considered good accuracy up to a value of 10%. From the test results on the concentration of LAS and ABS 50 to 100 mg / L , obtained ' accuracy value ' of 3.4 to 10.9 % , it can be said that the analysis procedure LAS and ABS with CO_2 sensor is accurate because it has 'accuracy value' smaller or in the range of 10 %. But for the concentration of LAS and ABS 10 and 25 mg / L obtained ' accuracy value ' 15 % and 38.5 % , it can be said that the analysis procedure LAS and ABS with CO_2 sensor is not accurate because it has ' accuracy value ' greater than 10 % .

The results of the calculation on the ' value of precision ' in LAS and ABS concentration range of 10 to 100 mg / L obtained 0.7 % to 22 %. This suggests that the ' degree of fit' between the ' average yield ' LAS and ABS test sample with the true value is 0.7% to 22%. According to the specifications CO_2 reactor, The good 'precision value' for reading 1000 ppm CO_2 concentration is 20%, it can be said that the analysis procedure LAS and ABS with ' CO_2 sensor method ' for concentrations of LAS and ABS 25 to 100 mg / L is precisely because ' the precision value ' obtained was 0.7 to 6.8 % and this value is smaller than ' accuracy values ' allowed is 20 % . But for LAS and ABS concentration 10 mg / L obtained 'precision value' 22 % , it can be said that the analysis procedure LAS and ABS with CO_2 sensor is not precision because it has 'precision value' is greater than 20 % . From this test it can be concluded that the analysis of LAS and ABS with using CO_2 sensor has good accuracy for LAS and ABS sample concentrations above 25 mg / L and has good precision above
10mg/ L.

Determining the Linearity Range

To determine the linearity range is made new again with the regression equation does not incorporate the largest data and obtained a linear equation of 4 concentration is y = 1.4429 x + 595.79

Deviation value (y_i-y ^) = actual absorbance - absorbance prediction

$$RSD = \sqrt{\frac{\Sigma(yi - y^\wedge)^2}{n-2}} = \sqrt{\frac{16.503}{4-2}} = 2.87$$

The Statistical Test

Ho = t-test <t-table, with the highest concentration of the standard solution, including the linearity of the calibration curve into relationship

H1 = t-test> t-table, with the highest concentration of the standard solution is not included in the calibration curve linearity relationship

t-test = | (y_test -y_table) / (RSD √ ((n +1) / n)) | = | (4.04) / (2.87 √ ((4 +1) / 4)) | = 1.26

t-table with db = 2 with a 95% confidence level for one-way t-test was 4.30

Decision: t-test <t-table, Ho is accepted

Conclusion: standard solution with a concentration of 100 mg / L still is in the region of linearity calibration curve. Or in other words it can be concluded that the measurement of LAS and ABS in the range of 10 mg / L to 100 mg / L are in the linear region.

3.3. Linearity Test on The Sample LAS and ABS, 100 mg/L With The Method of MBAS.

The test is performed to test whether the concentration of LAS and ABS 100 mg / L was linear with MBAs method, considering the new method was tested in the range of 0.2 to 0.4 mg / L.
Testing done by t test with hypothesis :
Ho = t - test < t - table , a standard solution with a concentration of 100 mg / L , including into the ' relationship linearity calibration curve '
H1 = t - test > t - table , a standard solution with a concentration of 100 mg / L , was not included into the ' relationship linearity calibration curve '

Test results yield values of t - test = 3.9 and t - table on db = 2 with a 95% confidence level for one -way t- test was 4.30.

Decision : t - test < t - table , Ho is accepted , so in conclusion , the standard solution with a concentration of 100 mg / L , is in the region of linearity calibration curve.

3.4. Comparison of Analytical Parameters' Two Methods

Table 1. Data for the comparison of analytical parameters, MBAS methods and photocatalytic methods - CO_2 sensor.

Analytical Parameters'	MBAS Methods (LAS + ABS)	photocatalytic methods CO_2 sensor. (CO_2)
Sensitivity (ppm)	0.469 - 0.482	1.58 – 1.72
Limit of detection (ppm)	0.06	125
limit of quantitation (ppm)	0.21	421
Precision (%)	0.00 – 0.15	3.4 – 38.5
Accuracy (%)	0.94 – 12.88	0.67 - 22
Linearity Range (ppm)	0.4 – 100	10-100

Sensitivity (S) is determined by the price of the slope of the standard calibration curve of the analyte (Massart et al., 1978), in which case both methods MBAS and methods photocatalytic - CO_2 sensor has good sensitivity.

For the parameters of the detection limit and quantitation limit, MBAs method has a detection limit and quantitation limits were lower than the method of photocatalytic - CO_2 sensor, because both methods measure different examples, MBAS method of measuring the concentration of LAS and ABS residual degradation, whereas the method of photocatalytic-CO_2 sensors measure the concentration of CO_2 that is formed from the degradation of LAS and ABS. According Caulcutt and Boddy, 1983, the limit of detection and quantitation limit is the lowest concentration of analyte that can still be detected by the methods specified confidence level. In this case the detection limit of the method developed is 126.5 ppm CO_2 and its quantitation limit of 421 ppm CO_2, meaning that the concentration is the smallest amount of analyte in a sample that can be detected, which still gives a significant response compared to blank.

The test results of the 'accuracy and precision' indicates that the method of MBAS, very accurate, and the precision the method is good for concentrations below 100 mg / L. While the method is developed, fairly accurate to concentrations above 25 mg / L and has a good precision for concentrations above 10 mg / L.

The test results of the linearity range of the method shows that the method of photocatalytic - CO_2 sensor is still linear in the concentration of LAS and ABS 10 to 100 mg / L while the MBAS method could be lower than the value that is 0.4 to 100 mg/L. According to Massart et al., (1980), the range of linearity of the calibration curve is determined by the lower limit indicated by the detection limit, while the upper limit is indicated by the largest concentration of analyte, with changes in sensitivity of 3%. This shows that the method is well developed, used to sample the analyte concentration is greater than or equal to 25 mg / L.

3.5. Comparing The Two Methods With Least Square Fitting Test

Test 'Least square fittings' done by comparing the measurement results with the solution of LAS and ABS standard methods MBAS, and predictive solution of LAS and ABS with method of photocatalytic - CO_2 sensor, calculated by regression equations were obtained.

Table 2. Comparison of concentrations of LAS and ABS were analyzed with MBAS, and analyzed by photocatalytic CO_2 sensor.

Initial concentration of LAS and ABS solution (mg / L)	Concentrations of LAS and ABS were analyzed with MBAS (mg / L)	Concentrations of LAS and ABS were analyzed with photocatalytic – CO_2 sensor (mg / L)
100	98.7	102.6
75	74.1	74.5
50	49.4	50.7
25	24.7	26.7
10	9.8	12.2
5	4.9	0

The results of this analysis are presented in the form of the calibration curve and can be seen in Figure 5.

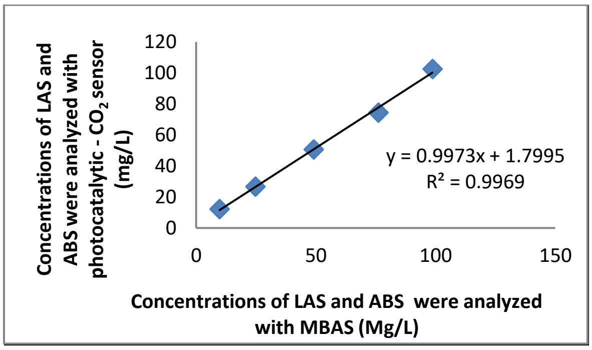

Fig. 5. Curve of Comparison of two analytical methods on the initial concentration of LAS and ABS standard solution: 100, 75, 50, 25, 10 mg/L.

Results calculated using the equation y = bx + a, for a standard calibration curve obtained by the regression equation y = 0.9973 x + 1.7995 with R^2 = 0.9969. Having tested 'range confidence' between a and b obtained that the slope value is actually there in the range of 0.993 to 1.001, so the price of b by 1. According to Massart et al. (1980), the ideal condition is when the Least square curve fitting to follow the linear regression equation y = bx + a, where b = 1 and a = 0. The test results in this study provide a price b = 1, but the 'value of a' is quite high, = 1.7995. To reduce the 'value of a' is by made a new range of concentrations 'LAS and ABS', without involve a concentration of 10 mg / L, so the concentration range became 25 to 100 mg / L (four points). Furthermore, Least square curve fitting made in this range and the results can be seen in Figure 6.

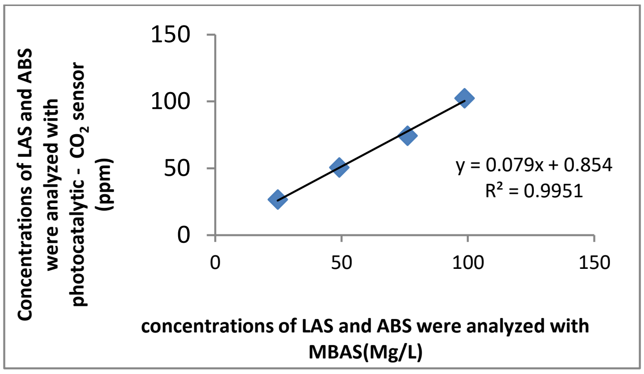

Fig. 6. Curve of Comparison of two analytical methods on the initial concentration of LAS and ABS standard solution: 100, 75, 50, 25 mg/L.

Results calculated using the equation y = bx + a, for a standard calibration curve obtained by the regression equation y = 1.0079 x + 0.986 with R^2 = 0.9969. Having tested a range of trust between a and b obtained that the slope value is actually there in the range of 0.999 to 1.016, because the price of b by 1. While the value of the intercept is actually there in the range of 0.560 to 1.410. This indicates that the standard methods of analysis methods MBAs did not differ significantly by method of photocatalytic CO_2 sensor, but there is an effect of constant error (the error remains) primarily for LAS and ABS concentration below 25 mg / L.

5. CONCLUSION

Reactor performance test results obtained the following analytical parameters, sensitivity: 0.394 to 0.460, the limit of detection: 0.16 mg / L, accuracy (percent relative error): 0.94% to 12.88% and accuracy (percent standard deviation): 0.12% to 0.14%, linearity range: 0.4 mg / L to 2 mg / L. Test results on several initial concentrations of LAS and ABS are different can be seen that the concentration of CO_2 sensor measurement results with theoretical concentrations have a linear relationship. If we assume that the CO_2 concentration curve comparison of theoretical and measurement results with the sensor through the zero point, then the LAS and ABS above 25mg/L produces better linearity.

6. ACKNOWLEGMENT

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