Asian Journal of Green Chemistry 6 (2022) 129-144

Asian Journal of Green Chemistry

Journal homepage: www.ajgreenchem.com

Original Research Article

Continuous flow injection analysis via NAG-4SX3-3D analyzer utilized to determination of resorcinol

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ARTICLE INFORMATION

Received: 11 February 2022
Received in revised: 26 April 2022
Accepted: 1 May 2022
Available online: 15 May 2022

DOI: 10.22034/ajgc.2022.2.3

KEYWORDS

Resorcinol
Continuous flow injection analysis
Turbidity
Potassium dichromate

ABSTRACT

A fast and sensitive method for detecting resorcinol by producing yellowish-green color species using the reaction of potassium dichromate with resorcinol in a sulfuric acid medium. NAG-4SX3-3D analyzer was used to evaluate the transducer energy response. To improve the sensitivity of the newly developed approach, the relevant parameter was explored. The linear range (0.05-32) mmol.L^{-1} for resorcinol measurement and RSD percent for the repetition (n=6) was significantly lower than 0.3% for (0.7, 23 millimol.L^{-1}) with L.O.D.=48.1687 ng/sample from the progressive dilution across the calibration graph's lowest concentration linear dynamic range (r=0.9997), (correlation coefficient), percentage linearity (R^2 %=99.95). The proposed approach was compared to the previous technique (UV-spectrophotometric at λ_{max}=273 nm). It can be concluded that, in addition to the technique's sensitivity (developed) and the use of a few chemicals, it outperforms the 10 mm irradiation of the classic reference method. Furthermore, continual dilution in CFIA enables the handling of high or low concentrations, opening up a larger range of applications. Based on the foregoing, the developed methodology is judged to be the most suited for resorcinol molecules compared to the reference techniques.

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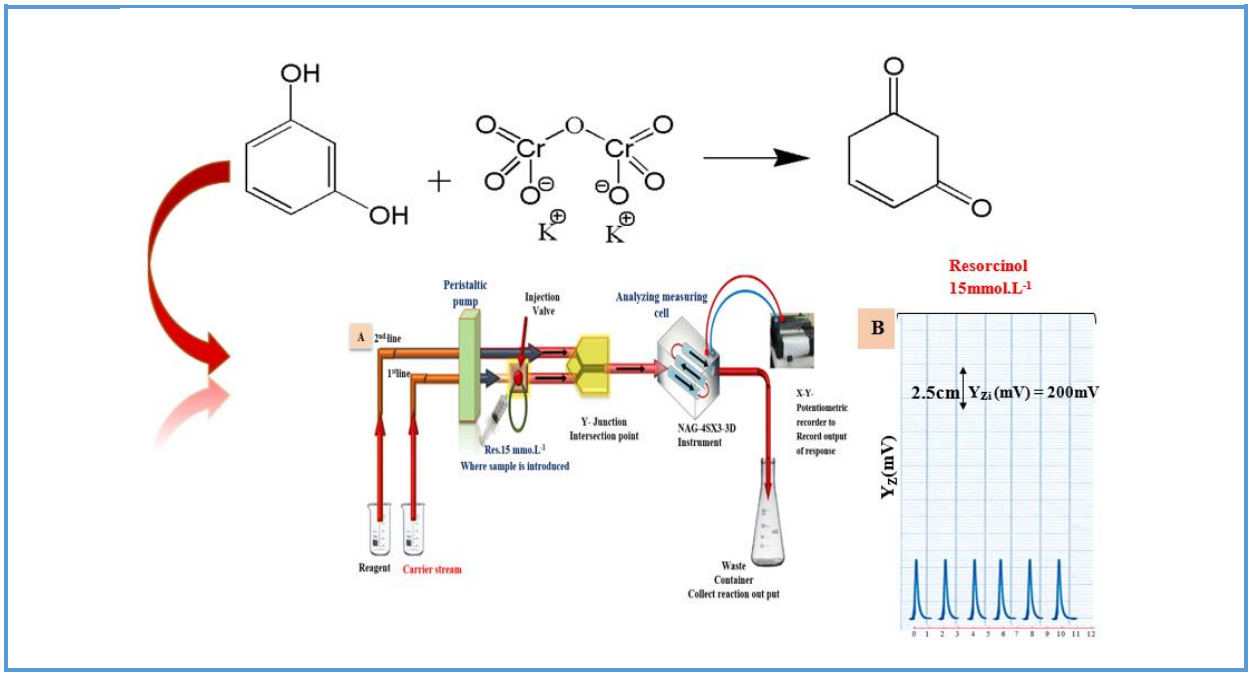
Graphical Abstract

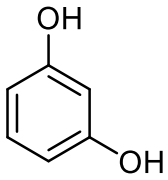


Introduction

Resorcinol (Res) 1,3-isomer of benzenediols, as illustrated in Scheme 1, is a dihydric phenol exhibiting characteristic phenol reactivity. It is a monoaromatic compound having two hydroxyl groups in meta position to each other that may be found in fossil fuels in the heartwood of Artocarpus and Moraceae species. Resorcinol ring-containing components have been discovered in various natural compounds, including plant phenolics which include resorcinol ring-containing components and are widely distributed in nature [1]. Resorcinol has widely utilized in various industries, including the production of rubber products [2]. Resorcinol is used in the rubber industry as a primer in latex fabric coating [3] and as a glue in rubber product manufacture, such as when attaching the ends of a conveyor belt. It is included in many hair color products because of its unique functioning as a coupler. It is also found in medicinal items [4] such as eye drops that can be purchased without a prescription and a variety of ointments for disorders as psoriasis and acne.

Local hyperemia, corrosion, itching, dermatitis, and the loss of superficial layers of the skin may occur when solutions or salves containing 3 to 25% resorcinol are used [5]. It causes skin and eye discomfort if eaten, absorbed, or breathed through the skin. The drug may have effects on the blood, inducing methaemoglobin production. It is considered goitrogenic, causing hypothyroidism. Resorcinol was discovered in an aqueous solution [6] as an intermediary in the anaerobic decomposition of methoxyphenol and as an irradiation product of 3-chlorophenol.

There are many methods for the determination of resorcinol, such as electromagnetic sensor [7], electrochemical activation of graphene sheets embedded in carbon films [8], and a surfactant enhanced graphene paste electrode [9], electrochemical oxidation [10], electrochemical detection [11].



Scheme 1. Structure of resorcinol

Experimental

Materials and methods

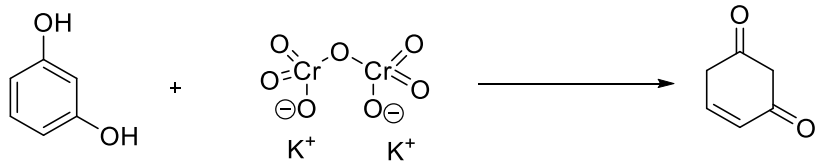
The solutions were produced using distilled water, and all of the compounds used were analytical reagent grade. By dissolving 11 g in 500 mL of distilled water, a 0.2 M standard solution of Resorcinol C_6H_4 $(OH)_2$ with molecular weight 110.1 g.mol^{-1}, BDH was made. A standard solution of potassium dichromate $K_2Cr_2O_7$ with a molecular weight of 294.22 g.mol^{-1} Hopkin and Williams LTD was made by dissolving 18.38 g of potassium dichromate in 250 mL of distilled water.

Apparatus

A flow cell manufactured from a handmade NAG-4SX3-3D analyzer [12] was used to obtain the output from the attenuation of incident light (0–180°). Figure 1**a** Potentiometric recorders were used to record the output signals (Siemens, Germany). A six-port injection valve and an ismatic peristaltic pump with a sample loop (Teflon, variable length), the traditional procedures were carried out using a Uv-spectrophotometric (Shimadzu, Japan).

Methodology

A manifold design for determining an aromatic organic chemical (resorcinol) Figure 1**a** by forming colored species with potassium dichromate. It consists of a two-line manifold system attached to the NAG-4SX3-3D analyzer. A sample segment introduction unit (injection valve with load injection location) is included in the system, allowing a certain quantity to be injected repeatedly with flawless dependability. The first line provides distilled water as a carrier stream for the sample zones of resorcinol 15 mmol.L^{-1} with 115 µL as a sample volume to meet with potassium dichromate in the second line at a 2.8 mL.min^{-1} flow rate for each line by Y-junction point before being introduced to the NAG-4SX3-3D analyzer. The x-t potentiometric record output was used to quantify the transducer energy response for the attenuation of incident light on colored species for a yellowish-green species which formed. Each solution was investigated three times. Scheme 2 proposed a mechanism for the oxidation of resorcinol by potassium dichromate. Figure 2 displays the output Y_z (mV) vs. t_{min} (d_{mm}) of the NAG-4SX3-3D analyzer transducer for 15 mmol.L^{-1} of resorcinol pharmaceuticals over time. The anther considers the synchronization of system outputs a new method in the NAG-4SX3-3D analyzer.



Scheme 2. Proposed reaction for resorcinol-$K_2Cr_2O_7$ system

Result and Discussion

The flow injection manifold system (Figure 1**a**) was used to investigate chemical and physical factors to determine the circumstances that would yield the reaction product, yellowish-green species, with the highest repeatability and sensitivity. The most straightforward strategy to optimize these variables was to keep them all constant while modifying them one by one.

Chemical variables

Effect of variable concentration of potassium dichromate

The measurements were carried out under the following conditions: A series of potassium dichromate solutions were generated by diluting the stock solution with distilled water to obtain concentrations ranging from 10 to 150 mmol.L^{-1}. Each line was measured three times with a reagent concentration of 15 mmol.L^{-1}, a sample volume of 115 µL, an open valve mode, and a flow rate of 2.8 mL.min^{-1} for the carrier stream (distilled water) and reagent. Figure 1**a** reveals the response profile for this investigation which shows that the energy transducer response fluctuates with potassium dichromate concentration when using the NAG-4SX3-3D analyzer.

It was noticed that an increase in the response of the colored species with an increase of potassium dichromate concentration up 100 mmol.L^{-1}, more than 100 mmol.L^{-1} led to broadening in high peak maxima and increase the peak base width (Δt_B), this due to increase the intensity of colored species which play as an internal filter in front of detector that prevents remaining light after absorption process from passes to solar cell. Therefore, 100 mmol.L^{-1} of potassium dichromate was selected as an optimum concentration in the following studies to give a maximum peak height and sharpness. The obtained result was tabulated in Table 1**a**, while Figure 1**b** and Table 1**b** demonstrate the segmentation pattern for selecting the optimum segment of Res. Systems, segment S_3 (i.e., 70-150 mmol.L^{-1}) for the resorcinol–$K_2Cr_2O_7$ system.

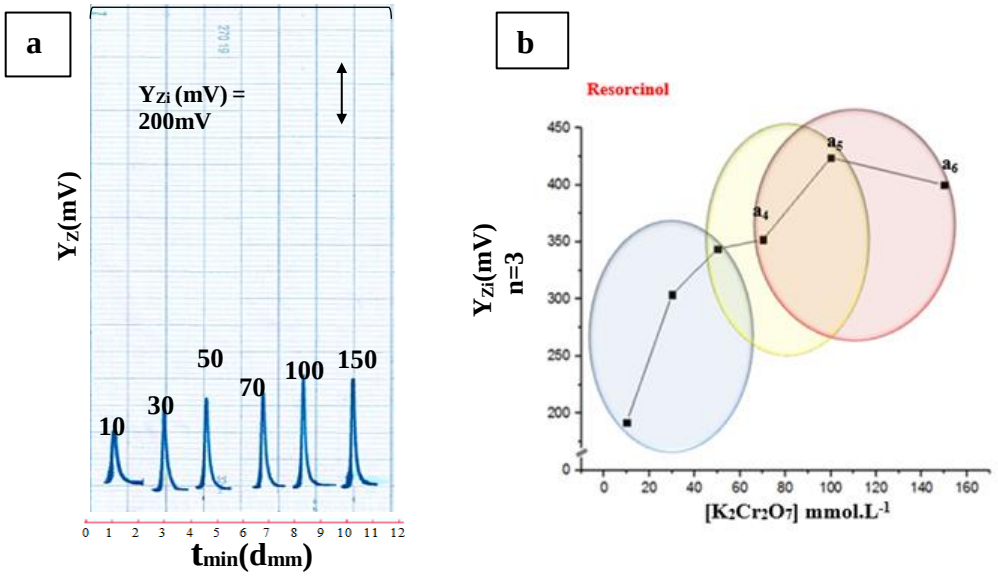


Figure 1. a) Response profile of potassium dichromate concentrations, b) Output of (S/N) energy transducer response, and three data points as one segment with optimum choice

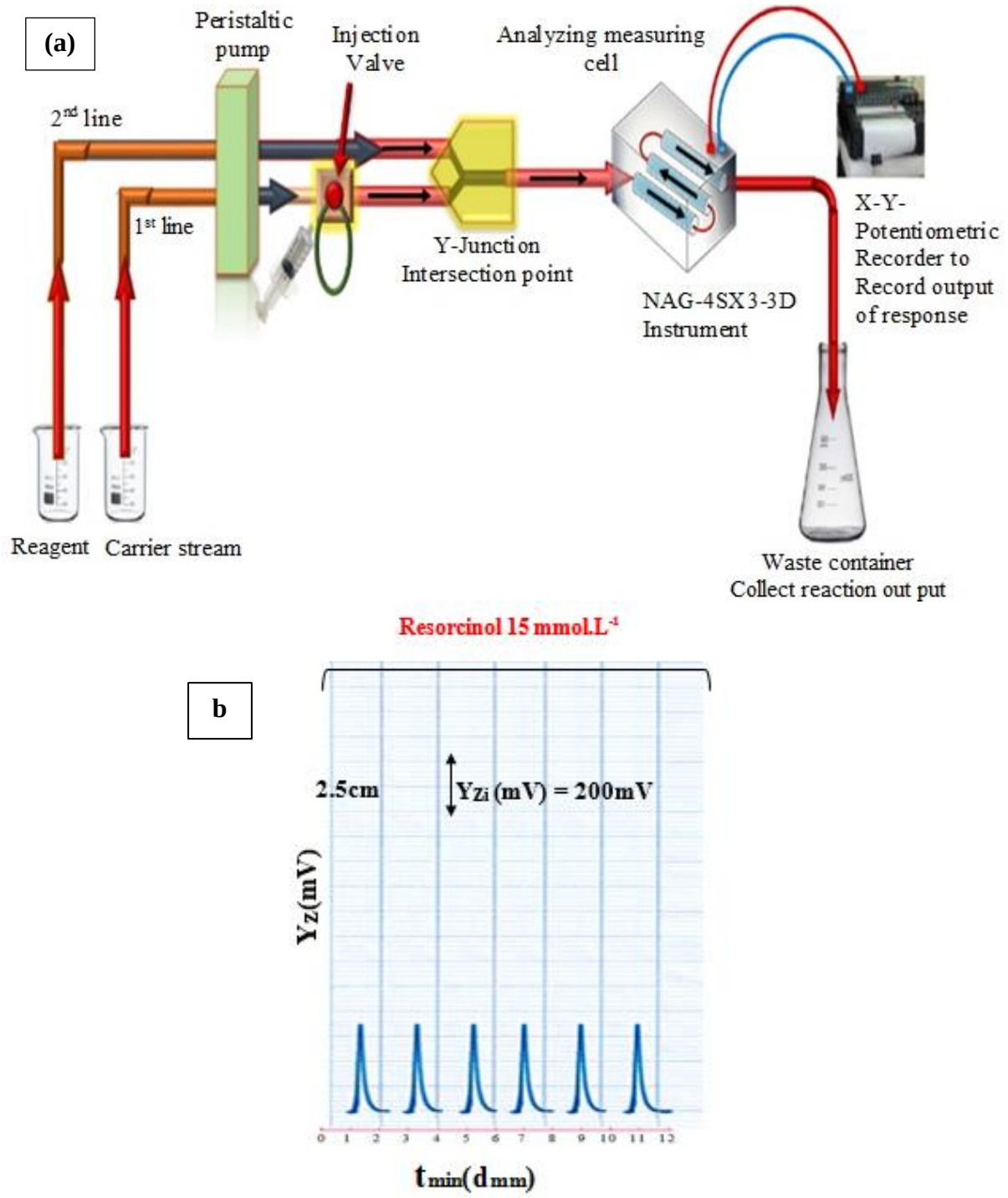


Figure 2. a) Diagram of manifold used for assessment NAG-4SX3-3D via reaction of resorcinol 15 mmol.L^{-1} with Potassium dichromate 50 mmol.L^{-1} to form yellowish green colored species. b) Profile of preliminary repeated experiments for assessment NAG-4SX3-3D instrument via reaction resorcinol with potassium dichromate to form yellowish species

Table 1. a) Effect of potassium dichromate concentration on precipitate formation of resorcinol, b) segmentation pattern slop-intercept with selection optimum segment for res-potassium dichromate system

A			
$[K_2Cr_2O_7]$ mmol.L-1	$\bar{Y}_{Zi}$(mV) average (n=3)	RSD%	Confidence interval at 95% $\bar{Y}_{Zi}$(mV)±t SEM
10	192	0.59	192±2.807
30	304	0.40	304±3.056
50	344	0.40	344±3.428
70	352	0.35	352±3.080
100	424	0.43	424±4.497
150	400	0.58	400±4.764

B					
Segment	$[K_2Cr_2O_7]$ range mmol.L^{-1}	Intercept mV	Slope mV/mmol.L^{-1}	correlation coefficient	Angle
S_1	10-50	166.00	3.80	0.965	75.256
S_2	50-100	251.37	1.66	0.950	58.983
S_3	70-150	339.76	0.49	0.540	26.095

Effect of various medium

Using certain resorcinol system conditions, resorcinol 15 mmol.L^{-1}-$K_2Cr_2O_7$, 100 mmol.L^{-1}, and a 115 µL sample volume, 2.8 mL/min^{-1} was the flow rate. The impact of various solutions was examined using a carrier stream. In addition to the aqueous medium, (CH_3COOH, Tartaric acid, Ascorbic acid, HCl, HNO_3, H_2SO_4, KCl, CH_3COONH_4) with a 0.4 mmol.L^{-1} concentration. Figure 3 shows that the investigated media generate a reduction in S/N-response. This might be due to a rise in agglomeration or the growth in aggregate density and compactness with one another, which leads to an increase in S/N response due to the effect of tiny solid particulate formation that causes a decrease in inter-spatial distances and increases incident light attenuation, this results in an increase in incident light intensity because there will be more empty spaces in between agglomerates of particulate except H_2SO_4. In this research study, H_2SO_4 medium was chosen as the best carrier stream for resorcinol because it was suited for sensitivity and yielded a greater reaction. The acquired findings are summarized in Table 2.

Effect of H_2SO_4 concentration

A variety of solutions ranging from 0.1 to 0.5 mmol.L^{-1} were produced. With a sample volume of 115 µL, a flow rate of 2.8 mL.min^{-1}, an open valve mode, and a reagent concentration ($K_2Cr_2O_7$) of 100 mmol.L^{-1}, an initial concentration of resorcinol of 15 mmol.L^{-1} was obtained. Each experiment was repeated three times, resulting in a rise in incident light attenuation as the concentration of H_2SO_4 increased. This was due to the shape of small-sized particulates, particularly if they were in the form of a nucleus, which accumulated in their packed blocked form, aiding in agglomeration. This will increase incident light attenuation of more than 0.5 mmol.L^{-1} and an increase in small size solubility. The best carrier stream was 0.5 mmol.L^{-1} of H_2SO_4. Table 3 shows the results.

Figure 3. Effect of medium on response profile

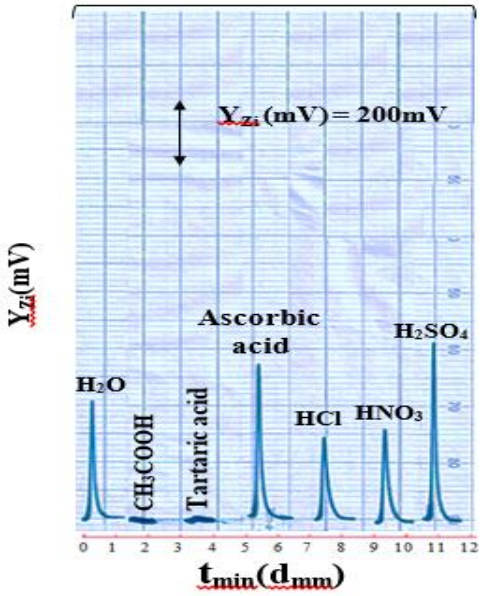


Table 2. Effect of different medium

Type of medium 0.4 mmol.L^{-1}	$\bar{Y}_{Zi}$(mV) average (n=3)	RSD%	Confidence interval at 95% $\bar{Y}_{Zi}$(mV)± t SEM
H_2O	424	0.41	424±4.298
CH_3COOH	0	0	0±0
Tartaric acid	8	12.25	8±2.435
Ascorbic acid	504	0.31	504±3.900
HCl	256	0.75	256±4.770
HNO_3	320	0.63	320±5.043
H_2SO_4	624	0.34	624±5.217

Table 3. Effect of variation H_2SO_4 concentration precipitation of resorcinol

[H_2SO_4] mmol.L^{-1}	$\bar{Y}_{Zi}$(mV) average (n=3)	RSD%	Confidence interval at 95% $\bar{Y}_{Zi}$(mV)± t SEM
0.1	120	0.86	120±2.559
0.2	264	0.75	264±4.919
0.3	448	0.44	448±4.894
0.4	624	0.32	624±4.993
0.5	800	0.26	800±5.093

Physical variables

Flow rate

An optimal concentration of Res. (15 mmol.L^{-1}), $K_2Cr_2O_7$ (100 mmol.L^{-1}), and H_2SO_4 (0.5 mmol.L^{-1}) were used with a sample volume of 115 µL. The flow rate varied from 1 mL.min^{-1} to 4 mL.min^{-1}. Table 4 summarizes the results collected. At low flow rates, the response time Δt_B was higher, as was the deformation of the top maximum peak response. This is due to an increase in the factor of dispersion. There was a drop in peak height when the flow rate was more than 2 mL.min^{-1}, which might be attributed to dispersion and dilution, resulting in an uneven response profile. As a result, the optimal flow rate for the resorcinol system was determined to be 2 mL.min^{-1}.

Sample volume

Variation sample volumes (82, 115, 139, 141, 175, and 281 µL) with open valve mode were evaluated with an appropriate flow rate of 2 mL.min^{-1} for the carrier stream and reagent. The concentration of resorcinol used was 15 mmol.L^{-1}. An increase in sample volume increased response height without affecting the response profile (Table 5). Above 175 µL, the peak maximum widened, the base width (Δt_B) increased, or the peak height decreased. The ideal volume for resorcinol to provide a better response profile was 175 µL, as shown in Figure 4.

Effect of reaction loop lengths

Coil lengths ranging from 0 to 30 cm were investigated. These lengths contain a volume of 0–942 µL directly linked after the Y-junction in the flow system Figure 5. The Res. (15 mmol.L^{-1})-100 mmol.L^{-1} $K_2Cr_2O_4$-0.5 mmol.L^{-1} H_2SO_4 system was utilized with a sample volume of 175 µL. The effect of reaction coil length on sensitivity as measured by the S/N energy transducer response it was determined that raising the reaction coil caused the response height to increase without changing the response profile. A larger volume (>785 µL) resulted in a widening of the peak height and an increase in the base width (Δt_B), most likely because of the continuously extended time duration of color species in front of the detector.

Table 4. Effect of Variation flow rate on precipitation formation of resorcinol

Pump speed Flow rate for each line	Flow rate mL.min^{-1}	$\bar{Y}_{Zi}$(mV) average (n=3)	RSD%	Confidence interval at 95% $\bar{Y}_{Zi}$(mV)± t SEM	Δt_{sec}	V_{add} (mL) at flow rate	C (mmo.L^{-1})	D.F	t_{sec}
5	1.0	1896	0.12	1896±5.764	162	5.515	0.3128	47.9565	90
10	1.5	1976	0.12	1976±6.012	114	5.815	0.2966	50.5655	54
15	2.0	1976	0.10	1976±5.093	54	3.715	0.4643	32.3043	30
20	2.5	1900	0.10	1900±4.919	60	5.115	0.3372	44.4783	24
25	2.8	800	0.25	800±5.043	90	8.515	0.2026	74.0435	36
30	3.0	720	0.30	720±5.391	60	6.115	0.2821	53.1739	18
35	3.5	600	0.37	600±5.540	54	6.415	0.2689	55.7826	12
40	4.0	480	0.50	480±6.012	42	5.715	0.3018	49.6957	12

Table 5. Effect of variation sample volume on precipitation formation of resorcinol

Length of sample segment cm r= 0.5	Sample volume µL	$\bar{Y}_{Zi}$(mV) average (n=3)	RSD%	Confidence interval at 95% $\bar{Y}_{Zi}$(mV)± t SEM	Δt_{sec}	V_{add} (mL) at flow rate	C (mmo.L^{-1})	D.F	t_{sec}
10.4	82	304	0.77	304±5.813	72	4.882	0.252	595366	30
14.6	115	1000	0.23	1000±5.739	90	6.115	0.282	53.1739	36
17.7	139	1976	0.10	1976±4.993	90	6.139	0.340	44.1655	36
18	141	1980	0.10	1980±4.919	90	6.141	0.344	43.5532	36
22.3	175	2020	0.10	2020±4.894	90	6.175	0.425	35.2857	36
35.8	281	2520	0.13	2520±7.974	78	5.481	0.769	19.5053	36

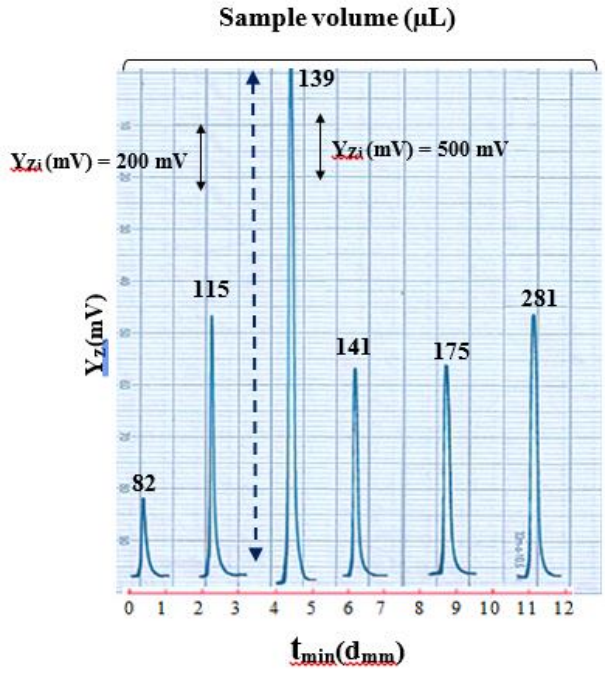


Figure 4. Response of varies sample volume on energy transducer response

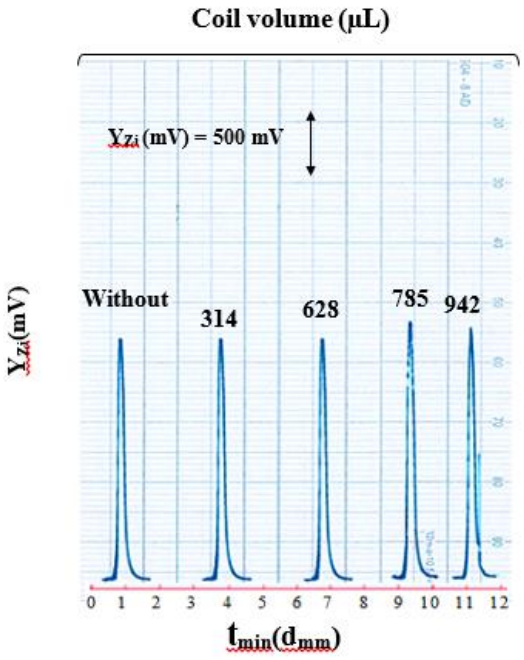


Figure 5. Response profile of coil volume on energy transducer response for the assessment of NAG-4SX3-3D via formation of yellowish green species

The Y-junction plays a critical role in the reaction's reactant mixing. The Y-junction was directly linked before the measurement cell in the flow system. Its influence on the response profile was investigated by varying the Y-junction at different parameters (Figure 6). The optimal concentration of Res. (15 mmol.L^{-1}) was utilized with a sample volume of 175 µL and a flow rate of 2 mL/min^{-1} for both the carrier stream and the reagent. Figure 6 depicts the whole profile of the Y-junction (meeting zone) impact of the S/N transducer energy response that was acquired. To investigate the influence on agglomeration, regulation, and regular distribution of particulates prior to the flow tube's entry, a variety of volume mixing chambers and an intersecting point in a larger diameter were used. However, particle scattering and dispersion and rising inter-spatial distances create a decrease in the capacity to prevent incident light from raising the height of the response measurement of the energy transducer Table 6. As a result, it was thought that removing the premix chamber or the crossing point at a higher tube diameter might be accomplished by using a manifold unit with 3 mm (I.D) entrances and a 3 mm (I.D) output. These indicate that the best Y-junction for mixing reactants and formation of precipitate particles in a sulfuric acid medium is 21.2 µL.

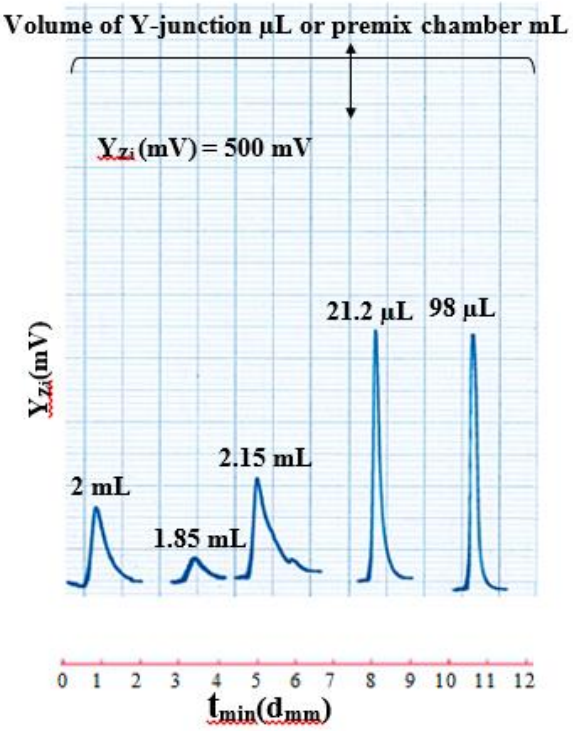


Figure 6. Response profile for assessing NAG-4SX3-3D instrument via formation of colored species of resorcinol

Table 6. Data set point obtained for Volume of Y-junction & premix chamber in the determination procedure of resorcinol

Type of Y-junction	Volume $\pi r^2 h$		$\bar{Y}_{Zi}$(mV) average (n=3)	t_{sec}	Volume mL At junction point	C (mm/L) DF
Intersection junction point	3 mm (ID) 3 mm (thickness)	21.2 µL	2020	34	2.4629	1.0658 14.0735
	5 mm (ID) 5 mm (thickness)	98.00 µL	784	34.5	2.5730	1.0202 14.7029
Premix chamber	14 mm (ID) 12 mm (thickness)	1.85 mL	80	35	4.3583	0.6023 24.9048
	14 mm (ID) 13 mm (thickness)	2.00 mL	248	36	4.5750	0.5738 26.1429
	14 mm (ID) 14 mm (thickness)	2.15 mL	312	36.5	4.7583	0.5517 27.1905

Determining the linear dynamic range for the variation of resorcinol on the S/N energy transducer response using a scatter plot

Physical and chemical variables were adjusted to their optimum values in the preceding section (Res-$K_2Cr_2O_7$ (100 mmol.L^{-1})-H_2SO_4 (0.5 n mmol.L^{-1}) system, 175 µL sample volume, no delay reaction coil, and 2.5 mL.min^{-1} flow rate for both carrier and reagent lines). For resorcinol, various organic compound solutions (0.05–50 mmol.L^{-1}) were created. Each measurement was taken three times. The average peak height (mV) of the transducer's energy response was plotted versus the concentration of the organic component. A

straight line graph (Figure 7a, b, c) was observed from 0.05 to 32 mmol.L^{-1} of resorcinol. Above 32 mmol.L^{-1}, the correlation coefficient value will drop, and linearity will be compromised. This is most definitely attributable to an increase in colored species in front of the detector, which might be related to light attenuation. The freshly established approach for determining resorcinol was compared to an existing reference method [13]. Specifically, the spectrophotometric method shown in Figures 8a and b, and Table 7 summarize the result obtained.

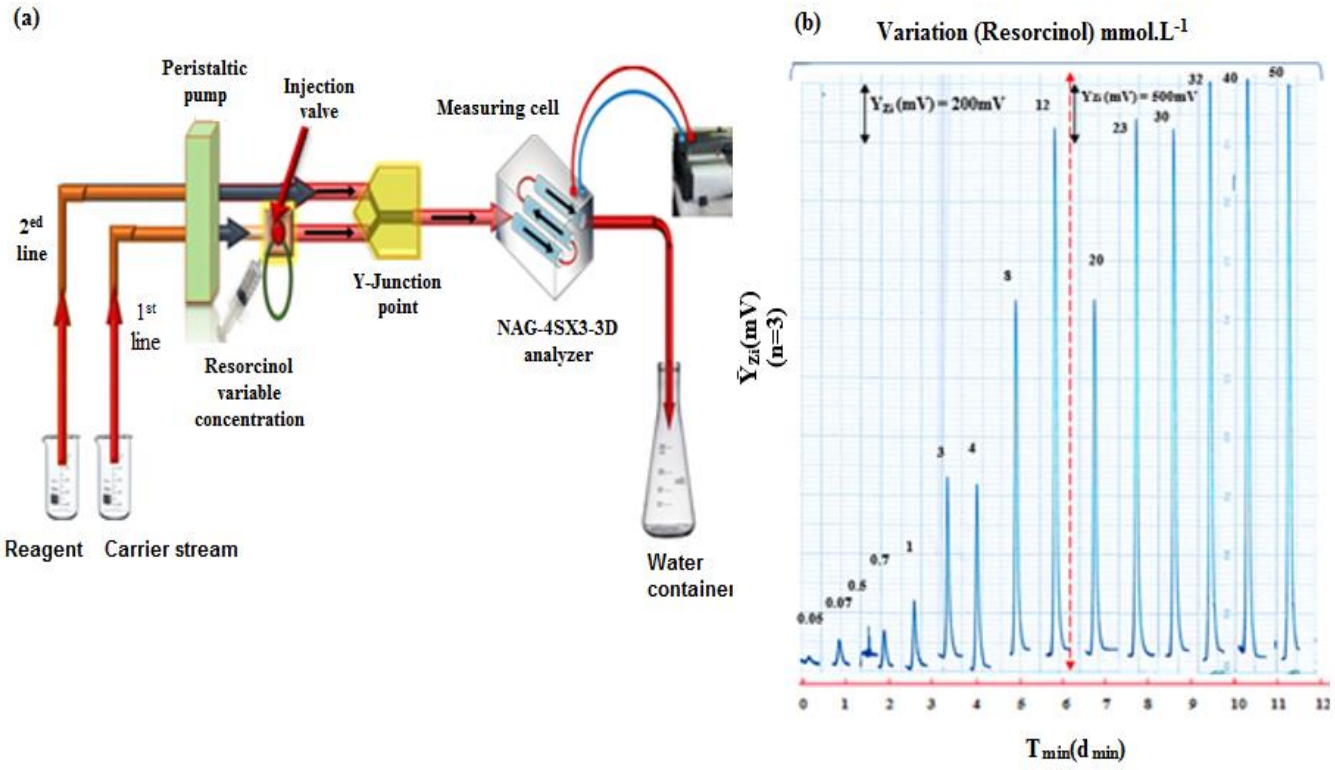
Limit of detection (LOD)

The limit of detection of resorcinol was calculated using three different methods, as tabulated in Table 8.

Repeatability

The measurements of two concentrations of catechol obtained across the whole test method in terms of precision summarize in Figure 9 and Table 9. Each measurement was done six times. The relative standard deviation was less than 0.2%, as shown in Figure 9 depicts a response profile for the concentrations applied.

Under the established optimum conditions (Res. (variable concentration)-$K_2Cr_2O_7$ (100 mmol.L^{-1} system, with 175 L sample volume, 2.5 mL.min^{-1} flow rate, and 21.2 µL Y junction point) the detailed comparison was made against the Uv-spectrophotometric (λ_{max}=273 nm) (for resorcinol) at the constant concentration used through the dynamic calibration range.



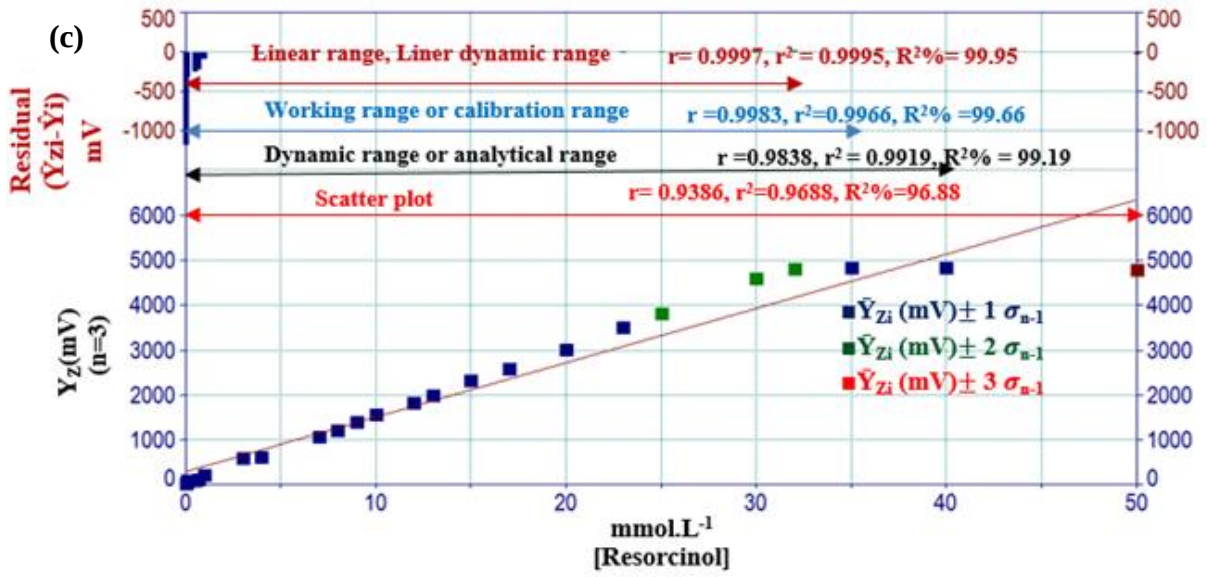


Figure 7. a) Flow gram system used for the determination of resorcinol, b) Some of the profiles versus time, potentiometric scanning speed 1 cm.min^{-1}, c) Different range for the effect of resorcinol concentration on attenuation of incident light using NAG-4SX3-3D analyzer for scatter plot range (0.005-2.5) mmol.L^{-1} for n=16

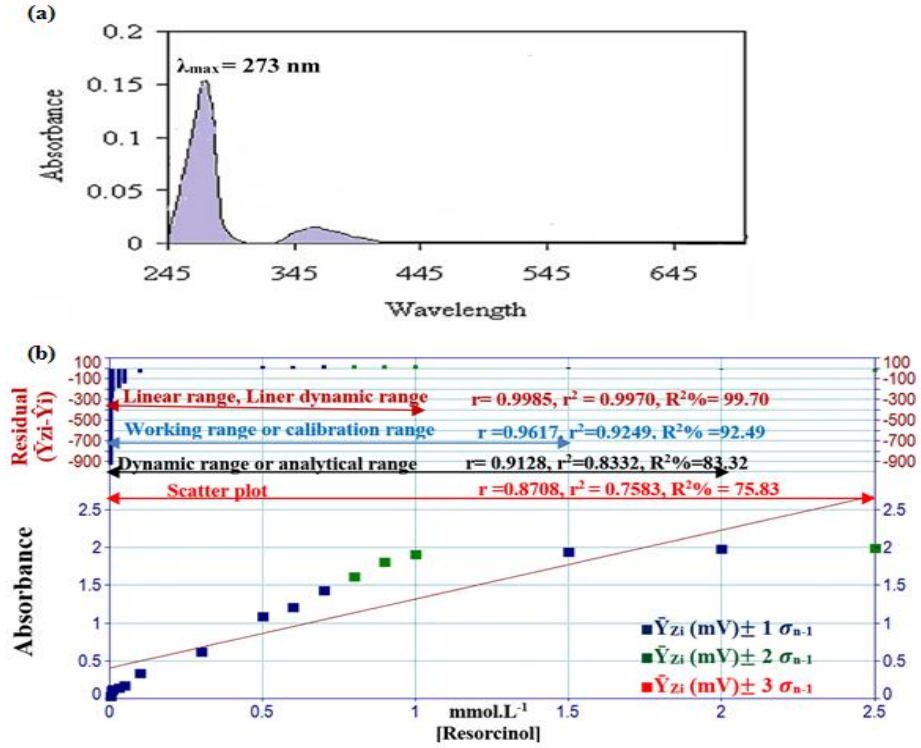


Figure 8. a) Uv-spectrum of resorcinol in λmax=273 nm, b) The scatter for resorcinol using a classical method at λmax=273 nm

Table 7. Summary of results for linear regression for the variation of (S/N) energy transducer response with resorcinol concentration using first-degree equation of the form $\hat{Y}=a+ b x$ at optimum conditions

Type of mode	Range of [Fe (II)] ion mmol.L^{-1}(n)	$\hat{Y}_{Z\,i}=a \pm S_a\, t+b(\Delta y/\Delta x_{mmol/L}) \pm S_b\, t$ [Fe (II)] mmol.L^{-1} at confidence level 95%, n-2	r, r^2, R^2%	t_{tab} at 95%, n-2	Calculated t-value $t_{cal}=/r/\sqrt{n-2}\,/\,\sqrt{1-r^2}$
		Developed method using NAG-4SX3-3D analyzer UV- Spectrophotometer at λ_{max}=273nm.			
Linear range or linear dynamic range	0.05-32 (21)	52.6162±24.5164+149.9786±1.6518 [Res.] mmol.L^{-1}	0.9997, 0.9995, 99.95	2.093<<190.031	
	0.005-1 (13)	0.0946±0.0361+1.8807±0.0680 [Res.] mmol.L^{-1}	0.9985, 0.9970, 99.70	2.2010<<60.8102	
Working range or calibration range	0.05-35 (22)	80.4651±64.9562+145.8924±3.9832 [Res.] mmol.L^{-1}	0.9983, 0.9966, 99.66	2.086<<76.405	
	0.005-1.5 (14)	0.1877±0.1780+1.5302±0.2743 [Res.] mmol.L^{-1}	0.9617, 0.9249, 92.49	2.1788<<12.158	
Dynamic range or analytical range	0.05-40 (23)	146.1495±144.1704+137.4224±8.0101 [Res.] mmol.L^{-1}	0.9838, 0.9919, 99.19	2.080<<35.6846	
	0.005-2 (15)	0.3058±0.2554+1.1727±0.3143 [Res.] mmol.L^{-1}	0.9128, 0.8332, 83.32	2.160<<8.059	
Scatter plot	0.05-50 (24)	300.2864± 278.0270+120.7758±13.6541 [Res.] mmol.L^{-1}	0.9386, 0.9688, 96.88	2.0739<<18.344	
	0.005-2.5 (16)	0.4089±0.2958+0.9094±0.2943[Res.] mmol.L^{-1}	0.8708,0.7583, 75.83	2.145<<6.628	

n: no. of measurement, $\hat{Y}_{Zi}$ (mV); estimated response (n=3) in mV for developed method and $\hat{Y}_{Zi}$ = estimated value without uniting for a spectrophotometric method or in NTU for turbidimetric method, r: correlation coefficient, r^2: coefficient of determination, R^2% (percentage capital R- squared): explained variation as a percentage/total variation and $t_{tab}= t_{0.05}/2$, n-2, the volume of measuring cell 1 mL for UV-Sp. and 10 mL for turbidimetric

Table 8. Detection Limit of Resorcinol using 175 µL as an injection sample and optimum parameters using Res (15 mmol.L^{-1})-[$K_2Cr_2O_7$] (100 mmol.L^{-1})- H_2SO_4 (0.5 mmol.L^{-1}) system

Practically based on the gradual dilution for the minimum concentration in scatter plot		Theoretical based on the value of slope x=3S_B/slope	Theoretical based on the linear equation $\hat{Y}=Y_b+3Sb$	Limit of quantitative L.O. Q $\hat{Y}=Y_b+10S_b$
Newly developed method (0.0025) mmo.L^{-1}	Classical method spectrophotometric method (0.001) mmol.L^{-1}			
48.1687 ng/sample	0.1101 µg/sample	0.2235 µg/sample	13.9307 µg/ sample	46.4356 µg/sample

Table 9. Repeatability of resorcinol at optimum parameters with 175 µL sample volume

Concentration of resorcinol mmol.L^{-1}	$\bar{Y}_{Zi}$ (mV) average responses (n=6)	RSD%	Confidence interval at 95% $\bar{Y}_{Zi}$(mV)$\pm t_{0.05/2}\,\sigma_{n-1}/\sqrt{n}$
0.7	120	0.290	120±0.3496
23	3500	0.082	3500±1.3786

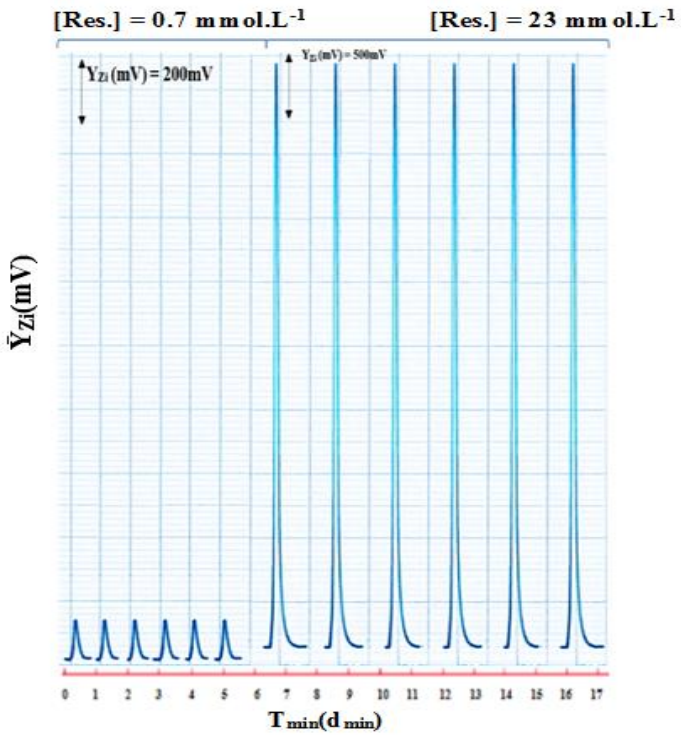


Figure 9. Y_{Zi}(mV) – t($_{min}$)(d_{min}) profile of seven successive measurements with repeatability of profile for 0.7 mmol.L^{-1}and 23 mmol.L^{-1} concentration of [resorcinol] using $K_2Cr_2O_7$ (100 mmol.L^{-1})-H_2SO_4(70 mmol.L^{-1}), using 175 µL as injection of sample loop and 2 mL.min^{-1} flow rate for each line. Also, high measurement repeatability at six high sensitivity of using 25 mm→500 mV

Comparison between reference methods already used with newly developed method using the NAG 4SX3-3D instrument, the comparison based on the sensitivity.

Table 10 contains an overview of the study's findings. Figure 10a, b illustrates a plot of two separate Y-axes at constant concentrations of resorcinol produced by calibration graph creation and a plot of Uv-spectrophotometric absorbance as a dependent variable against Uv-spectrophotometric absorbance NAG-4SX3-3D analyzer response for the same concentration (ranging from 0.05-1 mmol.L^{-1}). The slope value using the NAG-4SX3-3D analyzer (172.2043) is >45° (89.38°) more than using the classical method of Uv-spectrophotometric (1.8495) (Table 10), indicating that there is a significant difference between the two methods, i.e., the developed method has 93 times (172.2043/1.8495=93.109) more sensitivity than the traditional method.

Table 10. Summary of results for different methods using one molecule (Resorcinol molecule)

Resorcinol molecule Measurements expressed as an average of responses (n=3)					
[Res] mmol/L Independed variable	Developed method NAG-4SX3-3D analyzer		Abs. at λ_{max}=273 nm		$\bar{y}_i$ developed Vs $\bar{y}_{iAbs.}$
	$\bar{y}_i$(mV)	$\hat{y}_i$(mV)	$\bar{y}_i$Abs	$\hat{y}_i$Abs	$\hat{y}_{i(devl\ method\ -Abs)}$
0.05	24	48.90	0.181	0.210	46.403
0.1	98	57.51	0.34	0.303	61.171
0.3	96	91.95	0.62	0.673	87.177

0.5	104	126.39	1.093	1.042	131.109
0.6	135	134.61	1.21	1.227	141.976
0.7	156	160.83	1.43	1.412	162.410
0.8	178	178.05	1.619	1.600	179.964
0.9	200	195.27	1.81	1.782	197.704
1.0	224	212.49	1.911	1.967	207.085
Linear regression at confidence level 95%, n-2 $\hat{y}_I$=a±S_at+b ±S_bt[Res] mmol/L	40.2876±32.497+172.2043±51.009[Res] mmol/l		0.1177±0.066+1.8495±0.104[Res] mmol/l		29.5921±35.436+92.8795±27.647[Res] mmol/l
r, r^2, R^2%	0.9492, 0.9010, 90.10		0.9980, 0.9461, 99.61		0.9488, 0.9002, 90.02, 89.38°

X: Esorcinol molecule, ŷZi: in mV for developed method, without uniting for UV-Sp method., r: correlation coefficient, r^2: coefficient of determination, R^2% (percentage capital R- squared): explained variation as a percentage/total variation, UV–Sp.: UV –Spectrophotometric method, using a volume of the cell (quartz) 1 mL in UV–Spectrophotometric method

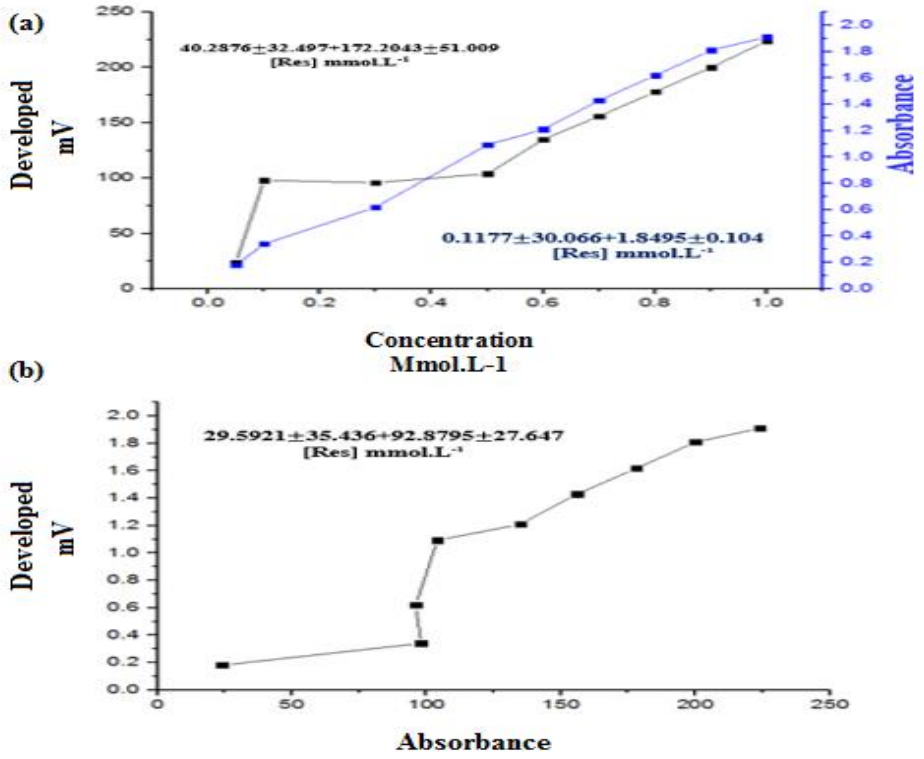


Figure 10. a) Energy transducer response expressed as an a average peak heights (mV) using NAG-4SX3-3D analyzer and Uv spectrophotometric method at λmax=273nm .b) Y predicated ($\hat{Y}_i$) using two methods NAG4SX3-3D Analyser (mV) and classical method Uv–spectrophotometry

Conclusions

The suggested approach is less costly than standard methods in apparatus and reagents. The NAG-4SX3-3D analyzer was employed in this investigation to produce a more accurate and faster result. The repetition RSD percent (n=6) was much lower than 0.3%, indicating that the proposed approach is precise enough. This approach may also be used to identify resorcinol, and it has the added feature of being able to achieve high sensitivity without using heat or extraction. The statistical analysis

results were identical to those obtained using the conventional technique.

Disclosure Statement

No potential conflict of interest was reported by the authors.

Orcid

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How to cite this manuscript: Nagham Shakir Turkie, Sarah Faris Hameed*, Continuous flow injection analysis via NAG-4SX3-3D analyzer utilized to determination of resorcinol**.** *Asian Journal of Green Chemistry*, 6(2) 2022, 129-144. DOI: 10.22034/ajgc.2022.2.3