

Novel method for determination of total phenolic compounds in wastewater after ultrasonic treatment by flow injection analysis with smart phone

Hakeem Jabbar Ilaybi

Chemistry Department , Faculty of Science , University of Kufa , Iraq

Corresponding author : email : hakeem.alkareemawi@uokufa.edu.iq

<https://orcid.org/0000-0003-2351-2028>

Mustafa Abdulkadhim Hussien

Department of Chemistry , Faculty of Science , University of Kufa , Iraq

email: mustafa.rabeea@uokufa.edu.iq

<https://orcid.org/0000-0002-2321-6678>

Abstract. Ultrasound waves are caused by oscillating molecular motions in a propagation medium. The waves have a very high frequency (20 kHz). Flow injection analysis is can analyze multiple samples, high accuracy, a very fast response time , modern technical devices that are small. This research intended to study the efficiency of ultrasound waves were determined total phenolic compounds in wastewater .Smart phone was used to investigate results and optimum conditions .The sample or standard phenol solution were injected into a carrier stream to react with 4-aminoantipyrine reagent then expose it to ultrasound waves (46 kHz) which was detected by spectrophotometer. A good linear calibration curve in the range of (250-2000 mg L⁻¹) was obtained with regression equation ($y=0.0108 x + 0.3453$) , ($R=0.9989$) . Results of the experiments showed that the ultrasonic method significantly decrease peak height after using ultrasound waves because of low measurement sensitivity due to effected on bonding process between total phenol compounds and the reagent, and the effect on the bonding of the components of the reagent .

Key Words : ultrasound , flow injection analysis , wastewater, total phenolic compounds , 4-aminoantipyrine,

1. Introduction : The field of acoustics known as ultrasonic deals with frequencies that are typically above the threshold of human hearing. As a result, the application of classical acoustics principles works equally well in the audible and visual realms ultrasonic regimes ⁽¹⁾ . Ultrasound a type of sound that is made up of mechanical waves that are the result of oscillating molecular motions in a propagation medium. The waves have a very high frequency equal to approximately (20 kHz) is separated into two categories: low-intensity and high-intensity. The human ear is unable to detect these waves (intensity waves) ⁽²⁾ . Ultrasound waves Cannot travel through vacuum, Reflective and refracted just like light waves ⁽³⁾ . The phenomenon of cavitation was discovered for the first time, an 1895 was the year it was first mentioned⁽⁴⁾ . Ultrasonic technology has attracted wide attention due to advantages of rapid decomposition, no secondary pollution and simple equipment ⁽⁵⁾ . Ultrasound Irradiation is a relatively new advanced oxidation technique that has emerged as a viable option . A response to the increased need for reduced levels of pollutants in the environment wastewater ⁽⁶⁾ . Ultrasound waves one of the novel techniques for enhancing the water treatment process ⁽⁷⁾ . Important characteristics of flow injection analysis are can analyze multiple samples, a very fast response time , small a sample size, high accuracy⁽⁸⁾ . It is also flexible in that it allows for

customization and invention and has a wide range of applications^(9,10). The most practical method for processing, transferring, and sharing data and images is via a smart phone. They are also cheap, generally accessible, user-friendly, and portable devices. Additionally, Bluetooth and Internet connectivity enable analysis to be performed wherever is convenient⁽¹¹⁾. The open accessibility of applications development tools enable with smart phone in recent years⁽¹²⁾. Phenol an aromatic organic molecule, Phenol poisoning can be caused by skin absorption, inhalation, ingestion, and a variety of additional means. Humans may die if they are exposed to high levels of phenol.⁽¹³⁾ In the study, a new method included Effect Ultrasound waves on determination of total phenolic compounds in wastewater using flow injection analysis.

2. Experimental

2.1. Chemicals

A stock solution of 100 ml standard phenol solution with concentration 2000 ppm phenol (C_6H_5OH) was prepared by dissolving 2.00 g of phenol in a small amount of boiled and cooled distilled water and diluted to a liter each milliliter of this solution contains one milligram of phenol. 4- aminoantipyrine reagent ($C_{11}H_{18}ON_8$) was prepared by dissolving (2 g) of 4- aminoantipyrine in a small amount of distilled water and dilute it to (100 ml) this solution is suitable for use for one day. Potassium ferricyanide solution ($K_3[Fe(CN)_6]$) was prepared by dissolving (8 g) of Potassium ferricyanide solution in a small amount of distilled water, dilute it to (100 ml) and then filter this solution is suitable for use for one week only. Ammonium chloride solution was prepared by dissolving (50 g) of Ammonium chloride in a small amount of distilled water and dilute it to a liter.

2.2. Equipment

1. UV-Visible Spectrophotometer, EMC-11UV, Emclab, Germany, (single Beam)
2. Electric balance, Bp301S, Sartorius, Germany
3. Ultrasonic device, Germany
4. smart phone device (Galaxy A30s), India

2.3. Flow injection analysis system

The standard solution or reagent were pumped for channel via a peristaltic pump to injection valve and were injected into a carrier stream, the sample was reacted with the reagent via reaction coil then to ultrasound waves (46 kHz) then flow cell of the spectrophotometer at 510 nm, the signal was measured by smart phone via SR program. Show (figure 1) using ultrasound waves with FIA instrument.

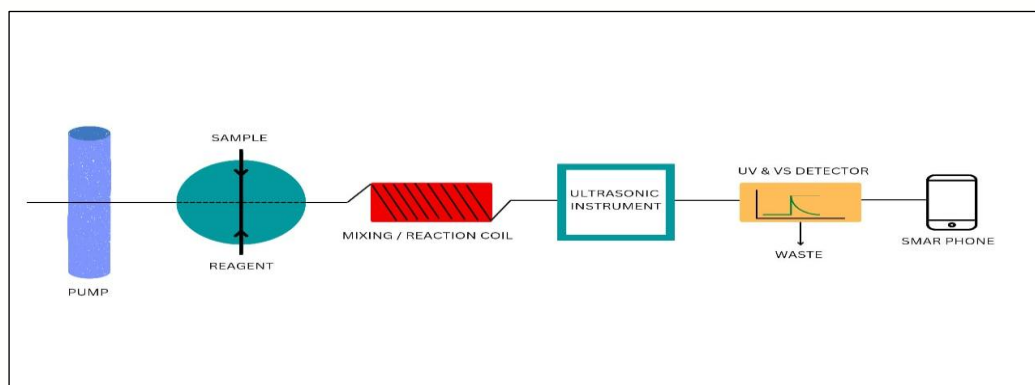


figure 1. Ultrasound waves with flow injection analysis system

2.4. Methods used in the measurement

A volume of 100 ml standard phenol solution with concentration 2000 ppm . Prepared 2 ml of ammonium chloride solution and then equalized to pH (10) by adding ammonium hydroxide , then added to it 2 ml of aminoantipyrine solution and mix well ,and 2 ml of ferric potassium cyanide , mix again . The light absorption is measured by colored standard solution using a spectrophotometer at a wavelength of 510 nm ⁽¹⁴⁾ .

3. Results and Discussion :

The effect of ultrasound device was studied on (Phenol and reagent) solutions by changing the peak height .

Effect ultrasound on 4- aminoantipyrine reagent with standard solution of phenol , the peak height decrease after using ultrasonic waves because of low measurement sensitivity due to effected on bonding process between phenol and the reagent show in (table 1 and figure 4) .

Effect ultrasound on 4- aminoantipyrine reagent with sample from wastewater , the peak height decrease after using ultrasonic technique show in (table 2 and figure 4) .

Effect ultrasound on 4- aminoantipyrine , the peak height decrease after using ultrasonic technique because effect on the bonding of the components of the reagent show in (table 3 and figure 4) .

3.1.The Calibration curve :

Series of concentrations of phenol was prepared .The curve was between (25-3000ppm) ,the study showed that the linearity of the results ranged from (250-2000ppm) , then there was a negative deviation, and the detection limit was 0.0113ppm (3 readings of blank) , (figure 2 and figure 3) .

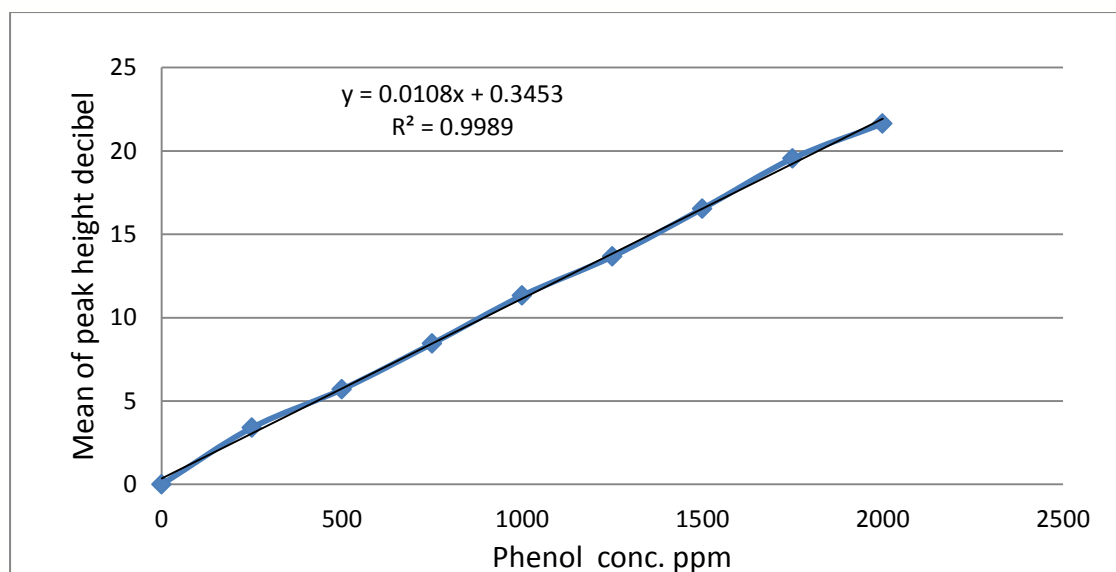


Figure 2. Calibration curve in FIA method using 4- aminoantipyrine reagent

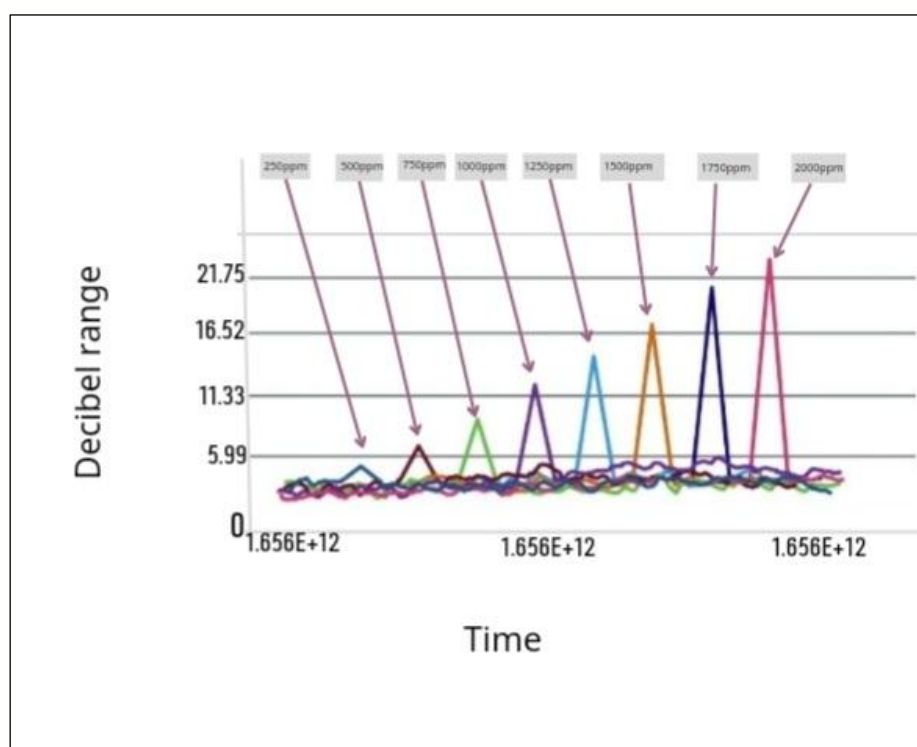


Figure 3. The change in phenols concentration of a FIA system with smart phone

3.2. Effect ultrasound waves on 4- aminoantipyrine reagent with standard solution of phenol

A series of standard solutions with a concentration of (2000ppm) were prepared and exposed to ultrasound waves (46 kHz) show in table 1.

Table 1. Effect ultrasound waves on 4- aminoantipyrine reagent with standard solution of phenol

Concentration of total phenols solution 2000ppm	Peak height dB			Mean of peak height dB	SD	RSD%
Before ultrasonic	21.74	21.75	21.75	21.74	0.005	0.022
After ultrasonic	4.09	4.07	4.07	4.07	0.011	0.270

3.3. Effect ultrasound on 4- aminoantipyrine reagent with wastewater sample

The wastewater samples were obtained from an environmental monitoring station. The samples were injected into the Flow injection system without any prior preparation after being diluted with $0.05 \text{ mol L}^{-1} \text{ H}_2\text{SO}_4$, and exposed to ultrasound waves (46 kHz) show in table 2.

Table 2. Effect ultrasound waves on 4-aminoantipyrine reagent with sample of wastewater.

4-amino antipyrine reagent with wastewater sample	Peak height dB			Mean of peak height dB	SD	RSD%
Before ultrasonic	5.07	5.09	5.09	5.08	0.115	2.263
After ultrasonic	2.98	2.95	2.93	2.95	0.025	0.847

3.4. Effect ultrasound waves on 4-aminoantipyrine reagent

The reagent solution a concentration of $30 \times 10^3 \text{ ppm}$ was exposed to ultrasound waves 46 kHz ,the results show in table 3.

Table 3. Effect ultrasound waves on 4-aminoantipyrine reagent

4-amino antipyrine reagent	Peak height dB			Mean of peak height dB	SD	RSD%
Before ultrasound	17.93	17.93	17.95	17.93	0.011	0.061
After ultrasound	2.88	2.86	2.86	2.86	0.011	0.384

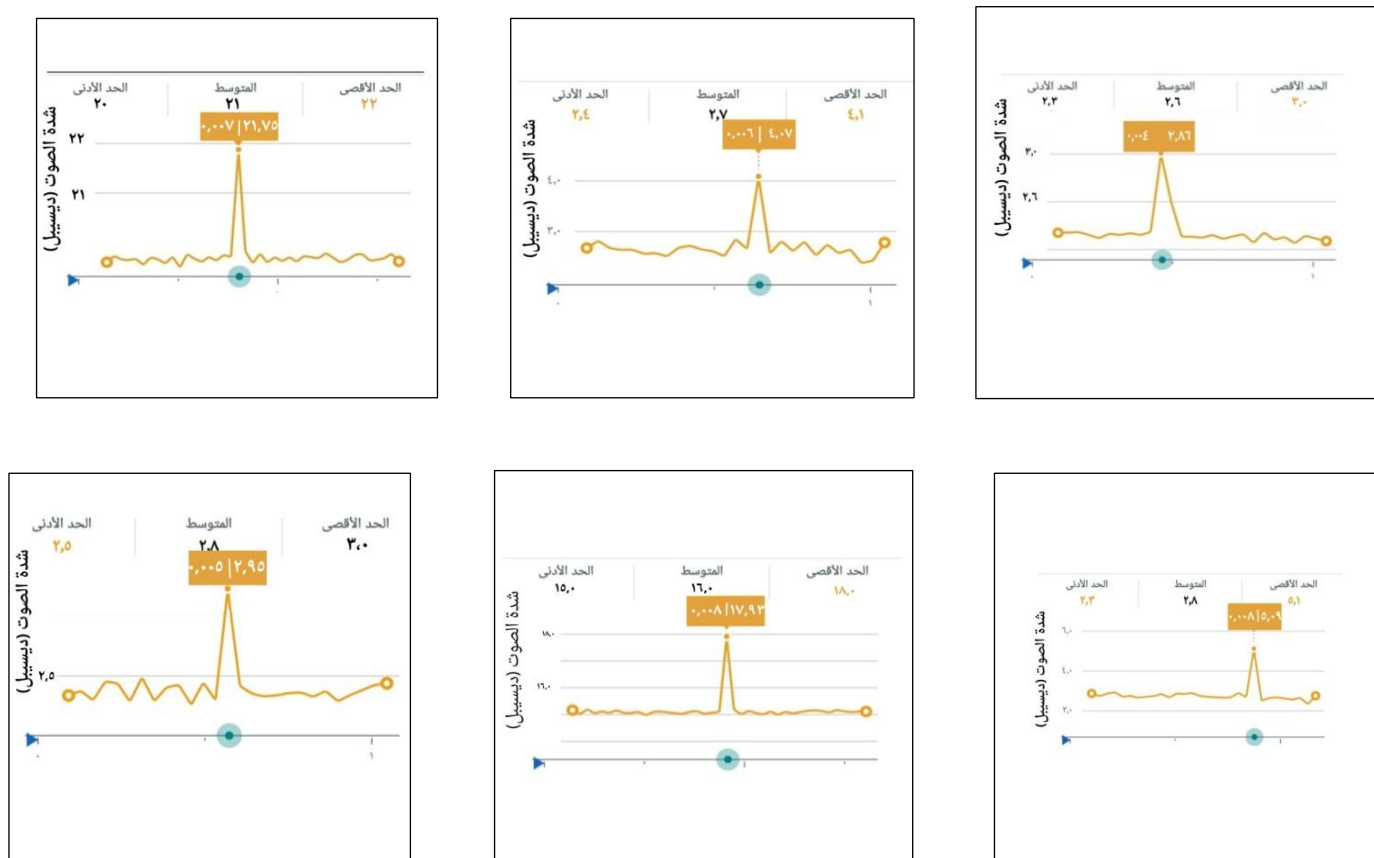


Figure 4. Sound intensity (decibel unit) of effect ultrasound waves on standard solution of phenol , wastewater, reagent

3.5. Conclusion: For the purpose of determining the total phenolic compounds in wastewater . results of the experiments showed that the ultrasonic method significantly decrease peak height after using ultrasound waves because of low measurement sensitivity due to effected on bonding process between total phenol compounds and the reagent in addition to the effect on the bonding of the components of the reagent .

References

- 1- Karl F. Graff , A history of ultrasonics ,physical acoustics , 15 ,1-97 , 1981.
- 2- Monica Gallo, Lydia Ferrara and Daniele Naviglio , Application of Ultrasound in Food Science and Technology , Foods 7(10),164 , 2018 .
- 3- Xinfeng Cheng , Jincal Sun , The principles of ultrasound and its application in freezing related processes of food materials , Ultrasonics sonochemistry , 27,576-585 , 2015 .
- 4- Thornycroft J , Sidney B .Torpedo boat destroyers .Proc Inst Civil Engineers , 122(51) , 1895 .
- 5- Xianzhen Xu, Dan Cao, Zonghua Wang, Jin Liu, Jun Gao,Minlang Sanchuan, Zhenjun Wang, Study on ultrasonic treatment for municipal sludge , Ultrasonics sonochemistry , 57,29-37,2019 .
- 6- Mahvi H A , , Application of Ultrasonic Technology For Water and Wastewater Treatment , Iranian J Publ Health, 38(2) , 1-17 , 2009 .

- 7- Akira Hiratsuka, Dhundi Raj Pathak, Application of ultrasonic waves for the improvement of water treatment , Journal of Water Resource and Protection, 5(6) , 604-610 ,2013
- 8- K.Leamsomrong, M.Suttajit , P.Chantiratikul, Flow injection analysis system for the determination of total phenolic compounds by using Folin-Ciocalteu assay, Asian Journal of Applied Sciences , 2(2),184-190, 2009 .
- 9- Claudia Ruiz-Capillas ,Jimenez Colmenero F, Determination preservatives in meat products by flow injection analysis (FIA) ,Food Additives and Contaminant, 25(10) ,1167-1178,2008 .
- 10- Calatayud- Martinez J. ,” Flow Injection Analysis of Pharmaceuticals”, Taylor & Francis e-Library, (3-10), 1988.
- 11- Zahraa .J. Salman ,Mustafa Abdulkadhim Hussein, Utilize smartphone as a novel detector for enzymatic urea hydrolysis in microfluidic system, Technology Reports of Kansai University, 63(2), 2021 .
- 12- Hassan H. Kadhim , Mustafa Abdulkadhim Hussein ,Novel semi-automation design for determination of iron in water using smart phone camera complementary metal-oxide-semiconductor (CMOS) biosensor as a detector device , Biomedicine and Chemical Sciences , 1(4) , 270-277 , 2022 .
- 13- Michalowicz J. , W. Duda (2007).Phenols -- sources and Toxicity .Polish Journal of Environmental Studies , 16 (3) , 2007.
- 14- Michael Dannis , Determination of phenols by the amino-antipyrine method , Sewage and Industrial Wastes,23(12) , 1951 .