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Edited by:
Prof. Abdussalam Salhin Mohamed.
Prof. Hisain Masoud Abomadina.
Dr. Ashraf Mustafa Abusenaina.
Dr. Fathia Abdulljawad Mosa

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The First Scientific Conference of the Faculty of Science – Sirte University
Environmental Pollution and Challenges of Environmental Sustainability (EPESC), Oct. 14, 2025

Extraction and Spectrophotometric Analysis of Nicotine in Natural and Processed Products Available in the Libyan Market

Ashraf M. Abusenaina**, *Ragwan M. Ghait, Abdussalam Salhin Mohamed

Chemistry Department, Faculty of Science, Sirte University, Sirte, Libya
Corresponding Author Email: abusenaina.ashraf@su.edu.ly

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Keywords: Extraction; $MKnO_4$; Nicotine; Oxidation; Spectrophotometry.

Abstract: This research aims to develop an analytical method for extracting nicotine from various natural and industrial products in the Libyan market and to estimate its concentration using a simple, rapid, and highly sensitive spectrophotometric technique. The method is based on the kinetics of permanganate oxidation of nicotine alkaloid in an aqueous sodium hydroxide solution at a constant ionic strength. Key parameters, including the optimal wavelength and equilibrium time of the resulting complex, have been evaluated and measured. The method demonstrates validity over a wide linear range of 16 to 964 ppm, with a detection limit of 4.86 ppm. Statistical calculations were performed based on five replicate analyses, and the percent error and relative standard deviation (RSD) values were reported. Additionally, the correlation factor (r^2 = 0.9953) and molar absorptivity (1.88×10^4 L $mol^{-1}.cm^{-1}$) were documented. The proposed method was applied to extract and determine nicotine from seven different types of cigarettes available in the Libyan market, as well as one type of local non-smoked tobacco (antiquated chewing tobacco). A high extraction efficiency was achieved, with recovery rates ranging from 97.8% to 100%.

1. Introduction:

Man has known the importance of plant secondary metabolic compounds in the last few decades. He has used the flowers and leaves of certain plants containing toxic, lethal, or repellent substances for insects and pests. He has also used some of their roots and fruits to treat some pathological conditions, prompting man to look for different parts of the plant and methods of preparation and to know its characteristics and effects (Qureshi & Qureshi, 1990; Khalil, 1979). Some plants, such as tobacco plants, have long been used to treat diseases such as headaches, colds, and ulcers. Alkaloids are secondary compounds found in tobacco plants, most notably nicotine alkaloids, with the synthetic formula "$C_{10}H_{14}N_2$, consisting of Pyridine and Pyrrolidine (Mansk & Holmes, 1950). Nicotine in the tobacco plant and some vegetables has been identified since the year 1938, where it was used as an effective compound to get rid of insects and pests due to its effect on the nervous system. Nicotine is also a good treatment when mixed with some other compounds for certain diseases of the brain such as Alzheimer's, tremors, and dementia, in addition to treating colon mucosa sores and effectively alleviating their attendant pain (Chakrvarty, 1976).

Nicotine alkaloid is also a toxic substance when consumed at high doses, so the smoker usually takes a few doses of nicotine that the body can deal with immediately by breaking them down into other disposable compounds and eliminating them before they cause damage. High intake of nicotine can lead to a sense of dizziness and stomach pain, especially in novice smokers or even in smokers who have smoked for a long period of time. Heart rhythm increases significantly in young people at a rate three times greater than normal compared to non-smokers of the same age (Al Shamaa et al., 2012), while increasing nicotine levels can result in severe poisoning from swallowing, inhalation, or skin contact. Although exposure to dangerous or lethal doses is rare, it may lead to initial symptoms, including notable signs such as nausea, vomiting, excessive saliva, stomach cramps, paleness, sweating, high blood pressure, accelerated heartbeat, and headaches (Frank & Schep, 1991).

Alkaloids or semi-alkaloids are substances classified as crystallized bases, combining with acids to produce salts. They contain the nitrogen element in their heterogeneous composition and are alkaline-like in their base properties (الطائي، 2020). They are abundant in high-end plants and few in lower plants such as fungi, pancreas (Ergotamine), pepper diodes, and in several different plants such as caffeine (Al Shamaa et al., 2012).

Nicotine is a semi-alkaline and toxic organic compound, with the chemical formula $C_{10}H_{14}N_2$ (Figure 1). Its molecular mass is 162.23 g/mol. It has an oily liquid texture of pyridine derivatives, which has a strong smell and a hot taste that tends to burn. It is colorless when pure, while it becomes yellow when exposed to air or light and then later brown. Nicotine is water-soluble and highly decomposable in organic solvents such as alcohol, chloroform, and ether, and is classified as a semi-alkali (alkaloid), so it is commonly associated with citric acid and malic acid (Mea & Stuart, 2013).

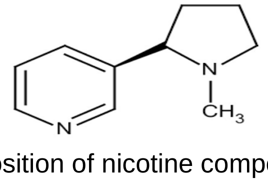

Figure 1: Chemical composition of nicotine compound (Mea & Stuart, 2013)

This study is to highlight the importance of nicotine and the widespread use of its industrial products in Libya's domestic markets, which has led to its abundant use by most of society. As a toxic substance, nicotine can cause death if taken at high doses, as well as other health risks affecting the heart and nervous system, not to mention being a major cause of cancer.

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Hence, there is a need to pay attention to a study to estimate nicotine concentration in some newly promoted cigarettes in the Libyan domestic market using the optical spectroscopy method. Therefore, the aim of the research is to extract nicotine from certain industrial products promoted in the Libyan domestic market and estimate its concentration using a very simple, fast, and economical spectrophotometric method.

2. Material and method

Chemicals and Reagents

All chemicals and solvents used were of analytical grades with high purity, ranging from 98=99%, and were used as received without further purification. Pure nicotine was were purchased from Riedel-de Haën, Germany, Potassium hexacyanoferrate (II), potassium permanganate, Zinc acetate, methanol and sodium hydroxide were purchased from Sigma-Aldrich.

Apparatus

All spectroscopic measurements were recorded on a double beam UV-visible (German-made Specord 210 Plus, company—Analytikjena), equipped with a 1.0 cm path length quartz cell, while a pH meter (Herison, Metrohm Ion-Analysis, Swaziland) was used for pH measurements. The samples were separated using a Chinese-made centrifuge (Centrifuge 300E). Heating operations were conducted using a German-made water bath (Memmert WNB 45).

Standard solutions

Standard nicotine solution: Standard Nicotine solution (**(6×10^{-3} M)**, was prepared according to Al-Tamrah (1999), by dissolving the properate amount of nicotine in distilled water 100 ml. Potassium permanganate 0.13 M stock solution was prepared by dis solving 1.98 g in 100 ml of distilled water. Other standard reagents, NaOH (2 M), $Zn(CH_3CO_2)_2.2H_2O$ (1.2 M), and $K_4[Fe(CN)_6],3H_2O$ (10.6 w/v %) were also prepared using analytical procedures.

Optimization of experimental conditions:

The absorbance of a set of standards (10 ml) solutions of nicotine, ranging from 1-10 ppm, was measured at λmax = 289 nm against the reference solution. The linear standard curve was then plotted, and the correlation coefficient and slope were recorded. Limit of detection (LOD) and limit of quantitation (LOQ) were calculated at optimum condition using the following equations (Miller, et al. 2001):

$$LOD = \frac{3SD}{b} \qquad \text{and} \qquad LOQ = \frac{10SD}{b}$$

Wher b is the slop, and SD is the standard deviation.

Real Samples:

Various samples of tobacco products available in the Libyan local market in Sirte city, taking into account the date of production, validity and storage methods and without any damage that may affect the nature of the product and the validity of the results were used. The following table shows the samples used in this research:

Table 1: Types of tobacco samples used in the study.

No.	Product	Nicotine (mg)	Validity	Country
1	Red Bon	0.6	2025	USA
2	Maxico Gold	0.5	2025	Switzerland
3	Napoli Red	0.6	2024	Italy
4	Manchester	0.9	2025	UK
5	Blue Galaxy	0.4	2024	UAE
6	L&M Blue	0.6	2025	Switzerland
7	Oris elite	0.6	2025	UAE
8	Snus	--	--	Libya*

** Homemade*

Extraction of Nicotine:

To a 50 mg sample of tobacco in a 50 ml flask, 10 ml of methanol was added with continuous stirring. The sample was then left to stand at room temperature for 30 minutes. 25 ml of distilled water, followed by 1 ml of 2 M NaOH solution, was added with stirring. The mixture was heated (100°C) in a water bath for 1 min and then left to cool to room temperature. The mixture was filtered, and the residue was rinsed with distilled water. 1 ml of 1.22 M zinc acetate solution, followed by 1 ml of 10.6% potassium hexacyanoferrate with stirring, was added. The total volume of the flask was topped up with distilled water. The solution was centrifuged and the top layer was then separated and placed in e50 ml flask.

The above method was applied for the extraction of nicotine from cigarette collected from local market. A 0.45 0.6 mg of tobacco sample were collected and nicotine was extracted and determined spectrophotometrically. The process was repeated five times under the optimal conditions.

Results and discussion

Optimization Conditions

Wavelength Selection

The maximum absorbance of the complex was recorded at λmax =289nm. Figure 2 shows the UV-Vis spectrum of nicotine-$KMnO_4$ complex, while Table 2 illustrats the absorbance of standards.

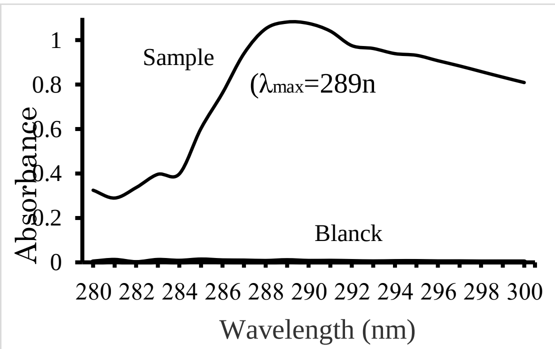

Figure 2: UV-Vis spectrum of the standard nicotine complex.

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Table 2: The UV-Vis absorption of standard nicotine solution (6 × 10^{-3} M) at different wavelengths.

λ_{max} (nm)	Absorbance		λ_{max} (nm)	Absorbance		λ_{max} (nm)	Absorbance	
	Blank	Sample		Blank	Sample		Blank	Sample
280	-0.0002	0.3245	287	0.0041	0.9398	294	0.0013	0.9391
281	0.0069	0.2893	288	0.0023	1.0507	295	0.0016	0.9315
282	-0.0032	0.3365	289	0.0056	1.0812	296	0.0003	0.9071
283	0.0068	0.396	290	0.0024	1.0748	297	0.0005	0.8837
284	0.0031	0.398	291	0.0029	1.0406	298	-0.0002	0.8583
285	0.0088	0.6015	292	0.0015	0.9751	299	-0.0001	0.8332
286	0.0048	0.7616	293	0.0002	0.9622	300	-0.0001	0.809

The Stability of the Complex

The optimum condition of the complex formation are summarized in Figure 3, where the absorbance of the complex was found stable after 25 days of preparation standing at room temperature.

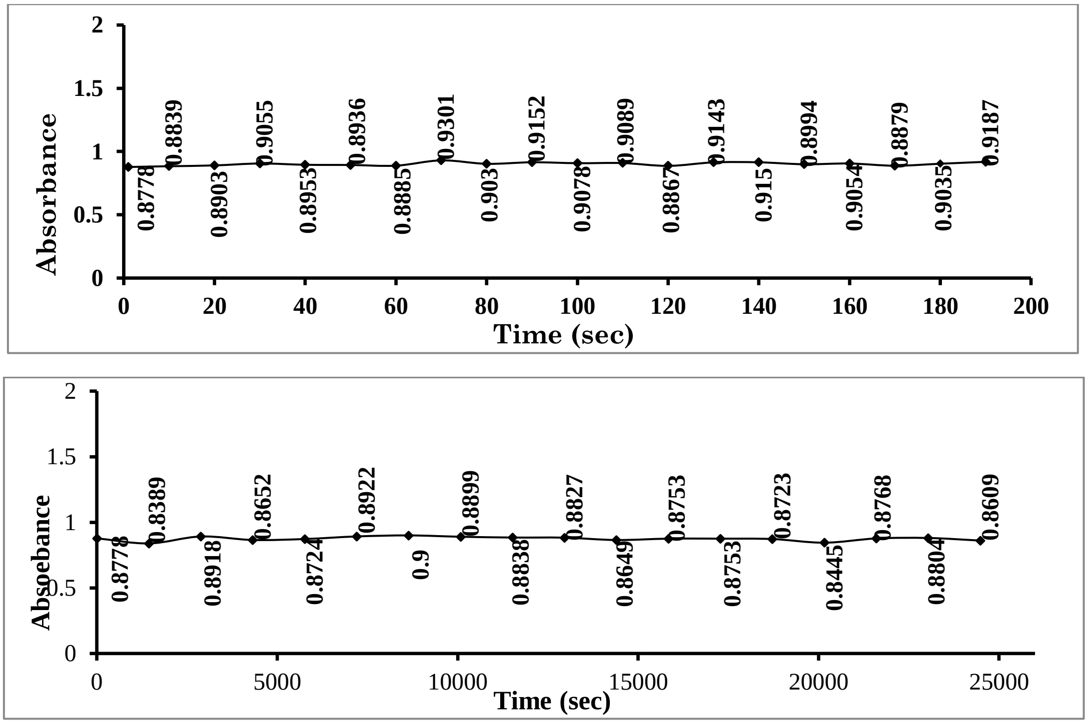

Figure 3: Effect of time on the absorption of standard nicotine solution. Measured each 10 min during the first day each (above), and within 24 days (bottom).

Limit of detection and Limit of quantitative:

The detection limit (LOD) is calculated by measuring absorption of the blank solution at the optimal conditions. Table 3 illustrates the stability of the absorbance of complex, measured at several times. The limit of detection (LOD) and limit of quantification (LOQ) were then calculated and found equals to 3.027×10^{-5} M and 1.0092×10^{-4} M at wavelength λ_{max} = 289 nm, respectively.

Table 3: Measuring the absorbance of the complex at different time.

Measurement	Absorbance (289 nm)	Measurement	Absorbance (289 nm)	Measurement	Absorbance (289 nm)
1	0.0018	11	0.0022	21	0.0011
2	-0.0019	12	-0.0003	22	0.0007
3	-0.0017	13	0.0018	23	0.0007
4	-0.0008	14	0.0016	24	0.0004
5	0.0018	15	-0.0017	25	-0.0024
6	-0.0002	16	0.0008	26	-0.0013
7	-0.0004	17	-0.0003	27	-0.0023
8	0.0017	18	-0.0009	28	0.0005
9	-0.0013	19	0.0056	29	0.0015
10	0.0007	20	-0.0029	30	-0.0005

The Calibration Graph

Under the optimum experimental conditions and applying the recommended procedure, a calibration graph was obtained. A straight-line calibration graph was plotted (Figure 4). The graph obeyed Beer's law, with a correlation coefficient of 0.993, a detection limit of 4.86 µg mL^{-1}, and a molar absorptivity of 1.88×10^4 L $mol^{-1}.cm^{-1}$. Table 4 summarizes the optimum conditions of the method.

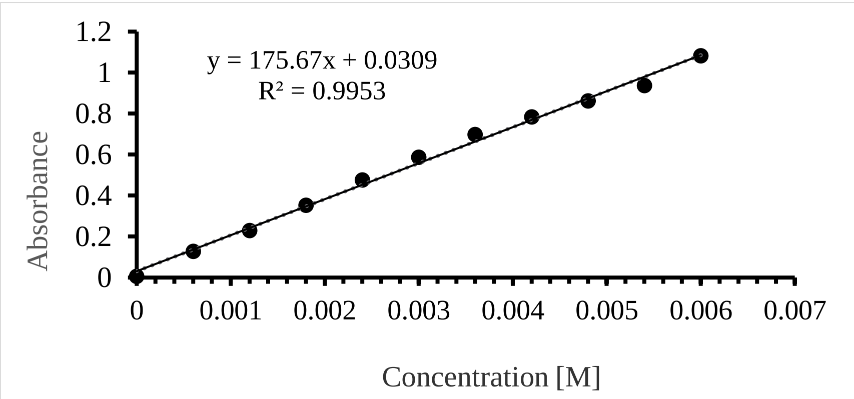

Figure 3: The standard curve for nicotine complex at λ_{max} = 289nm.

Table 4: The optimum conditions obtained from the calibration curve.

Limit of detection	4.86 µg ml^{-1}
Limit of quantitation	16.2 µg ml^{-1}
Limit of linearity	963.8 µg ml^{-1}
Linear range	16.2-963.8 µg ml^{-1}

Molar absorptivity	1.87947×10^{4} L $mol^{-1}.cm^{-1}$
Intercept	0.0309
Slope	175.67
Correlation coefficient	0.9953

Application of the method

In this study, nicotine was extracted from several commercial brands of tobacco products available in the Libyan market, following the recommended procedure. Each step was repeated five times under the same conditions. Figure 4 illustrates the amount of nicotine present in the studied samples compared to the manufacturers' claims.

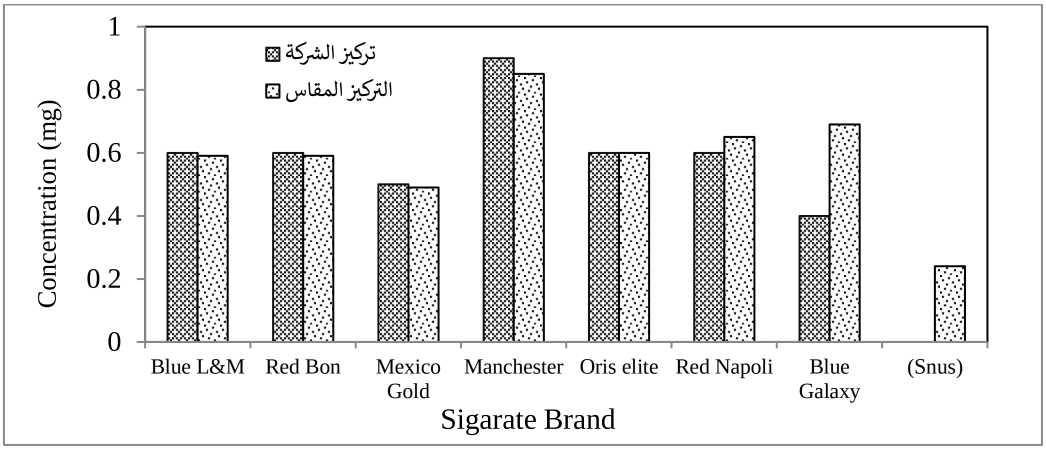

Figure 4: Comparison between the concentrations of nicotine calculated by the presence method and the commercial brands.

Conclusions

The extraction and determination of nicotine was highly achieved using the present method. The proposed method has adequate sensitivity, simple, rapid, easy handle, and involves low-cost instruments, compared to the most sophisticated techniques. Nicotine was successfully extracted from separate and spectrophotometrically determined. The method does not require the removal of excipients, sample pretreatment, and expensive reagents and solvents. The method is recommended to be adopted for the routine analysis in quality control laboratories.

Conflict of Interest: The authors declare that there are no conflicts of interest.

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