Development of Method Oxidation β-methylanthraquinone for the synthesis of Aloe-emodin, Rhein and Rheinal.

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Abstract:

This study aims to shed light on the development of a method of oxidizing□β-methylanthraquinone and to synthesis a group of Anthraquinones derivatives, the most famous of which are Aloe Emodin, Rhein and Rheinal.

This study aims to identify the best conditions and factors through which □-β-methylanthraquinone is oxidized in terms of the appropriate oxidizing agent, its quantity, method of stirring, duration of stirring, temperature, and other factors, and to study the effect of each factor and choose the most appropriate .

Then, the various products of the oxidation process are separated and identified using scientific methods in order to benefit from them in various chemical processes.

In conclusion, the ideal conditions for the gradual oxidation process of □β-methylanthraquinone were determined by studying the effect of the amount of oxidant, temperature, and duration of heating on the oxidation reaction, and the intermediate products of the oxidation process were separated and identified using scientific methods .

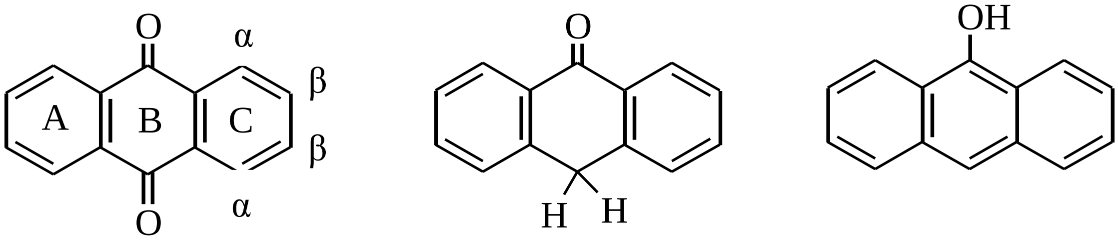
This method has the advantages of convenient operation, low cost, low pollution and easy manufacturing. These anthraquinone compounds can serve as new materials that can be widely applied in industries such as dyes, textiles, electronics, and papermaking.

The researcher recommends paying attention to: β-methylanthraquinone oxidation processes because it has multiple uses, such as manufacturing pharmaceutical raw materials, perfumes, chemical industries, and dyes, and it has significant therapeutic effects as anti-bacterial, anti-inflammatory, anti-viral, and anti-tumor.

Keywords: β-methylanthraquinone ، Oxidation ، Aloe Emodin, Rhein and Rheinal.

Introduction:

Anthraquinones constitute the largest (~90%) group of natural quinones. Their diversity is due to the presence in the structure of from one to eight substituents in the □α□- and β□-positions of rings A and C, the nature and relative location of the substituents, and different degrees of oxidation of rings (I, II, III) (Mireille et al. ,2017)(Muzychkina ,1998) (Fig. 1).



I
anthraquinone

II
anthrone

III
anthronol

Fig. 1 Quinone's and different degrees of oxidation of rings

The most common anthraquinones contain –OH, -OCH3, -CH3, -CH2OH, -CHO, -COOH groups and carbohydrate substituents (Fig. 2).

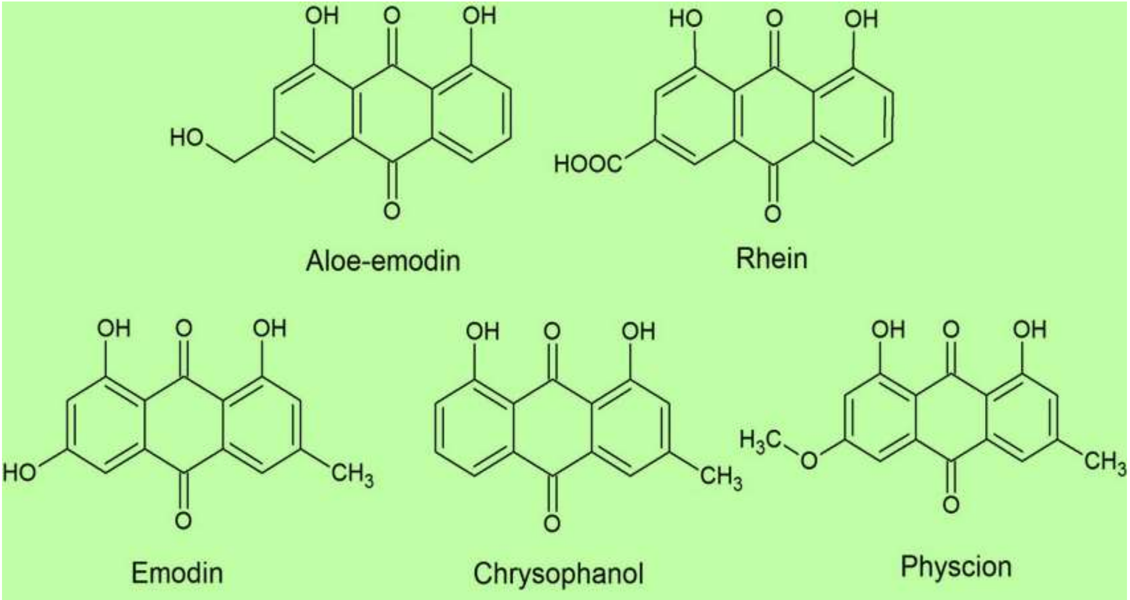


Fig. 2 The most common anthraquinones

The first information about the presence of anthracene derivatives in plant raw materials dates back to the beginning of the 20th century; to date, more than 700 of them have been described (Muzychkina ,1998).

9, 10-anthraquinone compounds are widespread in nature and are produced by the chemical industry in all developed countries of the world (Ram et al., 2004).

Historically, the first and still the main thing is their use as and for the production of organic dyes. Since ancient times, fabrics have been dyed with natural anthraquinone dyes, the most important of which was alizarin (Mohammad et al., 2019) (Khai et al., 2023) (Fig. 3).

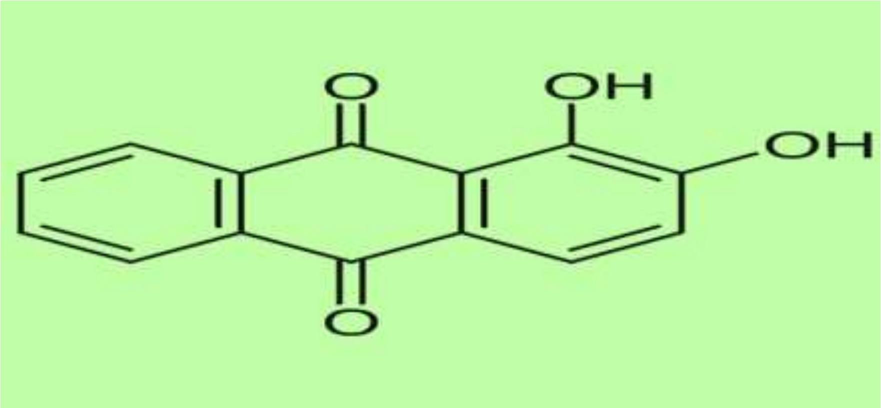


Fig. 3 Alizarin

Anthraquinone derivatives also serve as intermediate products for the production of polycyclic dyes, pigments and phosphors used in color photography and electrography, in optical quantum generators (lasers), liquid crystalline and photochromic materials, and scintillators (Jing et al., 2018) .

Currently, anthraquinone derivatives are used as catalysts for redox processes, including large-scale processes such as the production of hydrogen peroxide and cellulose (Qianhong et al., 2020).

Among anthraquinone compounds, drugs with various effects have been found (Abu Thaher, 2022).

Research into methods for the production of anthraquinones is experiencing rapid growth in connection with work on the synthesis of antibiotics - anthracyclines, which have pronounced anticarcinogenic properties (Muzychkina ,1998)(Abu Thaher, 2022) The anthraquinone series includes numerous analytical reagents (Amrita et al., 2016).

The use of anthraquinone derivatives as monomers, herbicides, fungicides, repellents, antioxidants, photoresists, and hydrogenation catalysts is described. There is no doubt that the uses of anthraquinones will continue to expand (Enas et al., 2016).

It is known that the oxidation products of 2-methylanthraquinone, used in the synthesis of a number of dyes, are of great value. Therefore, studying the oxidation reactions of these compounds is of great interest.

The literature describes numerous methods for oxidizing the □β-methyl group of anthraquinone into the carboxyl group with various oxidizing agents (Gorelik, 1983)(Ayyangar et al., 1961) (Karpukhin et al., 1971).

Our study differs from previous studies in several points:

1- In terms of the type of oxidizing agent, its quantity, and the method of adding it.

2- In terms of the heating method, duration of heating, and maximum heating temperatures.

3- For the first time, compound No. 2 was synthesized and identified using different means.

Despite the variety of methods for the oxidation of these compounds, intermediate products remain poorly studied.

This search is devoted to develop the method of oxidation□β-methylanthraquinone and to study of intermediate products of the oxidation of □β-methylanthraquinone into anthraquinone-β-carboxylic acid, the influence of temperature, the amount of oxidant and the duration of the reaction on the oxidation process.

Materials and Methods:

In the Department of Medicinal Plants of the National University of Pharmacy in Ukraine, under the supervision of Dr. N. S. Zhuravleva, we were able to develop the method of oxidation□β-methylanthraquinone.

A sample of 0.05 g (0.0002 mol) of chrysophanol (□β-methylanthraquinone) was dissolved under low heating in 2.5 ml of glacial acetic acid (CH_3COOH). To the reaction mixture, with vigorous stirring and heating in a water bath at a temperature not exceeding 70^0C, 0.15 g (0.0015 mol) (from 0.05 to 0.15 g) of thoroughly ground chromic anhydride (CrO_3) was added in parts. After heating the reaction mixture for 2 hours, substances I and II were detected; upon further heating for 1 hour, substance III was detected.

Oxidation products were studied by

- TLC – (thin layer chromatography) on Silufol UV-254 plates in the solvent system (hexane – ethyl acetate – acetic acid) (90:5:5) (system A) and
- Paper chromatography in the system (n-butanol – acetic acid – water) (4: 1:5) (system B).

Chromatograms were treated with various reagents: 5% sodium bicarbonate solution, aniline phthalate solution and 5% sodium hydroxide solution.

Compounds I and III were isolated using preparative chromatography; compound II could not be isolated.

Compound I is yellow-orange crystals with a melting point of 221-225° C. The UV spectrum of the alcohol solution has three intense maxima in the region of 225, 287, 430 nm, Rf = 0.14 (system A) and 0.85 (system B) - the spots after processing the chromatograms with a sodium hydroxide solution turned red (Fig. 4). (table. 1) (Scheme.1).

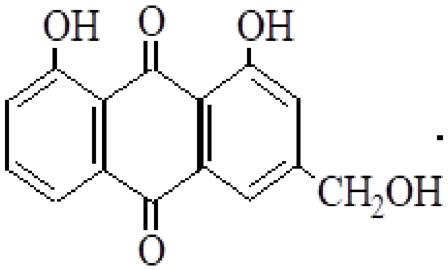


Fig. 4 Compound I

Compound III – yellow crystals with a melting point of 320-322°C. The UV spectrum of the alcohol solution has three maximums in the region of 230, 259, 436 nm, Rf = 0.61 (system A) and 0.57 (system B) - the spots after processing the chromatograms with a sodium bicarbonate solution turned red (carboxyl group) (Fig. 5) (table. 1) (Scheme.1).

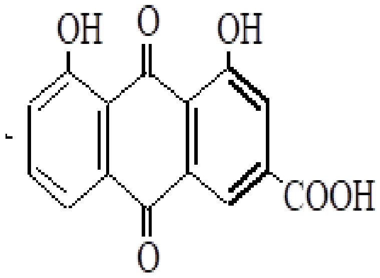


Fig. 5 Compound III

Compound II has a yellow color on the chromatogram, which, after treatment with a solution of aniline phthalate and subsequent heating, turns brown, which may indicate the presence of an aldehyde group in the compound molecule. Rf = 0.41 (system A) (Fig. 6) (table. 1) (Scheme.1).

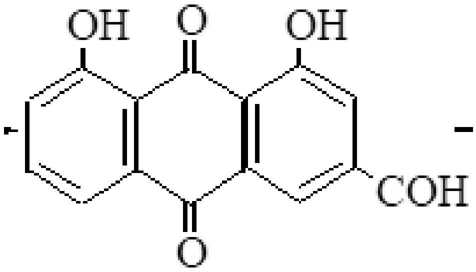
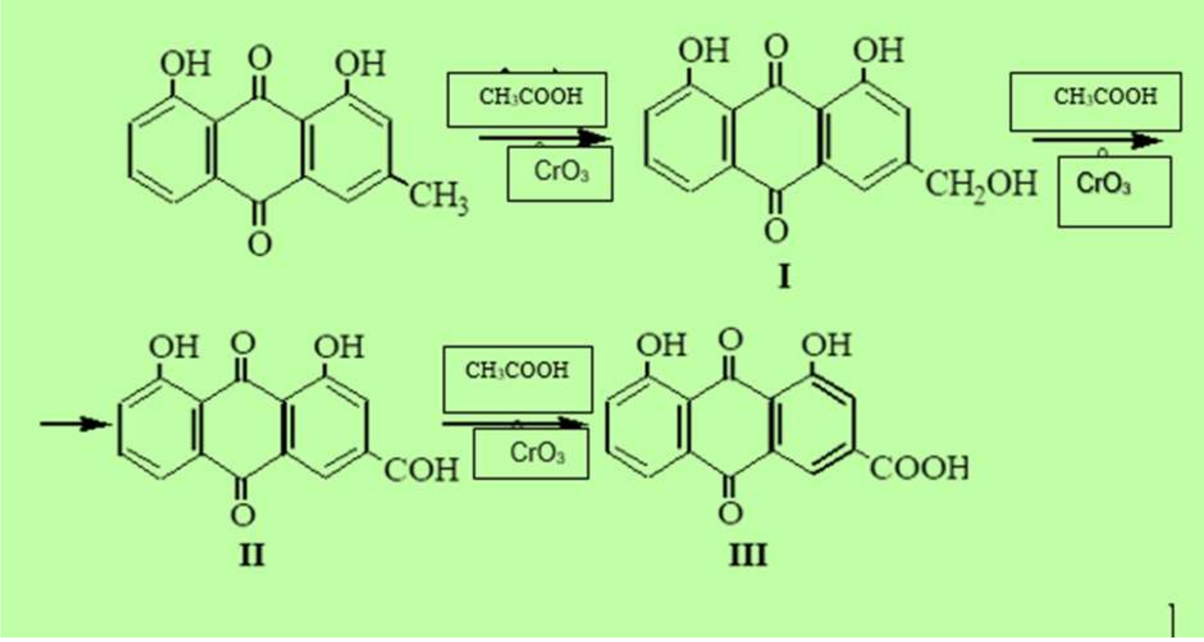


Fig. 6 Compound II



Scheme.1 β-methylanthraquinone oxidation

Table 1 : Physico-chemical properties of oxidation products

Compound	-R	Properties of compounds	
		m.p.^{0}C	R_f*
I	$-CH_2OH$	221-225	0,14 (A) 0,85 (B)
II	-COH	-	0,41 (A)
III	-COOH	320-323	0,61(A) 0,57(B)

* system: A - hexane – ethyl acetate – acetic acid (90:5:5)

System: B - n-butanol – acetic acid – water (4:1:5)

Results and Discussion:

One of the main tasks set for us was a detailed study of the intermediate products of the oxidation process of □β-methylanthraquinone and the study of the influence of various factors on this reaction.

Based on several attempts, it has been noted that the amount of chromic anhydride plays a very important role on the speed and completeness of the oxidation process. Thus, the interaction of 0.0002 mol of chrysophanol with 0.0015 mol of chromic anhydride at 70°C for 3 hours leads to the complete oxidation of the □β-methyl group into the □β-carboxyl group. The addition of chromic anhydride to the reaction mixture in small portions of 0.0005 mol every hour for 3 hours at the same temperature allowed us to isolate and establish the structure of the intermediate products of the synthesis (table.2).

Table 2 : Reaction conditions of method oxidation

Reaction conditions			
Amount of chromic anhydride, g	Temperature ^{0}C	Time, min	Compound
0,05-0,10	70	120	I
0,05-0,10	70-80	120	II
0,10-0,15	80	180	III

Based on physicochemical properties, spectral characteristics and based on the results of comparison with reliable samples, compound I was identified as aloe-emodin **Fig. 4** and (table. 1); compound III – rhein **Fig. 5** and (table. 1)

Based on chromatographic analysis and literature data (Bilal et al., 2011) (Agar et al., 1999) (Sudhir et al., 2005), it was assumed that compound II is rheinal **Fig. 6** and (table. 1).

This developed method has the advantages of convenient operation, low cost, low pollution and easy manufacturing. These anthraquinone compounds can serve as new materials that can be widely applied in industries such as dyes, textiles, electronics, and papermaking.

Conclusions

In conclusion, by examining the effects of oxidant concentration, temperature, and heating time on the oxidation reaction, the optimal conditions for the gradual oxidation process of β-methylanthraquinone were established. Additionally, scientific techniques were employed to separate and identify the intermediate products of the oxidation process.

The advantages of this approach are easy manufacture, low cost, minimal pollution, and convenient operation. These anthraquinone compounds have the potential to be novel materials with extensive applications in the paper, textile, electronics, and dye sectors.

Acknowledgments:

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تطوير طريقة اكسدة (β-methylanthraquinone) لتحضير Aloe Emodin, Rhein and Rheinal

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ملخص الدراسة:

تهدف هذه الدراسة الى القاء الضوء على تطوير طريقة اكسدة β-methylanthraquinone لتحضير مجموعة من مشتقات Anthraquinones ومن اشهرها Aloe Emodin, Rhein and Rheinal .

وتهدف هذه الدراسة الى التعرف على افضل الظروف والعوامل التي يتم من خلالها اكسدة β-methylanthraquinone من حيث العامل المؤكسد المناسب وكميته وطريقة التحريك ومدة التحريك ودرجة الحرارة وغيرها من العوامل ودراسة تأثير كل عامل واختيار الأنسب .

وثم فصل نواتج عملية الاكسدة المختلفة والتعرف عليها بالطرق العلمية من اجل الاستفادة منها في العمليات الكيميائية المختلفة.

في الخلاصة تم تحديد الظروف المثالية لعملية اكسدة β-methylanthraquinone التدريجية من خلال دراسة تأثير كمية المادة المؤكسدة ودرجة الحرارة ومدة التسخين على تفاعل الأكسدة و تم فصل المنتجات الوسيطة لعملية الأكسدة والتعرف عليها بالطرق العلمية .

تتميز هذه الطريقة بمزايا التشغيل المريح والتكلفة المنخفضة والتلوث المنخفض والتصنيع السهل. يمكن أن يكون لهذه المركبات الأنثراكينونية بمثابة مواد جديدة يمكن تطبيقها على نطاق واسع في صناعات مثل الأصباغ والمنسوجات والإلكترونيات وصناعة الورق

يوصي الباحث بالاهتمام: بعمليات اكسدة β-methylanthraquinone لان لها استخدامات متعددة مثل تصنيع المواد الخام الصيدلانية و العطور والصناعات الكيميائية والاصباغ ولها تأثيرات علاجية كبيرة كمضادة للبكتيريا والالتهابات والفيروسات والمضادة للأورام.

الكلمات المفتاحية: β-methylanthraquinone ، الاكسدة ، Aloe Emodin, Rhein and Rheinal.