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Review
Using 2,4-dinitrophenylhydrazine in spectrophotometric determination

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Abstract

2,4-Dinitrophenylhydrazine (2,4-Dnphh) is substituted hydrazine. It is structure contains hydrazine which is the main active functional group. 2,4-Dnphh is an important reagent in analytical chemistry it is used firstly in the identification (qualitative analysis) of carbonyl groups (aldehyde and ketones compounds). 2,4-Dnphh is react with aliphatic and aromatic carbonyl compounds to produce the corresponding 2,4-dinitrophenyl-hydrazone. The aromatic carbonyls give red precipitates compared with aliphatic carbonyls giving more yellow color. The two colored products were achieved according to the addition-elimination reaction, the reaction included nucleophilic addition of amino group (-NH2) to the carbonyl group(C=O), then the elimination of the H_2O molecule. Also, a modification of 2,4-Dnphh to produce a derivative can be used as a chemical sensor for some colorimetric detection of various compounds. Recently 2,4-Dnphh is used in quantitative spectrophotometric estimation of various compounds via oxidative coupling reaction and diazotization-coupling reaction, and also 2,4-dinitrophenylhydrazone-compound prepared from the reaction of 2,4-Dnphh with compound to be determined give good results in injection to the column of high-performance liquid chromatography. The present review included all methods as possible in the literature including the uses of 2,4-Dnphh in the qualitative and quantitative determination of various compounds.

Introduction:

2,4-Dinitrophenylhydrazine is one of the important organic compounds has the chemical formula [C6H3(NO2)2NHNH2]. 2,4-Dnphh is a solid compound with orange-red color, it is chemical structure (Figure 1) contains two nitro groups in ortho and para positions to hydrazine so it is substituted hydrazine.

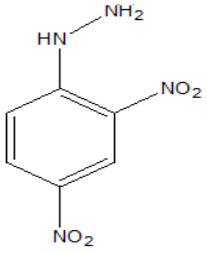
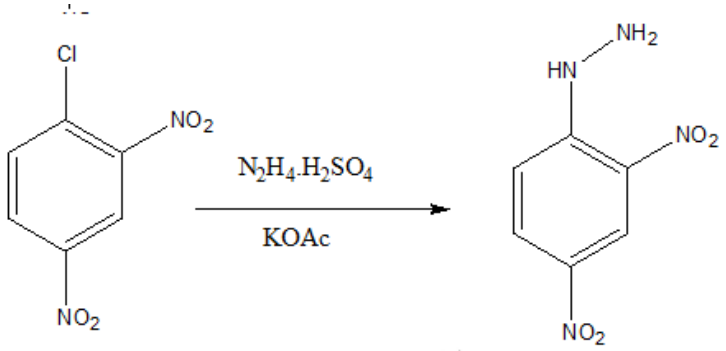


Fig. 1: The chemical structure of 2,4-Dnphh.

2,4-Dnphh can be prepared by the reaction of 2,4-dinitrochlorobenzene with hydrazine sulphate in the presence of $N_2H_4.H_2SO_4$ and KOAc (Scheme 1)[1].



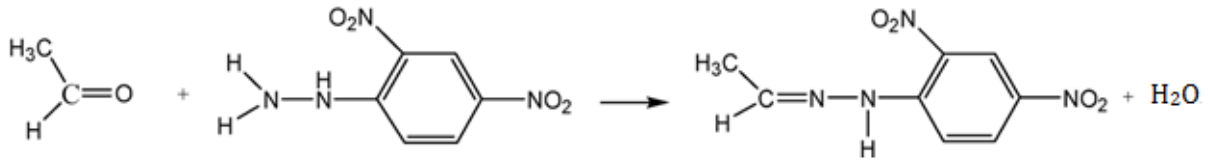
Scheme 1: Preparation of 2,4-Dnphh.

Dissolving 2,4-Dnphh in aqueous solution to prepared Brady's reagent, to be used for the identification of carbonyl compounds (aldehyde and ketone).

Other researchers prepared Brady's reagent or Borche's reagent, by dissolving 2,4-dinitrophenylhydrazine in a mixture solution containing methanol and a few milliliters of concentrated sulfuric acid[2].

The formation of a yellow, orange or red precipitate is indicated as a positive test of the presences of carbonyl groups. The aromatic carbonyls give red precipitates compared with aliphatic carbonyls give a more intense yellow color.[3]

2,4-Dnphh can reacts with aldehydes and also with ketones to form a 2,4-dinitrophenylhydrazone. An example reaction with ethanal [4] (Scheme 2).



Scheme 2: Reaction of 2,4–Dnphh with ethanal.

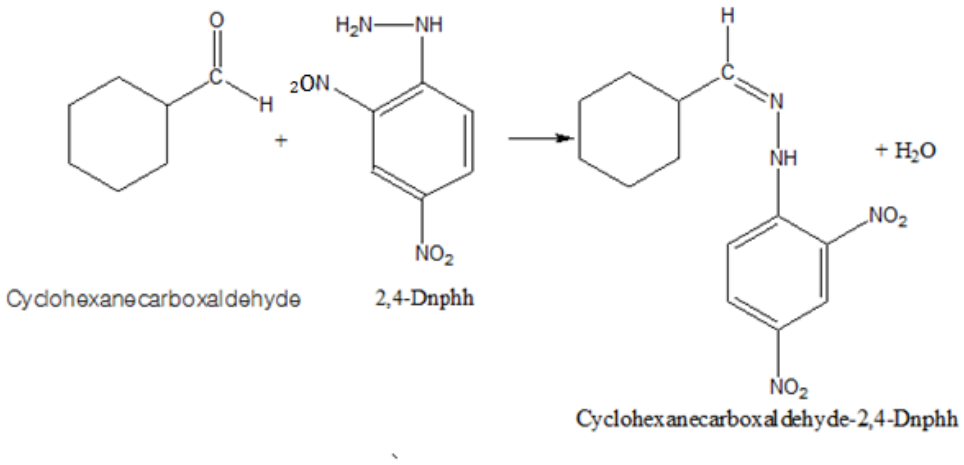
The condensation reaction to form the product (hydrazone) from the reaction of ketone with 2,4-Dnphh included loss of water, this suggested mechanism can be considered as an example of addition-elimination reaction, of the amino group (-NH2) undergo nucleophilic addition to the carbonyl group(C=O), then the elimination of a water molecule, as per the following equation:[5].

$RR'C=O + C_6H_3(NO_2)_2NHNH_2 \rightarrow C_6H_3(NO_2)_2NHN=CRR' + H_2O$

Recently a modification of the derivative 2,4- dinitrophenylhydrazine dithiocarbamate - silver nanoparticles can be used as am chemical sensor for some colorimetric detection of various compounds such as omeprazole [6].

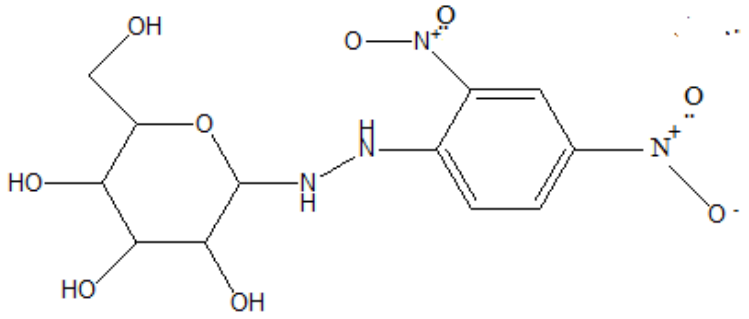
The liquid carbonyl compounds, for example, cyclohexanone can react with 2,4-Dnphh to produce solid derivatives. The reaction happens at one of the two NH_2 groups. The ion-pair

electrons of the NH_2 group attached to the carbonyl is less nucleophilic compared to those of the other NH_2 group (Scheme 3) [7].



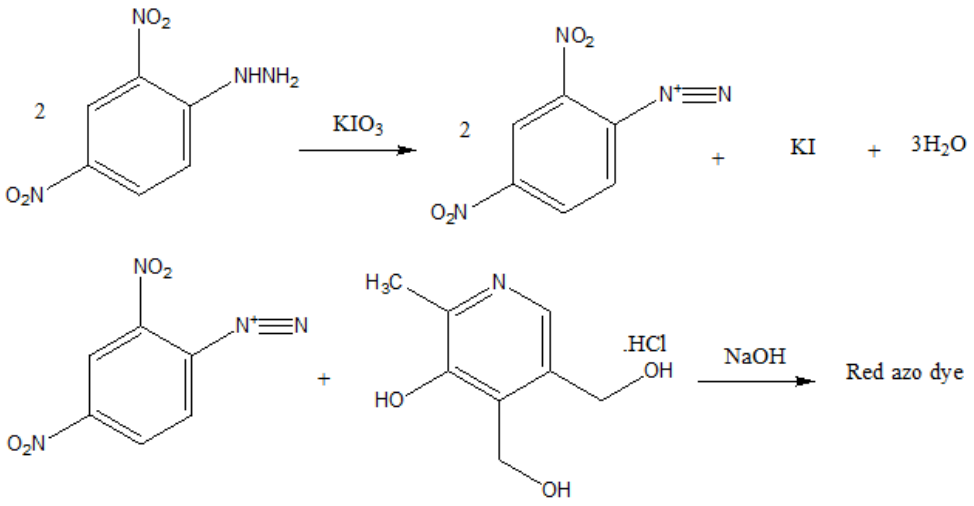
Scheme 3: The suggested reaction of cyclohexanone with 2,4-Dnphh.

2,4-Dnphh has been often used as a derivatizing agent for carbonyl compounds, including reducing compounds for example glucose to form 2,4-Dnphh- glucose derivative (Scheme 4), acetaldehyde, and various carbonyl groups, and these derivatives can easily determination by HPLC techniques. [8-10].



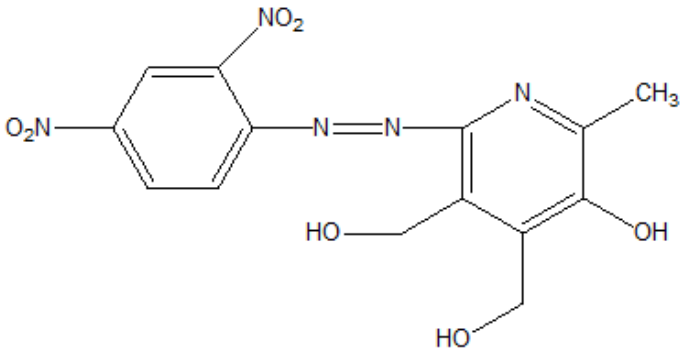
Scheme 4: 2,4-Dnphh- glucose derivative.

It has been shown that 2,4-Dnphh can be oxidized by various oxidizing agents such as potassium iodate or sodium periodate to produce diazotized 2,4- Dnphh as an intermediate compound which later can be under go coupling reaction with other compounds such as pyridoxine hydrochloride in alkaline medium to produce red azo dye that has the highest absorption at the wavelength of 522 nm. The proposed reactions as shown below in Scheme 5 [11].



Scheme 5: The proposed reactions to produce the red azo dye

The suggested structure of red azo dye is shown below.



Through the literature survey, many researchers used 2,4- Dnphh reagent in the estimation of various compounds. The reaction mechanism was explained concerning oxidation and coupling reaction, relying mainly on the use of the oxidizing agent in the first step of the reaction, and below Table 1 includes these types of reactions

Table 1: Using 2,4- Dnphh in determination various compound via oxidative coupling reaction.

Compound	λmax ,nm	Linearity µg/ml	ε L/mol.cm	Reference
Fungicide dithianon	550	.....	.....	[12]
Selenium(IV)	520	0.03-3.5	$3.1x10^4$	[13]
Vanadium	495	0.02-3.5		[14]
Vitamin C	280	.....	0.0323	[15]
Atorvastatin	479	4-10	$558.65 X10^3$	[16]
Ezetimibe	457	4-12	$409.34X10^3$	
Acyclovir&	414	20-60	.....	[17]
Ganciclovir	450	5-25		
Modafinil	476	2-7	$3.3297x10^5$	[18]
Carbamazepine	485	4-50	$6.7335x10^3$	[19]
Bisacodyl	522	2-20	6505	[20]
Mefenamic acid	528	2-8	$3.6873x10^4$	[21]
Sulphadiazine	486	3-15	$2.23x10^4$	[22]
Propranolol hydrochloride	481	1-35	6224.16	[23]
Catechol	385	1-40	$5.0866x10^3$	[24]
Resorcinol	404	1-25	$4.404x10^3$	
Lansoprazole	484.5	1-30	13260.132	[25]
Nateglinide	480	30-100	$0.331054x10^3$	[26]
Pregabalin	461	50-450	$0.273824x10^3$	[27]
Clopidogrel	412	10-30	$0.8817x10^4$	[28]
Gemfibrozil	421	2-10	$2.6081x10^4$	

While Table 2 also includes the estimation of various compounds, the researchers suggested an explanation for the reaction based on the principle of diazotization and coupling, depending on the interpretation of the formation of corresponding diazonium salt of 2,4-Dnphh when the reagent was oxidized by the oxidizing reagents.

Table 2: Using 2,4- Dnphh in determination various compounds via diazotization and coupling reaction.

Compound	λmax ,nm	Linearity µg/ml	ε L/mol.cm	Reference
Salbutamol	540	2.5-17	$2.19X10^4$	[29]
Ritodrine	510	2-29	$0.74X10^4$	
Amoxicillin Isoxsuprine	520	4-33	$1.00X10^4$	
	520	5-30	$8.04X10^4$	
Thymol	570	0.25-10	$2.2X10^4$	[30]
Diclofenac sodium	600	0.5-40	$2.0994x10^4$	[31]
Cefadroxil	515	7.5-75	7x103	[32]
Oxymetazoline hydrochloride	607	2.5-30	7242	[33]
Sulfathiazole	492	2-28	$1.1437x10^4$	[34]
Paracetamol	430	0.5-18.4 mg.mL-1	$2.776x10^4$	[35]
Tetracycline hydrochloride	360	0.1-9	$1.262x10^4$	[36]
Dopamine	560	5-50	$7.9x10^4$	[37]
Sulphamethoxazole	435	2-14	14412.77	[38]

Table 3 included the compounds determined via condensation reaction with 2,4-Dnphh to produce the corresponding hydrazone.

Table 3: Using 2,4- Dnphh in determination various compounds via condensation reaction.

Compound	λmax ,nm	Linearity µg/ml	ε L/mol.cm	Reference
Josamycin	411	10-160	.....	[39]
Eplerenone	430	5-35	3.177x104	[40]
Sitagliptin phosphate	400	2-10	0.2485x10-4	[41]
Cilostazol	355	2-20	2.2980x104	[42]
Haloperidol	456	3.6-10.8	2.84x104	[43]
Artemisinin	310	0.5-60	2.930x 104	[44]
Dihydroartemisinin	300	0.5-50	2.8x104	
Macrolide	542-545	5-40	1.48x104	[45]
antibiotrics	523-526	5-35	2.59x104	
	539-542	5-35	2.10x104	
Tolperrisone	520	2.5-15	2.4x104	[46]
Lamivudine	438	5-35	.....	[47]
Reactive carbonyl in proteins and peptides	370	.....	.....	[48]

Conclusion

2,4-Dinitrophenylhydrazine is an important reagent used to identify(qualitative) of carbonyl groups (aldehyde and ketones compounds), and also it is used in quantitative spectrophotometric determination of various compounds via various types of reactions, such as oxidative coupling, diazotization and coupling reaction and reacted with aliphatic and aromatic carbonyl compounds to produce the corresponding 2,4- dinitrophenyl-hydrazone (addition-elimination) reactions.

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مراجعة: استخدام 4،2- ثنائي نيتروفنيل هيدرازين في التقدير الطيفي

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4،2- ثنائي نيتروفينيل هيدرازين,الديهايدات وكيتونات,طرائق طيفية,الاكسدة والاقتران,الازوتة والاقتران

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الخلاصة:

يعد 4،2- ثنائي نيتروفينيل هيدرازين من معوضات الهيدرازين. إذ يحتوي في تركيبه على الهيدرازين وهو المجموعة الوظيفية الرئيسية النشطة. ويعد كاشف مهم في الكيمياء التحليلية اذ تم استخدامه أولاً في التشخيص النوعي لمجموعات الكاربونيل (مركبات الألديهايد والكيتونات). وذلك بتفاعله مع مركبات الكربونيل الأليفاتية والاروماتية لإنتاج 4،2- ثنائي نتروفينيل-هيدرازون المقابل. تعطي مركبات الكاربونيل الاروماتية رواسب حمراء مقارنة مع مركبات الكربونيل الأليفاتية التي تعطي على الاغلب اللون الأصفر. تم التحقق من الناتجين ذو اللونين ووجدا انهما يسيران وفقًا لتفاعل الإضافة والحذف، يتضمن التفاعل اضافة المجموعة الأمينية (-NH2) إلى مجموعة الكاربونيل (C = O) ، ثم عملية حذف جزيئة ماء. أيضًا يمكن استخدام الكاشف 2،4- ثنائي نيتروفينيل هيدرازين لإنتاج مشتق بوصفه مستشعر كيميائي يستخدم للكشف اللوني للمركبات المختلفة. تم استخدام 2،4- ثنائي نيتروفينيل هيدرازين مؤخرًا في التقدير الطيفي الكمي للمركبات المختلفة عن طريق تفاعل الاقتران التاكسدي وتفاعل الأزوتة والاقتران، وكذلك 2،4- ثنائي نتروفينيل هيدرازون المحضر من التفاعل مع المركب المراد تحديده يعطي نتائج جيدة في الحقن في عمود كروماتوغرافيا السائل عال الأداء. تضمنت المراجعة الحالية جميع الطرائق المتوفرة في الأدبيات التي تضمنت استخدامات 4،2- ثنائي نيتروفينيل هيدرازين في التقدير النوعي والكمي للمركبات المختلفة.