



Dye Sensitized Solar Cell Properties And Spore Germination Inhibition Activities Of Hydralazine Hydrochloride And Its Derivatives.

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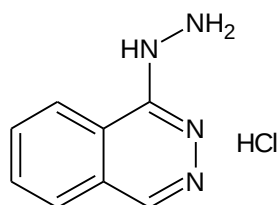
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Abstract: Hydralazine hydrochloride with its rich electron donating center as Nitrogen finds wide applications in medical and well as analytical fields. It is used as a vasodilator and complexing agent for Iron in spectroscopic studies. This paper reports the synthesis of hydralazine hydrochloride from naphthalene and the potential spore germination inhibition activities of the products formed in every step. Compounds 1-Hydrophthalazine, 1-Chlorophthalazine and Hydralazine Hydrochloride showed very good activity against *Fusarium oxysporum* in comparison to the standard fluconazole. The same three compounds are having considerable activity against *Curvularia lunata* also. 1-Chlorophthalazine and Hydralazine Hydrochloride showed very good photovoltaic activity of 0.85 and 0.425 % respectively under artificial irradiation. It showed an average of 1.3 mA of current output under direct sun illumination. Further studies incorporating few combination of dyes would further increase the current production of the DSSC's and make it environmental friendly.

Index Terms - Hydralazine hydrochloride, 1-Chloro phthalazine, Apresoline, DSSC, Spore germination inhibition.

I. INTRODUCTION

Hydralazine hydrochloride, also known as Apresoline, is a medication classified as an antihypertensive and vasodilator, primarily used to treat high blood pressure (hypertension) and heart failure. It works by relaxing the smooth muscles in blood vessels, causing the dilation of arteries and a reduction in systemic vascular resistance. This leads to lower blood pressure and less strain on the heart. Hydralazine is especially beneficial in cases where other antihypertensive medications may be unsuitable or ineffective. The drug contains a nucleophilic hydrazine group, which binds to free and protein-bound aldehydes, forming stable hydrazones and suggesting that hydralazine has anti-atherogenic properties.



1-Hydralazine hydrochloride

Hydralazine is commonly used in combination with other medications, such as diuretics or beta-blockers, to enhance its antihypertensive effects and help manage symptoms of heart failure. While it is usually administered orally, it can also be given intravenously in acute situations. Additionally, an orodispersible formulation of hydralazine has proven effective for patients who have difficulty swallowing other forms of the medication. Determining iron in real samples is no longer considered a significant analytical challenge; however, the use of alternative complexing agents for this purpose remains highly appealing. Some existing analytical methods have already utilized commercial drugs to measure iron content. For example, antibiotics such as chlortetracycline and norfloxacin have been employed to quantify Fe^{3+} in real samples. Hydralazine hydrochloride has also been reported as an alternative complexometric reagent for spectrometric determination of total iron content and has been successfully applied to real samples¹⁻⁷.

The release of drugs from microspheres can be controlled by factors such as the extent and nature of cross-linking, the size of the microspheres, and the level of drug incorporation. This particular drug was synthesized in our laboratory using standard procedures.

Recent developments in photovoltaic technology have brought Dye-Sensitized Solar Cells (DSSCs), also known as Grätzel cells, into the spotlight. Developed by Michael Grätzel and Brian in the 1990s, these cells have gained significant attention for their high solar-to-electric conversion efficiency, reproducibility, cost-effectiveness, and versatility. A standard DSSC consists of a dye (photosensitizer), an electrolyte solution, and a semiconductor material, typically TiO_2 . The dye absorbs sunlight, gets excited, and transfers electrons to the semiconductor, which then carries them to the electrode to generate current. Since the initial DSSC energy conversion of 7.1%, efficiency has improved to 11.5%. A device made of fluorine-doped glass slides measuring 5 cm by 5 cm can achieve 5.52% energy conversion. G24 Innovation Ltd., using the technology pioneered by Grätzel, manufactures flexible DSSC modules through a low-cost, roll-to-roll process, producing 0.5 watts of power under direct sunlight. Miyasaka et al. developed a large-scale 2.1 m by 0.8 m DSSC module with eight 10 cm panels¹⁻¹⁵. Two synthesized compounds with extensive conjugation were subjected to photovoltaic analysis⁸⁻¹⁵.

Microbial contamination of food is a persistent challenge that significantly impacts crop production and determines the shelf life of both processed and unprocessed foods. Fungi, bacteria, and viruses cause considerable yield losses, which are becoming more critical as the global population grows rapidly, increasing the demand for food. Food and agricultural product contamination is particularly problematic in tropical and subtropical regions, where the climate and agricultural practices favor fungal growth and toxin production. As a result, fungal contamination of grains can occur both in the field and during storage, with the level of contamination largely influencing the rate of grain deterioration. Grains stored for long periods before consumption or distribution are especially vulnerable to mycotoxin contamination, although toxin production can begin even before harvesting or storage. The main fungal species affecting crops in the field include those from the genera *Alternaria*, *Cladosporium*, *Fusarium*, *Curvularia lunata*, and *Drechslera*. *Fusarium* and *Aspergillus* species, such as *F. verticillioides*, *F. proliferatum*, *A. flavus*, and *A. parasiticus*, are the most common contaminants of corn worldwide.

Once viable, fungal spores will eventually germinate. In the case of mycelial fungi, germination typically involves the production of one or more germ tubes. Before a germ tube emerges, many spores need an external nutrient supply, followed by hydration, swelling, and an increase in metabolic activity. The use of pesticides raises environmental concerns, making it essential to explore better alternatives. The compounds we have synthesized are water- or ethanol-soluble, making them promising candidates for antifungal activity. These compounds were tested for their ability to inhibit spore germination using the cavity slide method, with *Fusarium oxysporum* and *Curvularia lunata* strains.

II. MATERIALS AND METHOD

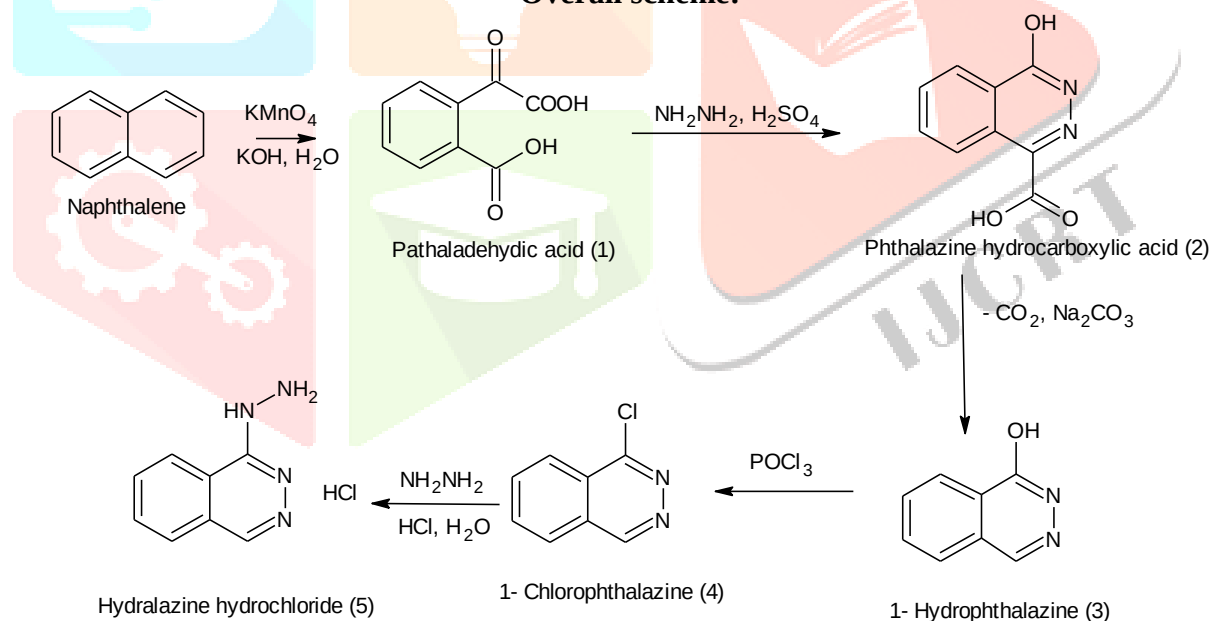
The synthesized compound are preliminary examined by melting point (Open capillary method) determination it is confirmed by IR (KBr) and NMR spectral date (400 mHz). All organic solvents used for the synthesis of analytical grade.

The chemicals used for organic synthesis, are as follows:

Compound name	Molecular formula	Molecular weight	Density	Company	Assay
Naphthalene	C ₁₀ H ₈	128.17	1.025	Sigma-Aldrich	98.0%-102.0%
Potassium Hydroxide	KOH	56.11	2.04		85.0%-100.0%
Potassium permanganate	KMnO ₄	158.03	2.70		99.0%-101.0%
Hydrochloric acid	HCl	34.46	1.18		36.5%-38.0%
Sulphuric acid	H ₂ SO ₄	98.08	1.84		95.0%-98.0%
Sodium carbonate	Na ₂ CO ₃	105.99	2.54		99.0%-101.0%
Acetic acid	CH ₃ COOH	60.05	1.049		99.0%-101.0%
Phosphorous oxychlride	POCl ₃	153.33	1.67		98.0%-102%
Hydrazine hydrate	C ₈ H ₈ N ₄ .HCl. H ₂ O	214.67	1.35		98.0%-102%

Synthesis of Hydralazine hydrochloride

Overall scheme:



A Synthesis of **Phthalaldehydic acid**

5 grams of Naphthalene was taken into a clean, dry round-bottom flask, 50 ml of potassium hydroxide solution was added and stirred until dissolution. Potassium permanganate solution was then added to the RB flask dropwise with continuous stirring until clear solution was obtained. Resulting clear solution was filtered and washed with cold water. Neutralized the filtrate with Hydrochloric acid, cooled the solution to induce crystallization, separated solid by filtration dried, recrystallized and melting point was determined.

B Synthesis of **Phthalazine hydrocorboxylic acid**

3 grams of Phthalaldehydic acid was taken into a clean dry round bottom flask. 10 ml of concentrated Sulphuric acid (H₂SO₄) was slowly added to it with stirring. Hydrazine Hydrate was added dropwise to the reaction mixture while stirring until the solution becomes solid. On addition of ice water solid separated. They solid was filtered dried, recrystallized and melting point was determined.

C Synthesis of 1-Hydrophthalazine

3 grams of Phthalazine hydrocarboxylic acid was taken into a clean round bottom flask. Sodium Carbonate solution was added to it and stirred until dissolution. A piece of Copper metal was then added to the reaction mixture, boiled for 30-40 minutes or until the solution turned dark brown, cool to room temperature and acetic acid was added slowly to the cooled solution while stirring until precipitation occurs. The separated solid was filtered, dried, recrystallized and melting point determined.

D Synthesis of 1-Chlorophthalazine

3 grams of 1-Hydrophthalazine was taken into a clean dry round bottom flask. POCl_3 was added dropwise to the reaction mixture with stirring. Stirring was continued until reaction was complete. The solid that separated was filtered, dried, recrystallized and melting point determined.

E Synthesis of Hydralazine Hydrochloride

1gram of 1-Chlorophthalazine was taken into a clean dry round bottom flask. Hydralazine Hydrate was added to the mixture with constant stirring for 10-15 minutes. Hydrochloric Acid (1-2ml) was added to the reaction mixture and allowed the mixture to stand for 10 minutes, solid separated. The solid that separated was filtered, dried, recrystallized and melting point determined.

III. RESULTS AND DISCUSSION

All synthesized compounds were confirmed through IR and NMR spectra and are as shown in Figure 1 to Figure 7. The spectral details are summarized in Table-1. These were in correlation with the already reported data and hence taken up for further studies.

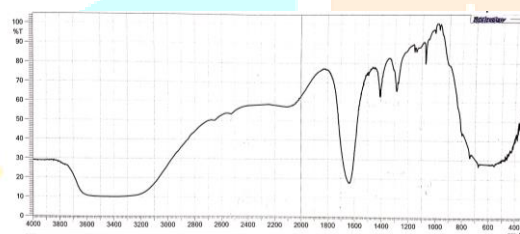


Figure-1: IR of pathaladehydic acid (1)

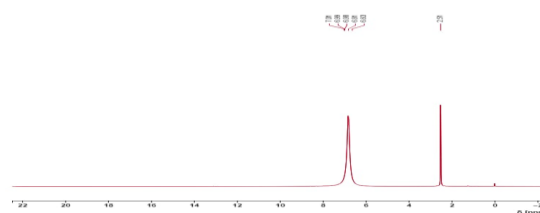


Figure-2: NMR of pathaladehydic acid (1)

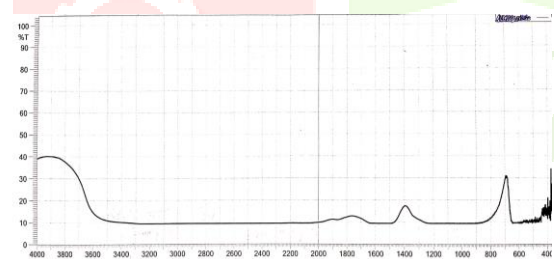


Figure-3: IR of Phthalazine hydrocarboxylic acid (2)

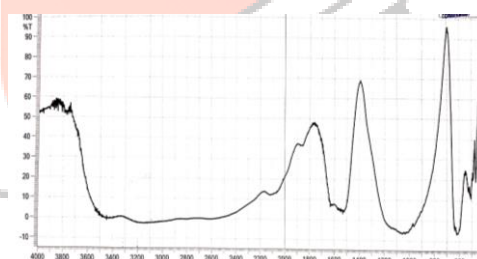


Figure-4: IR of 1-Hydrophthalazine (3)

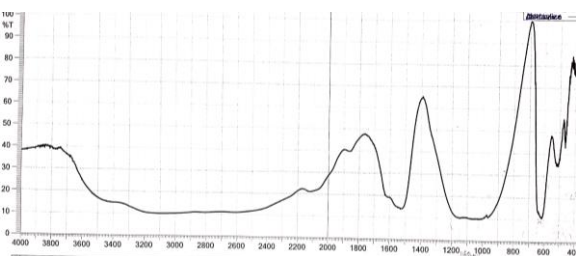


Figure-5: IR of 1-Chlorophthalazine (4)

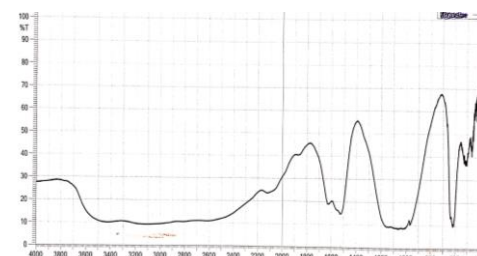


Figure-6: IR of Hydralazine hydrochloride (5)

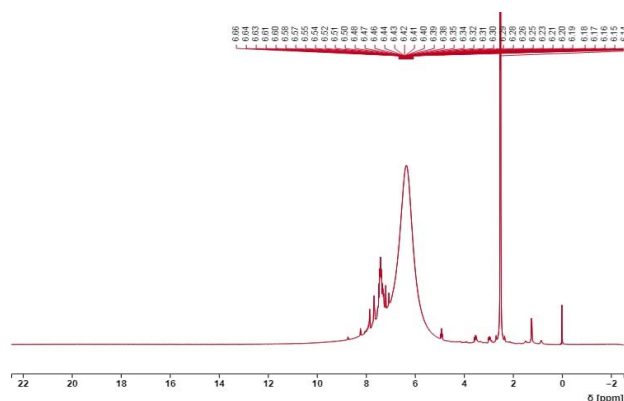


Figure-7: NMR of Hydralazine hydrochloride (5)

Table -1: Spectral details , physical constant and yield.

Comp. No.	IR	NMR (δ ppm)	MP/BP (°C)	Percentage Yield (%)
1	2500-3300(-COOH) 1500-1430(Benzene ring)	6.42 6.29	230	44.75
2	1300-1000(-CO)	-	245	35.6
3	3320 (-NH)	-	208	78.14
4	3200(-OH)	-	160	58.08
5	1500-1650(-NH ₂)	6.98 2.51	275	73.12

SPORE GERMINATION INHIBITION ACTIVITY

Talbe-2 shows the results of spore germination inhibition activity of all the synthesized compounds along with standard and control.

Table 2: Spore germination inhibition activity of the synthetic compounds

Compound code (0.05 g)	Standard (Fluconazole)	Control	<i>Fusarium oxysporum</i> NCIM 1281	<i>Curvularia lunata</i> NCIM 1131
1	97% ± 0.04 and 95% ± 0.04	Distilled water – 0% DMF– 0%	95.3 ± 0.04	91 ± 0.04
2			93.3 ± 0.04	80 ± 0.04
3			98.3 ± 0.04	95 ± 0.04
4			97.3 ± 0.04	94 ± 0.04
5			96 ± 0.04	91 ± 0.04

Key: p < 0.05 – Significant

Compounds 3, 4 and 5 show very good activity against *Fusarium oxysporum* in comparison to the standard fluconazole. The same three compounds are having considerable activity against *Curvularia lunata* also.

P-V STUDIES

The following PV graphs were obtained for the different DSSC prepared using, synthesized 1-chlorophthalazine and Hydralazine hydrochloride as dyes. All slides were illuminated at a distance of 14 cm from source using tungsten filament as source. Control slides were done with plain solutions of different pH. All control slides showed no conductivity. The results were plotted using MS Origin and are as shown in figure-2 and Figure-3.

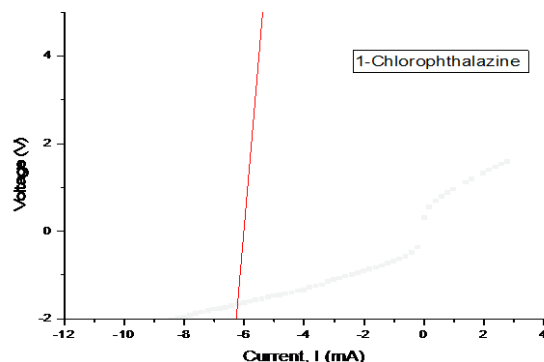


Figure -2: I vs V graph of DSSC prepared using 1-chlorophthalazine as dye
Cell efficiency = 0.85 %

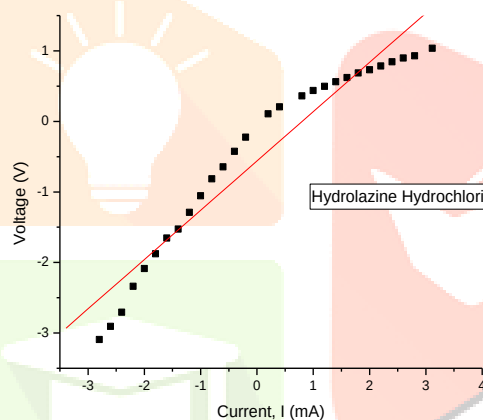


Figure -3: I vs V graph of DSSC prepared using hydralazine hydrochloride as dye
Cell efficiency = 0.425 %

IV. CONCLUSION

The synthesis of hydralazine hydrochloride is cost efficient, green and gives results in good yield. Phthalazine hydrocarboxylic acid (3), 1-Chlorophthalazine (4) and Hydralazine hydrochloride (5) show very good antifungal activities and hence can be adopted as a natural pesticide. 1-Chlorophthalazine and Hydrolazine Hydrochloride showed very good photovoltaic activity of 0.85 and 0.425 % respectively under artificial irradiation. It showed an average of 1.3 mA of current output under direct sun illumination.

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