



Sustainable production and spectroscopic study of novel heterocyclic compounds synthesized from Carbendazim via green chemistry

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KEYWORDS

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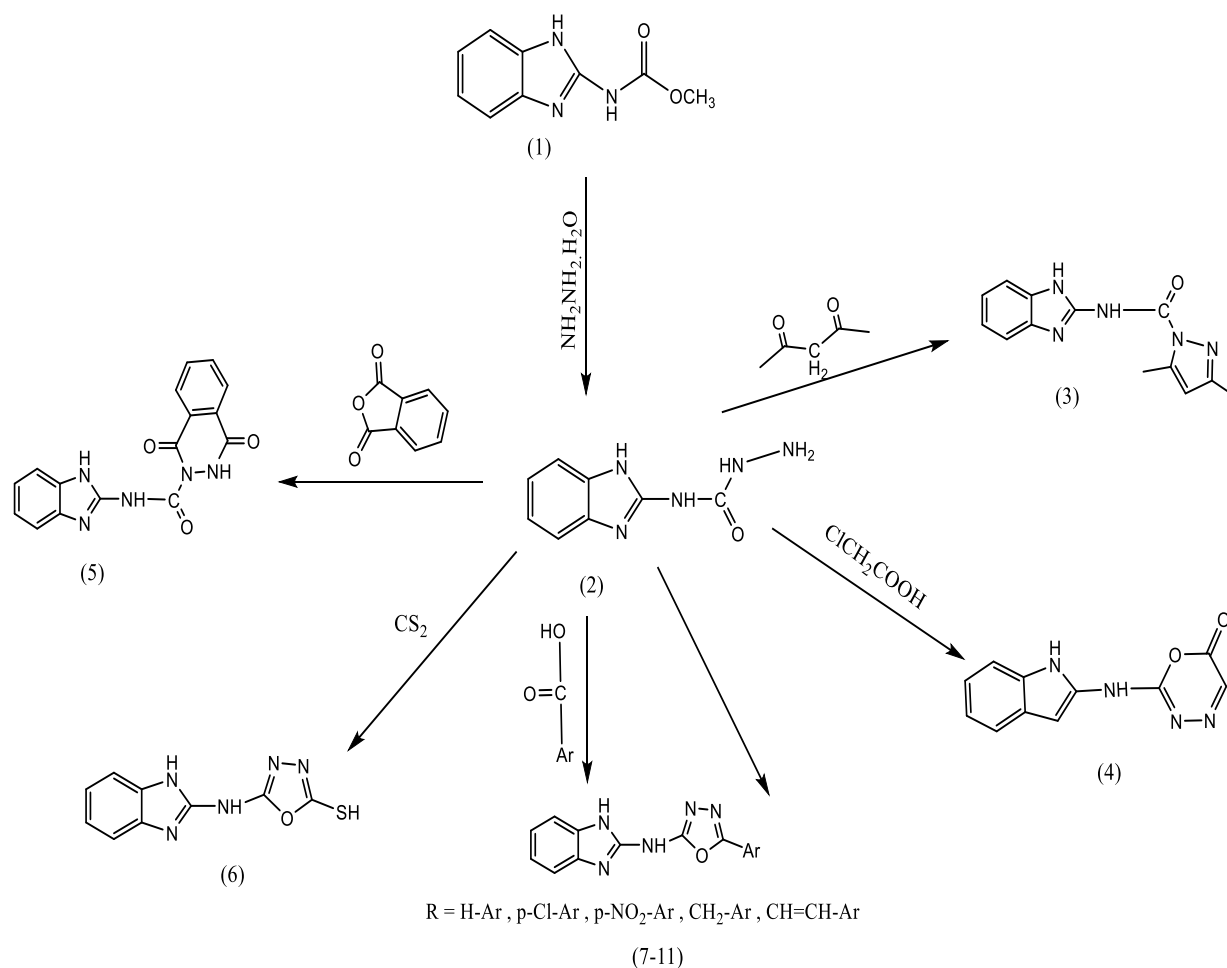
ABSTRACT:

In this research, a series of heterocyclic compounds with both five-membered and six-membered rings were synthesized. These compounds include oxadiazole, thiadiazol, thiazole, oxadiazine, thiadiazine, and triazine, among others. The synthesis process began with the conversion of the ester carbendazim into a hydrazide, followed by its reaction with various reagents, resulting in a sequence of compounds labeled as (3-6). Subsequently, these hydrazides were treated with benzoic acid derivatives, leading to the formation of compounds labeled as (7-11) in a sequential manner. This synthesis approach resulted in a range of heterocyclic compounds for further study and analysis.

I. INTRODUCTION

Carbendazim, also known as Benzimidazole, is a chemical compound that plays a pivotal role in safeguarding plants against pests and harmful insects. This contributes significantly to elevating crop productivity and preserving crop quality, thereby aiding in meeting the global food demand [1]. Nonetheless, with advancements in chemistry and scientific research, there is an exploration of the potential for creating novel organic compounds derived from Carbendazim. These derivatives exhibit distinct structural

features, incorporating both five-membered and six-membered rings, which contribute to their diverse properties and interactions within biological systems [2,3]. The purpose of these studies is to deepen our comprehension of the properties and reactions of Carbendazim and its derivatives. Furthermore, these newly developed compounds have the potential to enhance agriculture and environmental preservation [4,5]. The analysis and assessment of these compounds pave the way for innovative applications in agriculture, plant conservation, and environmental sustainability.



SCHEM I: Synthesis Compounds (2-11)

II. EXPERIMENTAL WORK

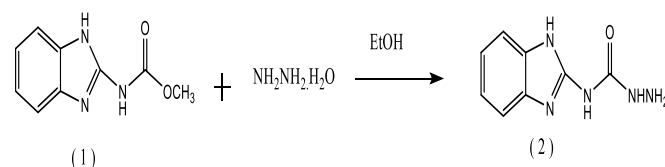
2.1-Materials:

All chemicals and solvents utilized in the research were sourced from reputable suppliers, including Fluka, Scharlau, Aldrich, and BDH. Melting points were determined without any corrections and measured using Electrothermal Gallen Kamp melting point apparatus. Infrared (FT.IR.) spectra were acquired using a Bruker FT.IR. spectrophotometer and recorded as (KBr) disks. At the University of Basrah, Iraq, ¹H-NMR and ¹³C-NMR spectra were obtained with the aid of an Inova 500 MHz NMR spectrometer, employing DMSO-d₆ as the solvent and TMS (Tetramethyl silane) as the internal standard for calibration. During the course of the reactions, an

ultrasonic water bath from ISOLAB was employed, equipped with a 3-liter capacity tank and operated at a frequency of 40 kHz.

2.2: Methods:

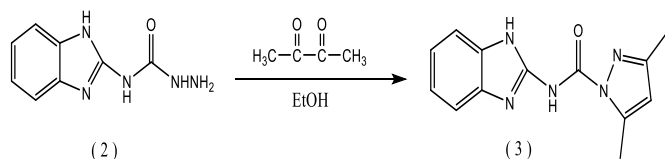
Preparation of N-(1H-benzo[d]imidazol-2-yl) hydrazine carboxamide (2)





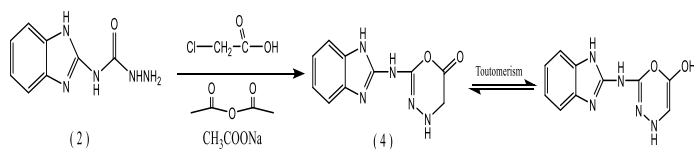
In a conical flask, 0.01 moles (equivalent to 1.91 grams) of Carbendazim were combined with 10 mL of 99% hydrazine hydrate within a solution containing 30 mL of absolute ethanol. Subsequently, this mixture was subjected to refluxing for a duration of 5 hours. Following the reflux process, the resultant precipitate was isolated through filtration and subsequently rinsed with distilled water. These steps culminated in the production of the final product (labeled as "2"). This end product exhibited a white coloration and possessed a melting point exceeding 300°C, although it exhibited decomposition at such elevated temperatures. The yield obtained from this reaction was determined to be 65% [6].

Preparation of N-(1H-benzo[d]imidazol-2-yl)-3,5-dimethyl-1H-pyrazole-1-carboxamide (3)



To synthesize compound (3), a reaction was conducted using 0.00078 moles (equivalent to 0.15 grams) of compound (2) and 0.001 moles (0.1 mL) of acetylacetone dissolved in 15 mL of absolute ethanol. The reaction mixture was then subjected to ultrasonic irradiation for a duration of 2-3 hours. After cooling, the resulting precipitate was separated through filtration and subsequently washed with distilled water, ultimately yielding the final product. This end product exhibited a white appearance and had a melting point falling within the range of 234-238°C. The reaction produced a yield of 54% [7].

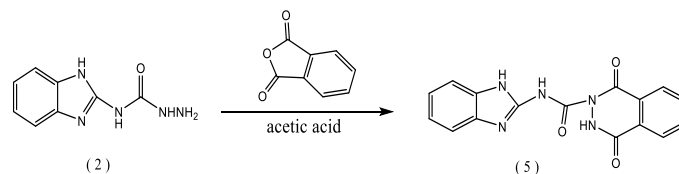
Preparation of 2-((1H-indol-2-yl) amino)-6H-1,3,4-oxadiazin-6-one (4)



To synthesize compound (4), a reaction was carried out using 0.00078 moles (equivalent to 0.15 grams) of compound (2) in combination with 0.00077 moles (0.073 grams) of chloroacetic acid. This reaction occurred in the presence of

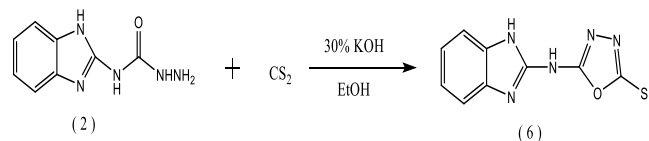
0.002 moles (0.184 grams) of sodium acetate and acetic anhydride. The reaction mixture was then exposed to ultrasonic treatment for a duration of one hour. Subsequently, the mixture was allowed to cool and poured onto crushed ice. The resulting precipitate was separated through filtration, dried, and the solid product (designated as "4") was obtained. This final product displayed a white appearance and exhibited a melting point within the range of 170-173°C. The reaction yielded a 62% product yield [8].

Preparation of N-(1H-benzo[d]imidazol-2-yl)-1,4-dioxo-3,4-dihydrophthalazine-2(1H)-carboxamide (5)



To obtain compound (5), a reaction was conducted using 0.00078 mol (0.15 g) of compound (2) and 0.00074 mol (0.11 g) of phthalic anhydride in 15 mL of acetic acid. The reaction mixture was then exposed to an ultrasonic device for a duration of 2-3 hours. Following this, it was allowed to cool and poured onto crushed ice with stirring. The mixture was left undisturbed for a few minutes to facilitate the formation of a precipitate. The resulting precipitate was subsequently filtered, washed with distilled water, and dried, resulting in the final product. This final product appeared white and exhibited a melting point within the range of 113-115°C. The yield for this reaction was 55%.[8].

Preparation of 5-((1H-benzo[d]imidazol-2-yl) amino)-1,3,4-oxadiazole-2-thiol (6)

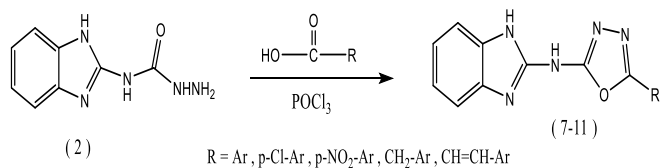


To synthesize compound (6), a reaction was initiated by combining 0.01 moles of compound (2) with 0.02 moles of carbon disulfide, along with 5 mL of 30% potassium hydroxide, all within a 50 mL solution of absolute ethanol. The reaction mixture was then subjected to an ultrasonic wave apparatus for a duration of two hours. Subsequently, it was



allowed to cool and poured over crushed ice. The resulting solution was then acidified with concentrated hydrochloric acid, leading to the formation of a precipitate. This precipitate was subsequently separated through filtration, resulting in the production of the final compound (6). The final product appeared as dark gray and displayed a melting point within the range of 258-261°C. The reaction achieved a yield of 63% [9].

Preparation of N-(1H-benzo[d]imidazol-2-yl)-1,3,4-oxadiazol-2-amine and its derivative (7-11)



Compounds (7-11) were synthesized by mixing 0.00078 moles of compound (2) with either benzoic acid, p-chloro benzoic acid, p-nitro benzoic acid, phenylacetic acid, or cinnamic acid, all dissolved in 10 mL of absolute ethanol. This reaction was carried out in the presence of 5 mL of phosphorus oxychloride. Subsequently, the reaction mixture was exposed to ultrasonic treatment for two hours. Following this, the mixture was allowed to cool, and an equivalent amount of a basic solution (NaOH) was added to it. The resulting mixture was then filtered to isolate the precipitate, which was subsequently subjected to a re-crystallization process [9-11].

TABLE I: The physical properties of Compounds

Comp.No.	R	m.p. °C	Yield %	Color
7	Ar-	112-115	73	Brown
8	p-Cl-Ar	169-172	62	white
9	p-NO ₂ -Ar	223-225	52	Greenish yellow
10	-CH ₂ -Ar	208-210	66	Yellowish white
11	-CH ₂ =CH-Ar	128-130	56	Yellowish white

III. RESULTS & DISCUSSION:

TABLE II: FT-IR of synthesized compounds (2-11)

Comp. No.	FT-IR (KBr) Vcm ⁻¹					
	C=O	C=N	NH	Ar-H	C-O-C	Others
2	1697	1625	3336	3057	....	N-N,1078
3	1726	1624	3355	3201	....	CH-aliph.2908



4	1717	1623	3226	3003	1284	N-N,1087
5	1732	1614	3344	3060	....	N-N,1114
6	.....	1630	3272	3110	1322	C=S, 1469
7	.....	1629	3229	3070	1289	.....
8	.....	1678	3510	3093	1245	C-Cl , 850
9	.....	1625	3367	3114	1292	C-NO ₂ , 1345
10	.....	1627	3372	3062	1346	CH ₂ Aliph. 2844
11	.....	1628	3368	3058	1286	C=C Aliph. 1675

TABLE III: shows the ¹H-NMR & ¹³C-NMR Spectrum of synthesized Compounds (3-5)

Comp. NO.	Structure	¹ H-NMR, DMSO-d ₆ , δ (ppm)	¹³ C-NMR, DMSO-d ₆ , δ (ppm)
3		8.30 (1H, S, H1), 9.23 (1H, S, H2), 2.32 (1H, S, H3), 7.03 (1H, S, H4), 7.04-7.38 (4H, m, Aromatic)	121.27-134.73(C- aromatic rings); 134.7(C=N); 143.00 (C=O amide); 40.58 (CH); 39.33(CH ₃)
4		11.74 (1H, S, H1), 12.58 (1H, S, H2), 7.76 (1H, S, H3), 3.90 (1H, S, H4), 7.12-7.69 (4H, m, Aromatic)	114.38-121.90(C- aromatic rings); 147.36(C=N); 172.53 (C=O amide); 43.93 (CH ₂);



5		8.99 (1H, S, H1), 11.87 (1H, S, H2), 9.44 (1H, S, H3), 7.08-7.97 (4H, m, Aromatic)	111.87-135.64(C- aromatic rings); 152.34(C=N); 166.73 172.55 (C=O amide);
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TABLE IV: shows the $^1\text{H-NMR}$ & $^{13}\text{C-NMR}$ Spectrum of synthesized Compounds (7-11)

Comp. NO.	Structure	$^1\text{H-NMR}$, DMSO- d_6 , δ (ppm)	$^{13}\text{C-NMR}$, DMSO- d_6 , δ (ppm)
7		8.037 (1H, S, H1), 11.661 (1H, S, H2), 7.065-7.881 (8H, m, Aromatic)	114.23-137.21(C- aromatic rings); 148.53(C=N); 161.07(C=N-O)
8		7.94 (1H, S, H1), 8.542 (1H, S, H2), 5.962-7.772 (8H, m, Aromatic)	129.21-131.61(C- aromatic rings); 138.25(C=N); 166.93(C=N-O)
9		8.30 (1H, S, H1), 9.11 (1H, S, H2), 7.15-8.37 (8H, m, Aromatic)	113.27-149.11(C- aromatic rings); 148.13(C=N); 162.35(C=N-O)
10		9.653 (1H, S, H1), 10.313 (1H, S, H2), 4.340 (1H, S, H3), 7.215-7.894 (9H, m, Aromatic)	111.20-136.20(C- aromatic rings); 151.48(C=N); 33.07(CH ₂); 169.42-173.17(C=N-O)



11		<p>8.610 (1H, S, H1), 9.853 (1H, S, H2), 6.508-6.99 (1H, S, H3&H4), 7.215-7.894 (9H, m, Aromatic)</p>	<p>119.62-134.60(C- aromatic rings); 144.41(C=N); 113.44 (CH); 134.87(CH-Ph); 168.05(C=N-O)</p>
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IV. CONCLUSIONS:

In this research, we successfully converted esters, particularly Carbendazim, into hydrazides using straightforward and simplified methods while ensuring suitable reaction conditions. Subsequently, we utilized these hydrazide compounds in reactions with various other compounds, including acetylacetone, phthalic anhydride, benzoic acid, and its derivatives, as demonstrated in Scheme 1. On a parallel note, we also transformed Carbendazim esters into potassium salt compounds by introducing carbon disulfide, and further reacted the resulting compound, triazine, with various other compounds, such as chloroacetic acid and benzoic acid, among others, as illustrated in Scheme 2. This systematic approach led to the creation of a diverse range of heterocyclic compounds, featuring both five-membered and six-membered rings. The potential applications of these compounds extend to the fields of medicinal and agricultural chemistry, opening up avenues for further exploration and innovation.

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