A Review on Ultrasound Assisted Synthesis of Heterocyclic Compounds

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Abstract— Our goal in this work is to explore how using ultrasound waves can increase the effectiveness and speed of producing heterocyclic chemicals. We illustrate the advantages of ultrasound through a series of studies, highlighting enhanced yields, faster reaction times and higher reaction rates. Compared to conventional techniques, ultrasound assisted synthesis offers better selectively and efficiency.

Keywords: Ultrasound assisted synthesis, Heterocycles, Conventional techniques.

I. INTRODUCTION

A contemporary and environmentally acceptable method of accelerating organic synthesis[1-4]. Sonochemistry studies the chemical effects and uses of ultrasonic vibrations. Sonochemistry uses ultrasonic vibrations with a frequency range of 20-100KHz to conduct chemical reactions[5]. Sonochemistry is a technique that is employed in many fields, including medicine, industry, microbiology, oceanography, electronics and material sciences[6-9]. Richard and Loomis published the first study on chemical effects of ultrasound in 1917[10].

Cavitation is responsible for the impact of ultrasound during organic reaction. Strong impulsions are produced by the rarefaction-compression cycle in the activation process, which involves the separation of liquid molecules and subsequent collapse of bubbles. This process results in short-lived zones of high temperature and pressure. These small hotspots can be compared to tiny reactors where sound energy is transformed into useful chemical form[11-14].

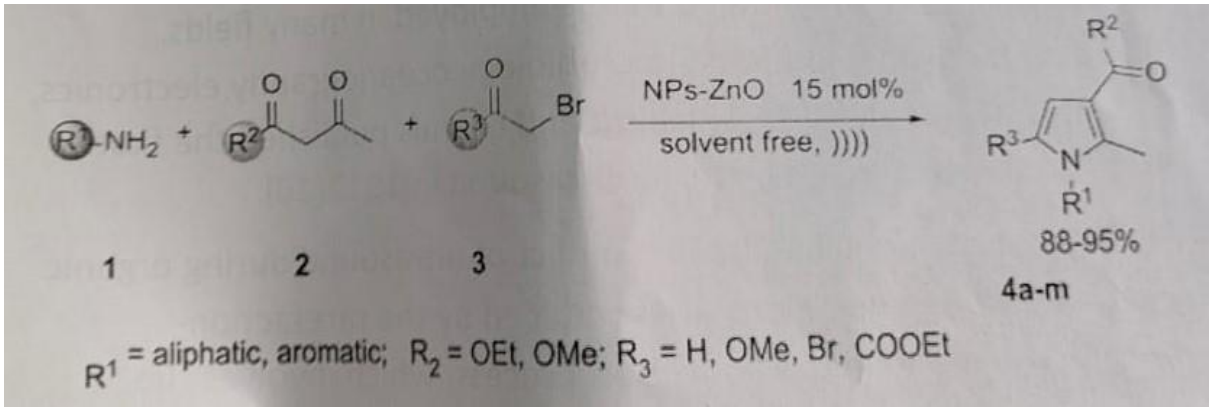
Numerous naturally occurring compounds, vitamins, medications, proteins, colours and physiologically active substances all contain heterocyclic compounds. The majority of heterocycles have several uses in industrial chemistry, synthetic medicines and agrochemicals [15-20].

II. ULTRASOUND IN SYNTHESIS OF HETEROCYCLES

Heterocyclic compounds play a crucial role in ultrasound assisted synthesis. By using the sonication process, many heterocycles have been produced as reported in the literature.

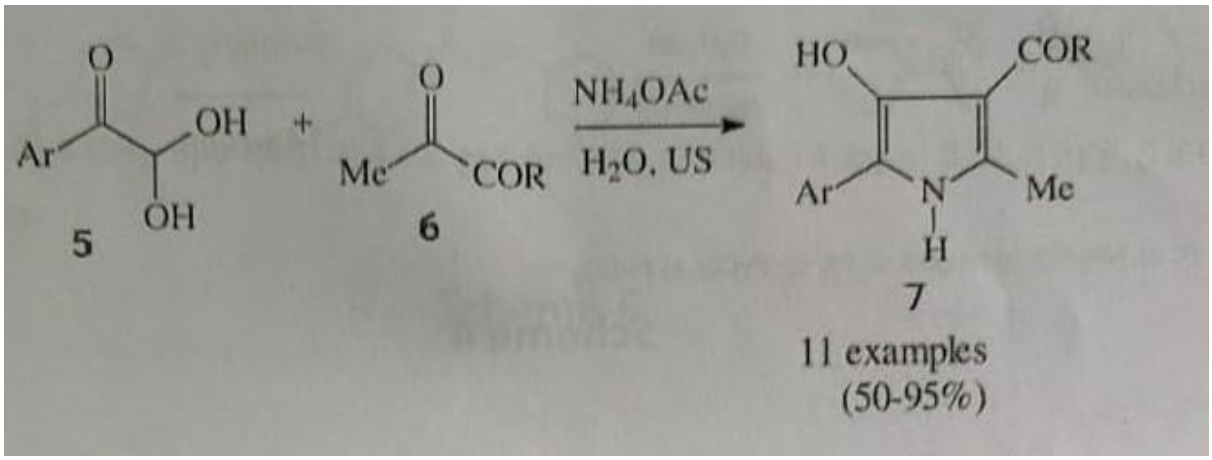
Heterocyclic compounds with significant medicinal and agrochemical activities, such a pyrroles, pyrazoles, imidazoles and tetrazole etc. are frequent core structures found in a wide variety of natural and synthesized chemicals [21-22].

Shahvelayati et al. produced 1,2,3,5-tetra substituted pyrrole (4) derivatives (Scheme 1) using one-pot multicomponent reaction involving amines (1),1,3-dicarbonyl compounds (2) and α-haloketones (3) under ultrasound assisted protocol in presence of ZnO nanoparticles under solvent free conditions with good yield[23].



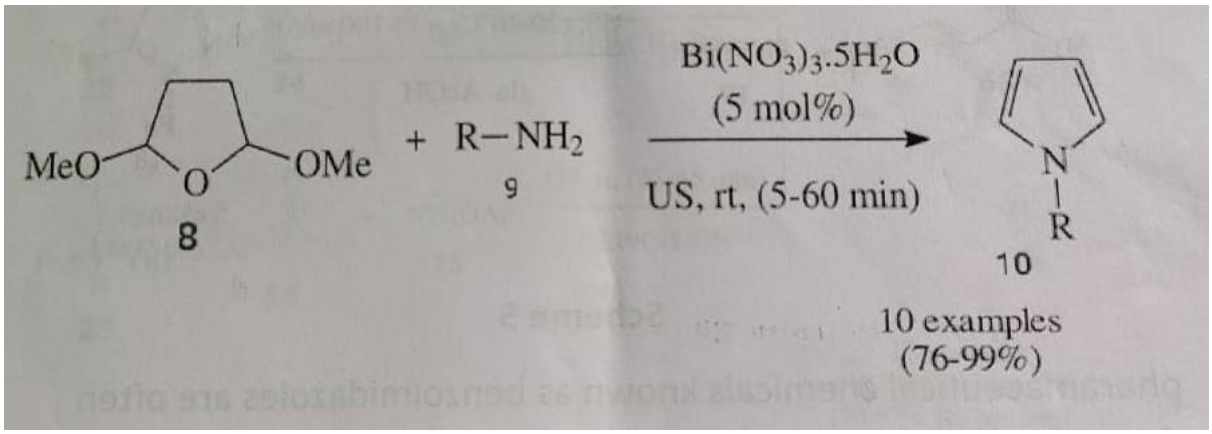
Scheme 1

Through a three component reaction involving substituted arylglyoxal hydrate (5) and β-dicarbonyl compounds (6) in the presence of ammonium acetate in aqueous media 5-aryl-4-hydroxy-1H-pyrrole-3-carboxylic acid esters (7) were created. Good yields of the products were achieved without the need for filtration (scheme 2) [24].



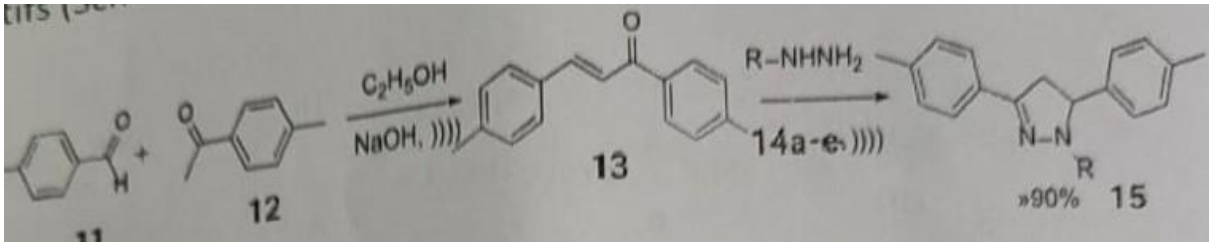
Scheme 2

By creating 2,5-dimethoxy tetrahydrofuran(8) and various amines(9) in the presence of catalytic amounts (5 mol%) of bismuth mitrate pentahydrate under ultrasonic irradiation at room temperature, a number of N-substituted pyrole derivatives (10) were created (Scheme 3) [25].



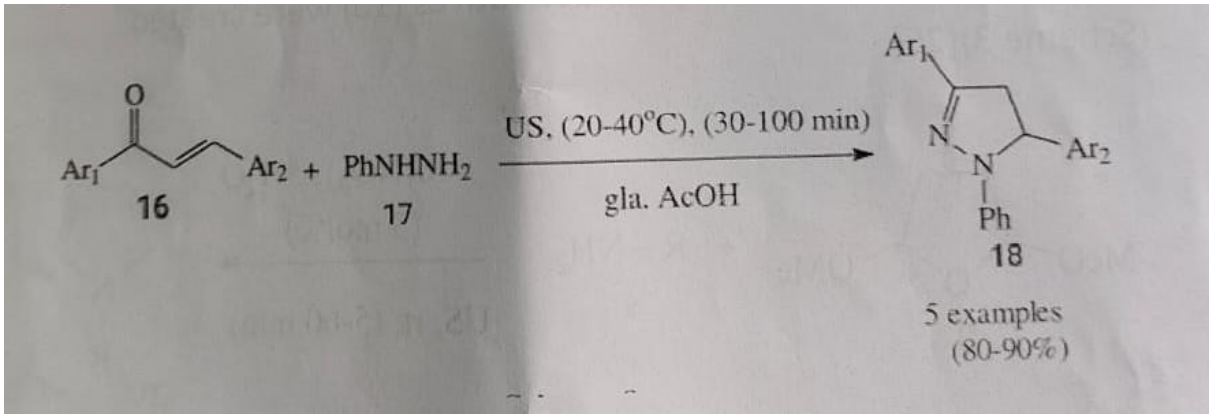
Scheme 3

Pyrazolines are significant pharmacological scaffolds that have aaplications as antibacterial, cardiovascular, insecticidal and antidepressant medication. Green methods for the synthesis of pyrazoline (15) from 4-methylbenzaldehyde (11), 4-methylacetophenone (12) and substituted hydrazines (14a-e) were developed by M.G. Kharatmol and D.M. Jagdale. Described method is cost effective and novel for the synthesis of biologically important motifs (Scheme 4) [26].



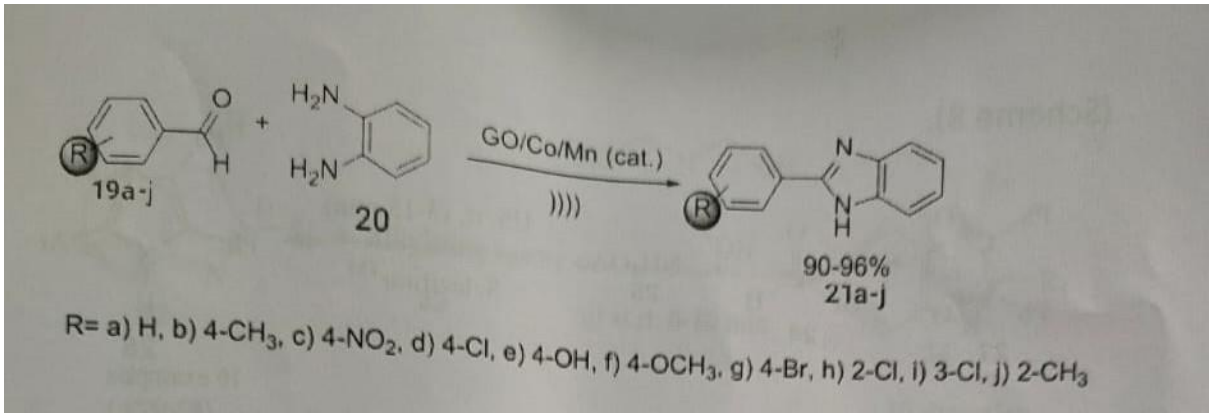
Scheme 4

N-aryl pyrazolines (18) were synthesized with US support, according to a 2010 publication by gupta and colleagues [27]. The cyclization reaction of chalcones (16) with phenyl hydrazines (17) in the presence of acid catalyst (glacial acetic acid) produced the pyrazoline ring in good yields (Scheme 5).



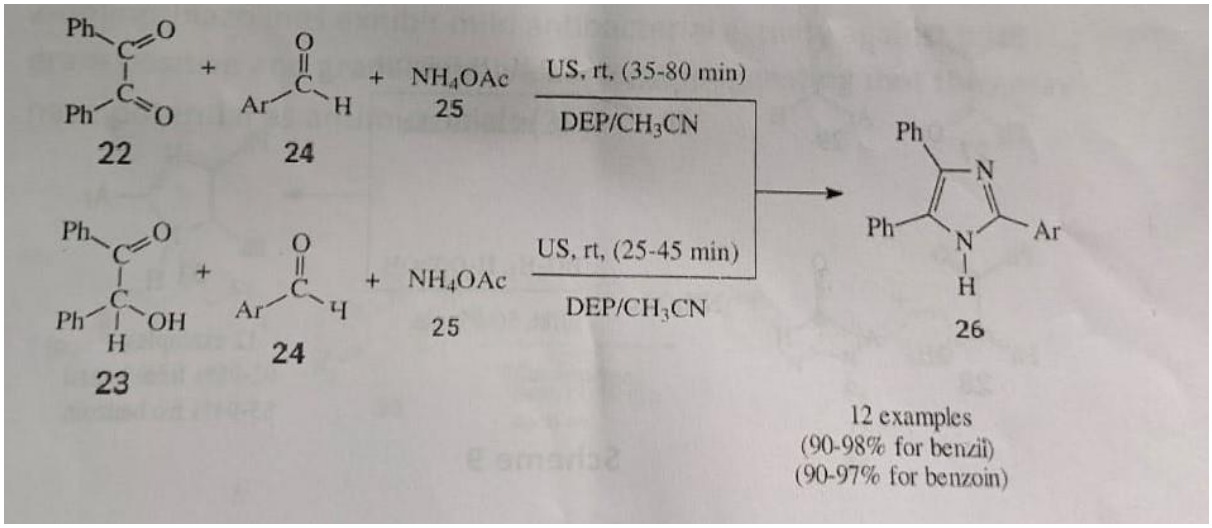
Scheme 5

Pharamaceutical chemicals known as benzoimidazoles are often created using a laborious condensation reaction technique involving a variety of catalysts. For the synthesis of benzimidazoles (21a-j) using aldehydes (19a-j) and 1,2-benzenediamine (20) irradiated by ultrasounds under solvent- free conditions, Karami et al. used a novel GO-based stable catalyst (Scheme 6) [28].



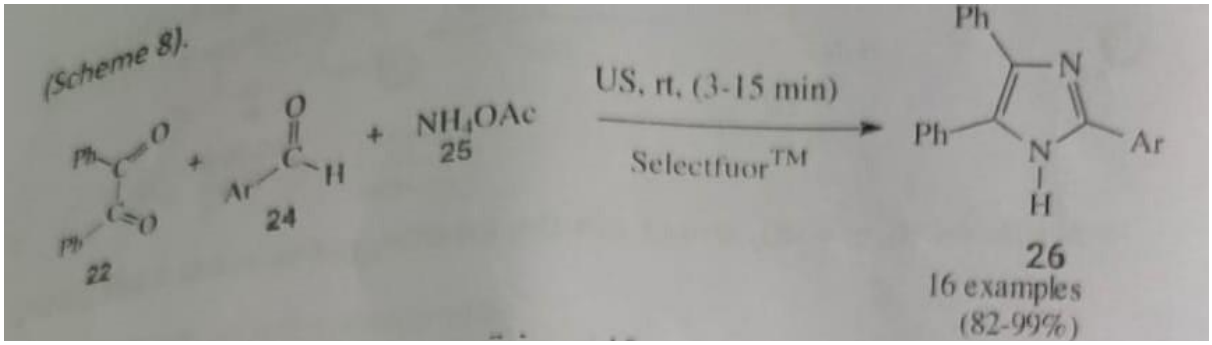
Scheme 6

The synthesis of 2-aryl-4,5-diphenyl-1H-imidazoles (26) by condensation reactions of benzyl (22) or benzoin (23) with aromatic aldehyde (24) and ammonium acetate (25) using diethyl bromophosphate (DEP) as a mild oxidant under ultrasound irradiation at room temperature was reported by Nagargoie and coworkers[29]. (Scheme 7)



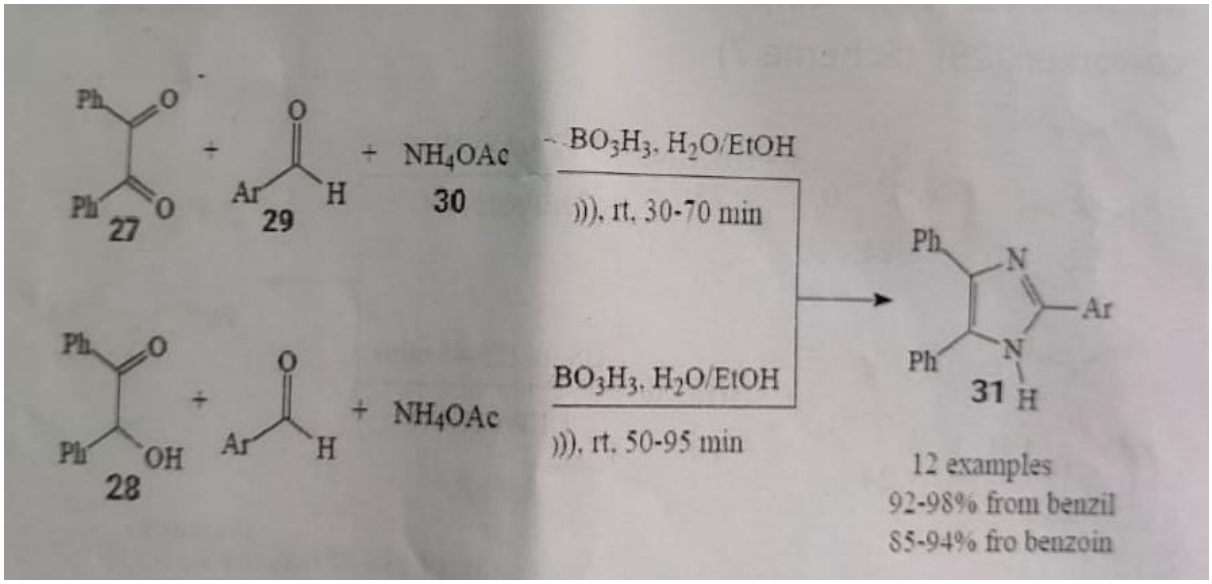
Scheme 7

Heravi and colleagues [30] demonstrated that $selectfluor^{TM}$ (15% mol) can be utilized as acatalyst in conjunction with ultrasonic irradiation to produce 2,4,5- trisubstituted imidazoles (26) from benzyl (22), aromatic aldehydes (24) and ammonium acetate (25). The products were obtained in excellent yield in short reaction times (Scheme 8).



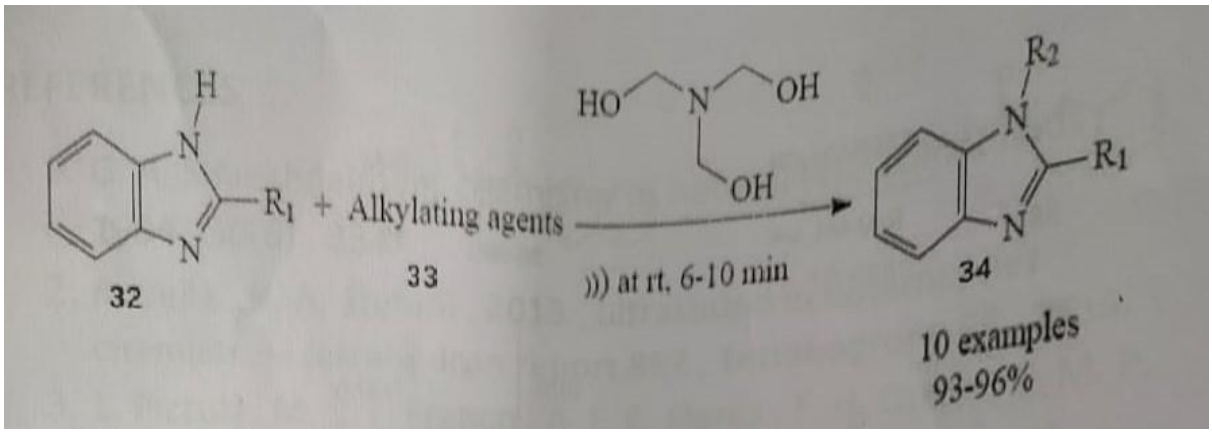
Scheme 8

In a three component one pot condensathion of benzyl (30), benzoin (36), aldehydes (32) and ammonium acetate (33) in aqueous medium under ultrasonic irradiation at room temperature with BO_3H_3 as a catalyst, Shelke et al. [32] revealed the synthesis of 2,4,5-triaryl-1H-imidazoles (34). (Scheme 9)



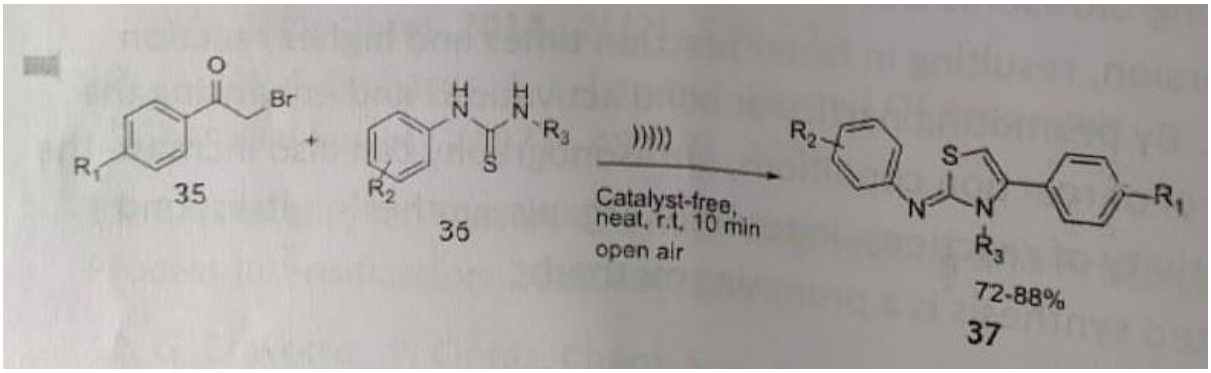
Scheme 9

Through the use of triethanol amine as a solvent under ultrasonic irradiation, Srinivas et al. [31] produced a range of N alkyl benzimidazoles (34) by reacting 2-substituted 1H- benzimidazoles (32) with different alkylating agents (33) (Scheme 10).



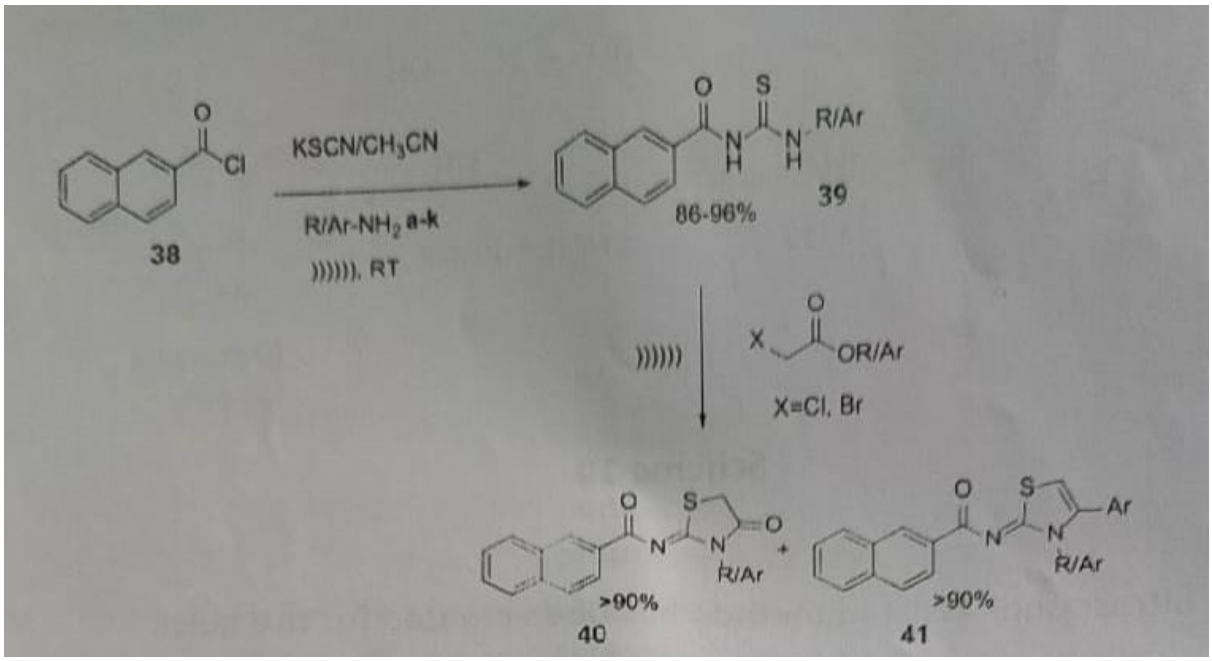
Scheme 10

An ultrasound- assisted method has been created for quick method has been created for the quick synthesis of a variety of biologically active 2- iminothazolines (37 a-y) from readily available α-bromoketones (35) and thioureas (36a-y) under solvent- and catalyst- free conditions at room temperature in open air (scheme 11). According to reports, the 2-iminothiazolines exhibit mild antibacterial activity against both gram positive and gram negative bacteria, suggesting that they may have potential as antimicrobials [33].



Scheme 11

Arafa et. al have described the ultrasound- assisted synthesis of a number of thiourears and their conversion into thiazolidines (40, 41). The reaction rate and yield were successfully increased using ultrasound technology in compared to conventional methods [34].



Scheme 12

III. DISCUSSION

When compared to conventional approaches, ultrasound assisted synthesis is more efficient and selective. By raising the yield of desirable goods, it improves efficiency and selectivity. Utilizing ultrasonic waves facilitates better reactant mixing and dispersion, resulting in faster reaction times and higher reaction rates. By promoting particular bond activations and enhancing the control of reaction conditions, ultrasonography can also increase the selectivity of reactions. In terms of organic synthesis, ultrasound assisted is a promising method.

IV. CONCLUSION

This study reveals that the shown here serves as examples pf crucial role of ultrasound assisted synthesis in green chemistry. Most of the reactions that happen during ultasonication are environment friendly and generate high yields are all benefits of ultrasound in chemical reactions.

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