International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

An Evulative Study on Different Methods of Multi-Component Synthesis on Heterocyclic Compounds

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Abstract:
Heterocyclic compounds have a significant role in our daily lives. These compounds make up the biggest and most diverse organic compound family. Heterocyclic compounds have one or more hetero atoms in their molecular structure. The number of heterocyclic compounds is growing fast as a result of extensive synthetic research and their usefulness in synthetic chemistry. They might be cyclic or acyclic. Primarily, they are utilized as medications, agrochemicals, and veterinary goods. In addition, they are used as sanitizers, developers, antioxidants, corrosion inhibitors, copolymers, coloring agents, and anticancer medicines. They are utilized as vehicles in the synthesis of other organic molecules. In this article, we discuss the majority of newly synthesized or extracted biologically active heterocyclic compounds, such as antibiotics like penicillin and cephalosporin and alkaloids like vinblastine, morphine, and reserpine.

Keywords: biological activity, medicinal chemistry, heterocyclic compounds

Introduction

Heterocyclic compounds are cyclic organic compounds that contain at least one hetero atom. Nitrogen, oxygen, and sulfur are the most frequent heteroatoms, although heterocyclic rings containing additional hetero atoms are also well-known. A carbocyclic compound is a ring-shaped carbon-containing organic cyclic compound.

The most frequent heterocycles comprise nitrogen (N), oxygen (O), or sulfur (S) heteroatoms and have five- or six-membered rings (S). Among the simple heterocyclic compounds, pyridine, pyrrole, furan, and thiophene are the most well-known. Five carbon atoms and one nitrogen atom make up the ring of a pyridine molecule. Each molecule of pyrrole, furan, and thiophene has a five-membered ring comprised of four carbon atoms and one element of nitrogen, oxygen, or sulfur, respectively. Both pyridine and pyrrole are nitrogen heterocycles; their ring molecules include both nitrogen and carbon atoms.

Objective:

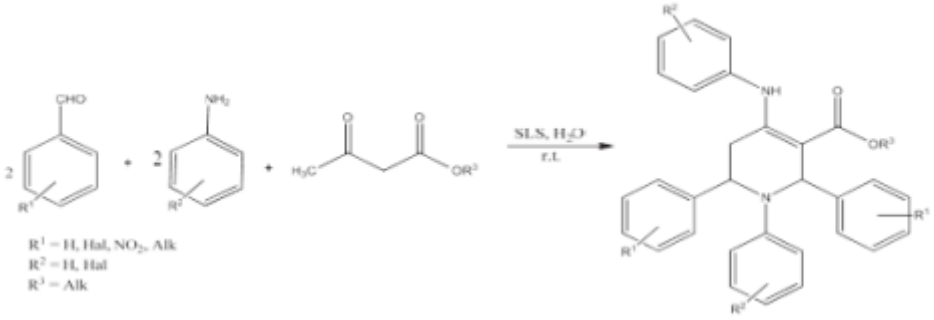
To outline the different methods of multi-component synthesis on heterocyclic compounds

Discussion:

Heterocyclic compounds comprising nitrogen, oxygen, and sulfur atoms are commonly prevalent in a variety of natural products and physiologically active molecules, functional materials, ligands, and

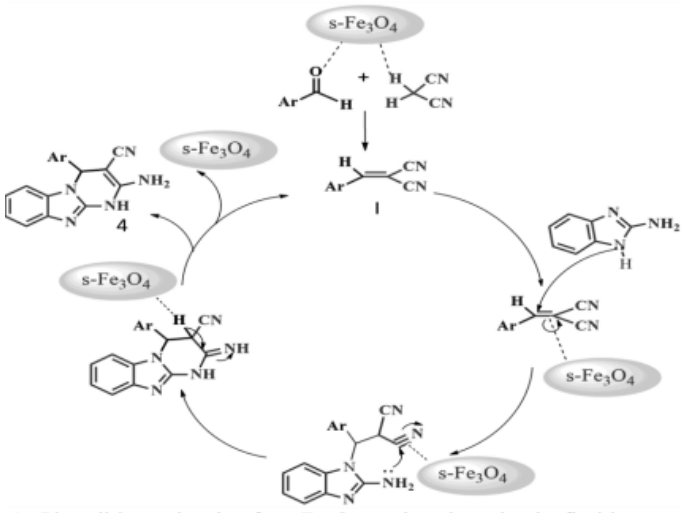
catalysts, and are also utilized in organic synthesis as versatile building blocks. Particularly, several pharmaceuticals and agrochemicals include heterocyclic moieties. Significant effort has been expended on the development of synthetic techniques for the synthesis of heterocyclic molecules. In the continuing of our research program aimed at the development of novel synthetic techniques for the creation of a variety of heterocyclic compounds under moderate and eco-friendly circumstances, we will continue to focus on the synthesis of new approaches.

Maleki et al. offer an effective and environmentally friendly method for the synthesis of different substituted 1,5-benzodiazepine derivatives using a one-pot, three-component catalytic process (Method-1). The reaction involving o-phenylenediamine, dimedone, and aldehyde derivatives was conducted at room temperature in the presence of CuFe2O4 nanoparticles as a magnetic heterogeneous nanocatalyst. High product yields, quick reaction durations, ease of operation, mild reaction conditions, non-toxicity, and simple handling and purification.



Method 1. One-potmulti-componet synthesis of substituted piperidines

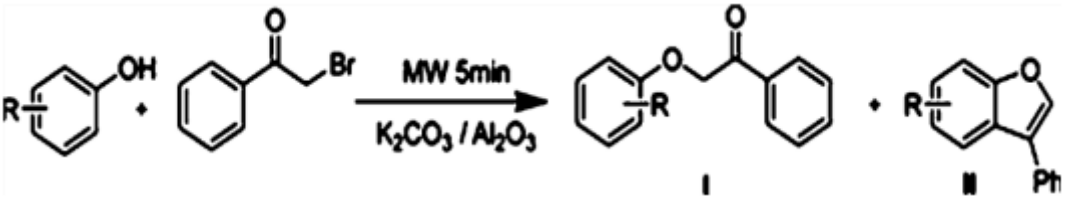
They have discovered a simple and effective ultrasound-assisted multicomponent synthesis of physiologically active imidazopyrimidine derivatives (Method-2) catalyzed by starch-functionalized magnetite nanoparticles in an aqueous medium at ambient temperature. Broad substrate scope, high atom economy, simple separation of products and catalyst from the reaction mixture, great conversion, shorter duration, chemo selectivity, environmentally friendly solvent, and biocatalyst make this procedure an efficient alternative to previously described protocols.



Method-2: Plausiblemechanismfors-Fe3O4catalyzedsynthesisofimidazopyrimidine

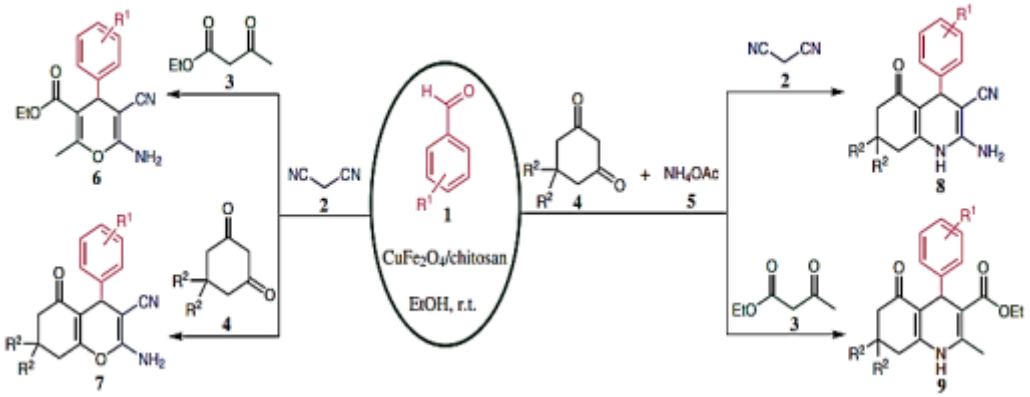
Wang et, al From phenols and phenacyl bromide, O-alkylation, carbon–carbon coupling/cyclization, and dehydration olefination tandem reactions were utilized to generate a one-pot synthesis of functionalized

benzofurans. Under microwave irradiation and solvent-free conditions, inorganic bases based on alumina were utilized in the reactions. ether formation as byproducts was also noted (Method-3)



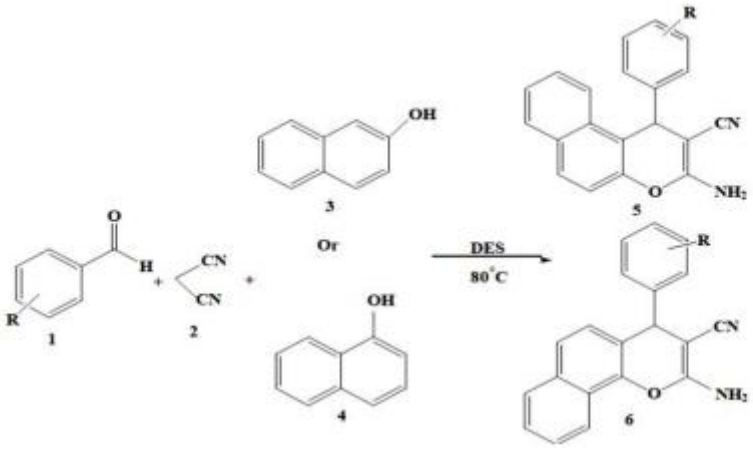
Method-3:MW-assistedsolid-statesynthesisof3-phenylbenzofurans.

Ali et al At ambient temperature, they demonstrated an effective magnetic bionanocomposite CuFe2O4/chitosan as a green catalyst for the one-pot multicomponent synthesis of a wide variety of N- and O heterocycles in ethanol, a green solvent. All of the reactions are straightforward for a wide range of aromatic aldehydes (Method-4) with both electron-donating and electron-withdrawing groups, resulting in high-to-excellent yields of the appropriate N- and O-heterocycles. The use of a green solvent, a green and non-toxic catalyst, simple separation of catalyst using an external magnet, catalyst recyclability and reusability in multiple reaction runs, a straightforward work-up procedure, high-to-excellent yields, and mild reaction conditions are all noteworthy benefits of this protocol.



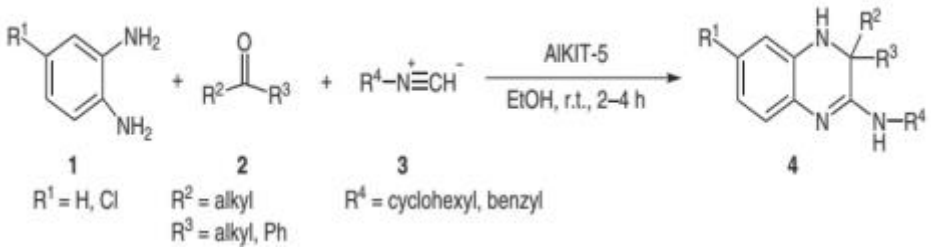
Method - 4: Synthesis of 2-amino-4H-pyrans, 2-amino-4H-chromens and poly hydroquinolines.

Leila et al report a DES based on oxalic acid and choline chloride for the manufacture of aryl-substituted aminochromenes (5) or (6) by the multicomponent reaction of aldehydes (1), malononitrile (2), and a-naphthol (4) or b-naphthol (3). (Method 5). In order to improve the reaction conditions, a model reaction including 4-nitro-benzaldehyde (1 mmol), malononitrile (1 mmol), and b-naphthol (1 mmol) was conducted utilizing choline chloride, oxalic acid, and various DES; the results are presented in Table 1. The objective of these exploratory studies was to acquire the highest yield in the shortest amount of time. As demonstrated, oxalic acid-choline chloride (1:1 molar ratio) at 800C produced the greatest results.



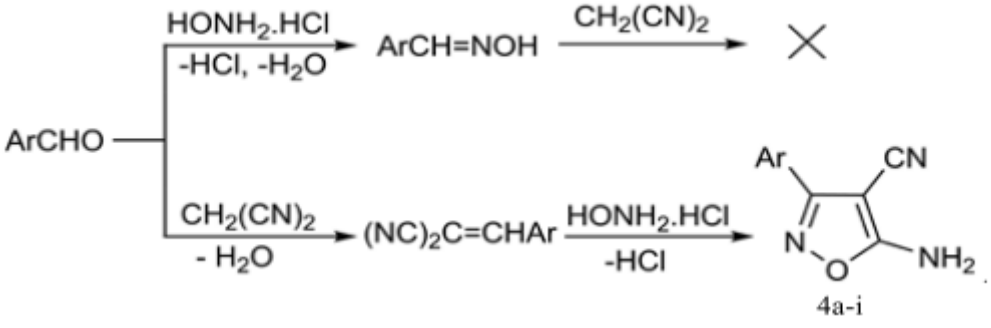
Method-5: Multicomponent synthesis of chromenes in DES.

Shobha and her colleagues They show how to make multifunctional 3,4- dihydroquinoxalin-2-amine derivatives via a three-component condensation of substituted o-phenylenediamines (OPDA), di-verse ketones, and different isocyanides in the presence of an AlKIT-5 catalyst. (-Method6)which was viewed as exceptionally dynamic and particular, manage ing great yields (85-98%) in ethanol at room temperature (24 h).



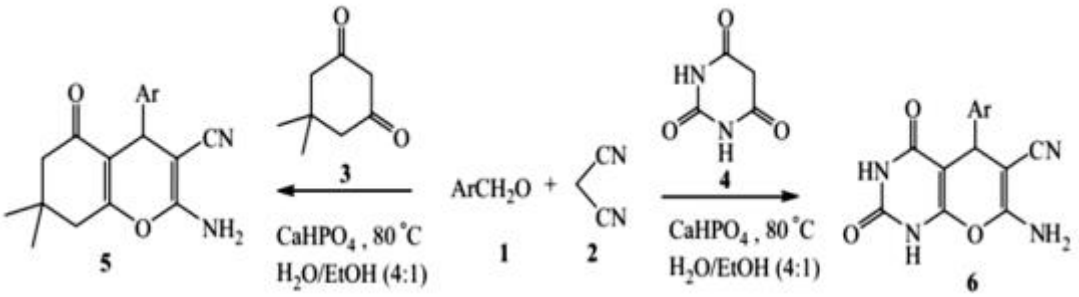
Method- 6: 3, 4-dihydroquinoxalin-2-aminederivativessynthesis usingAlKIT5catalystat room temperature

Hamid et al. described how some ingenious 5-amino-isoxazole-4-carboni-triles were structured using a green and effective multicomponent technique with good product yields and rapid reaction times. Consideration was given to the antimicrobial activity of isoxazoles against a variety of bacterial and infectious diseases. Compounds 4a, b, and d had significant inhibitory potential. Isoxazole 4i also shown significant cell strengthening activities.

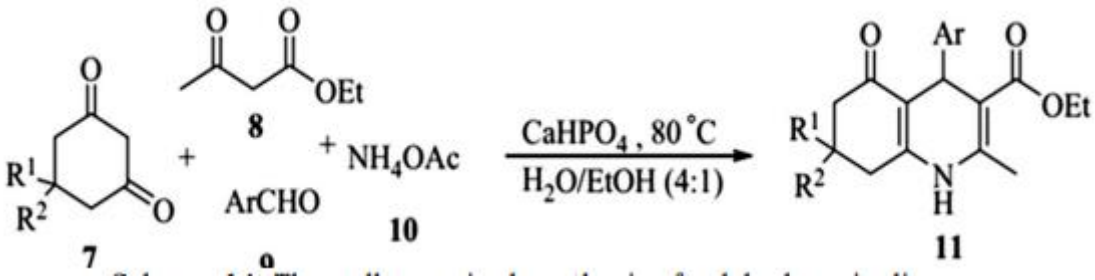


Method 7: Synthesis of 5aminoisoxazole4carbonitriles with several components

Bodaghifard and colleagues They've shown how to make tetrahydrobenzo[b] pyran, pyrano [2,3-d] pyrimidinone(method-8), and poly-hydroquinoline derivatives using a simple and efficient process. (Method-9). When compared to earlier methods, the present technique has a number of clear advantages, including the avoidance of toxic organic solvent discharge, the ease of the process, and the use of a commercially available and inexpensive catalyst. Other advantages of this technology include high product yields and catalyst reuse.

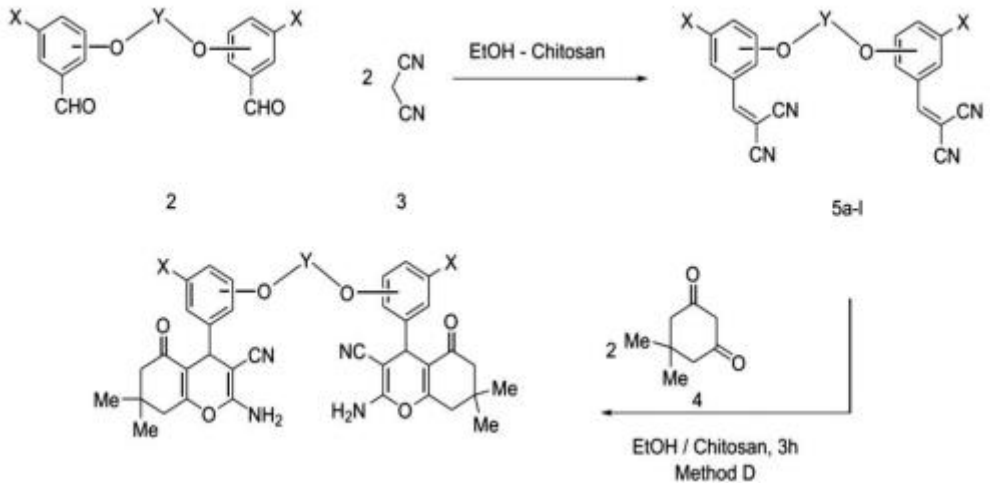


Method 8: Tetrahydrobenzopyran and pyranopyrimidinone derivatives synthesis



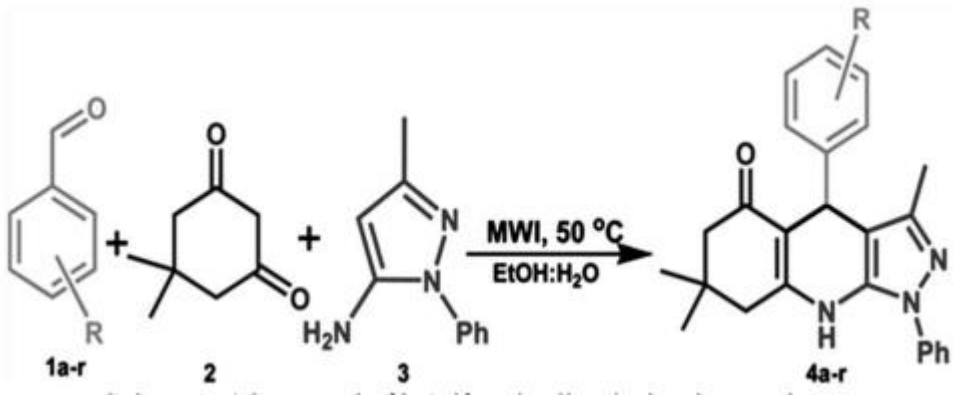
Method-9: The well-organized synthesis of polyhydroquinolines

Soad et al. have presented a comprehensive approach for the synthesis of bis-chromenes using a straightforward, efficient, and environmentally friendly method. This synthesis was carried out under both thermal and microwave irradiation conditions. Notably, the incorporation of chitosan as a heterogeneous and reusable catalyst demonstrates promising potential for practical industrial applications of this procedure (method-10). The methodology they propose offers several notable benefits, including significantly reduced reaction times and enhanced cost-effectiveness of the catalyst. By employing microwave irradiation, the reaction time was remarkably shortened to just 10 minutes, in stark contrast to the 3–5 hours required by traditional methods.



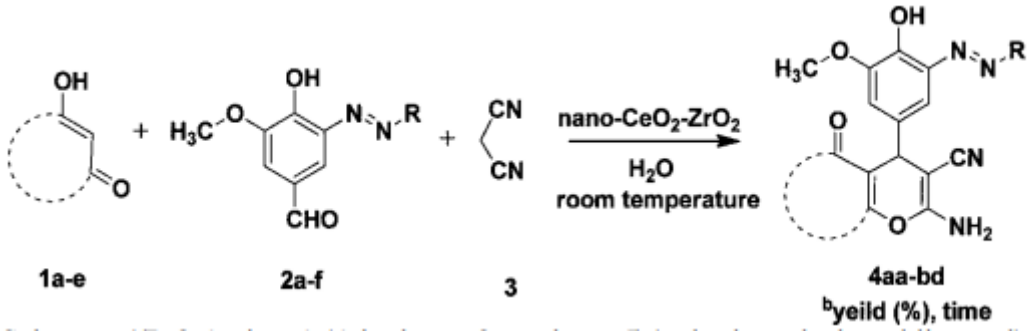
Method -10: The synthesis of bis(4H-chromene-3-carbonitrile) derivatives using chitosan as catalyst under microwave-assisted reaction conditions.

Khumalo and colleagues employed microwave (MW) irradiation to successfully synthesize eleven novel pyrazolo-[3,4-b]-quinolines using a catalyst-free approach and an aqueous solvent system. This method offers several key advantages, including operational simplicity, a straightforward workup process, gentle reaction conditions, rapid reaction times, high yields with exceptional purity, and the elimination of column chromatography for compound purification. Notably, this protocol represents the first instance of utilizing MW irradiation for the synthesis of pyrazolo-[3,4-b]quinoline derivatives within an aqueous ethanol (EtOH) solvent (method-11). The present approach holds great promise as an innovative synthetic strategy for generating a diverse range of drug-like compounds, which could have significant applications in the fields of drug discovery and pharmaceutical research.



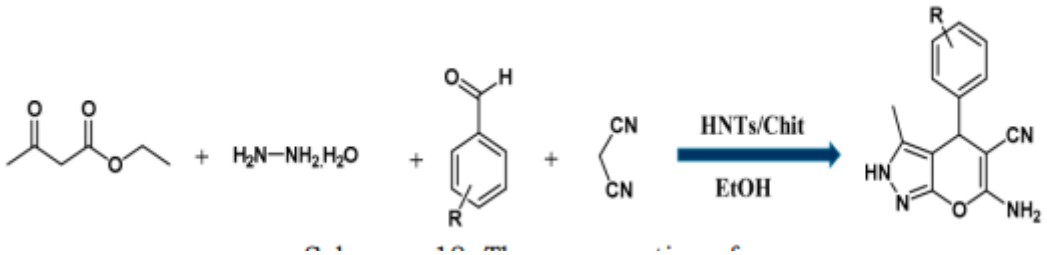
Method-11: pyrazolo-[3,4-b]-quinolinederivatives a three component green synthetic route

Sagar and colleagues have presented a highly effective and streamlined multicomponent reaction conducted in an aqueous environment. This innovative approach involves the use of zirconium-doped ceria nanoparticles as a heterogeneous catalyst for the synthesis of novel phenyldiazenyl-chromene derivatives (method-12). The process begins with 1,3-dicarbonyl compounds, 4-hydroxy-3-methoxy-5-(substituted-phenyl diazenyl) benzaldehydes, and malononitrile as starting materials. The utilization of this catalyst within an aqueous medium contributes to the efficiency of the reaction and represents a significant advancement in the field of synthetic chemistry.



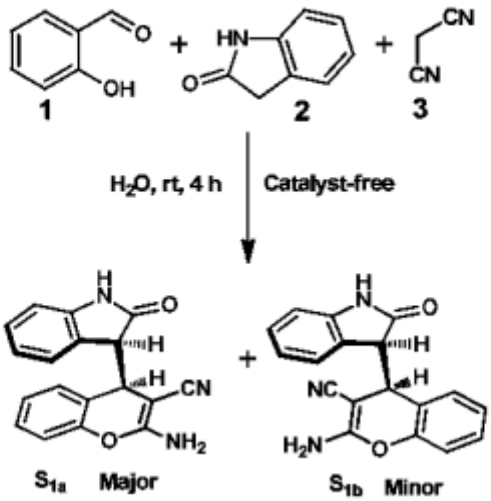
Method 12: 2-Amino-4-(4-hydroxy-3-methoxy-5-(substituted-phenyldiazenyl)- chromene-3-carbonitrile Derivatives 4aa-bc synthesis

Diana and her team propose a novel approach in their study, suggesting the use of nano composites that rely on natural and environmentally friendly materials. In their research, they successfully modified halloysite nanotubes with chitosan, creating an effective nanocatalystfor organic reactions (method 13). This method offers advantages such as mild reaction conditions, catalyst reusability, and eco-friendliness, making it a promising avenue for further exploration in the field of catalysis.



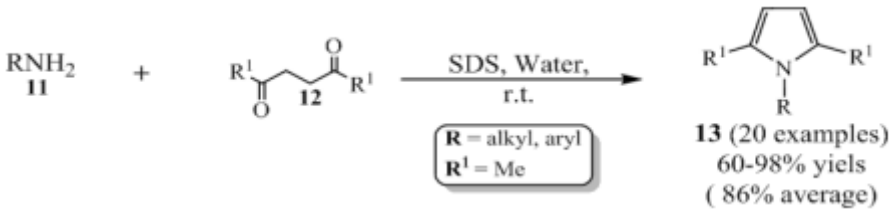
Method - 13: The prepersation of pyranopyrazolederivativesusingHNTs/Chitcatalyst.

Balakrishnan and his research colleagues showcased a noteworthy achievement in their work by demonstrating a catalyst-free three-component synthesis conducted in water at room temperature. This synthesis led to the creation of a hybrid heterocyclic scaffold, specifically an oxindole attached to a 4H-chromene-3-carbonitrile compound. This novel structure incorporates two physiologically active functional groups and two contiguous stereo centers, all achieved in good yields. Notably, this approach not only highlights the potential of multicomponent reactions (MCRs) for accessing innovative scaffolds but also underscores the method's efficiency and positive impact on the environment (method-14). The researchers explored various heterocycles and components to understand their effects on the reaction in order to produce novel 4-heterocycle-substituted 4H-chromene compounds.



Method -14: oxindolyl substituted 4Hchromene-3-carbonitrile synthesis without Catalyst

Veisi and his team introduced an environmentally conscious variation of the conventional experimental method to synthesize N-substituted pyrrole. This innovative approach involves utilizing sodium dodecyl sulfate (SDS) as a key component and performing the synthesis in water at room temperature. The researchers employed the Paal-Knorr cyclization reaction, a well-established procedure in pyrrole synthesis. In this method, a primary amine (denoted as 11) reacts with a 1,4-diketone (denoted as 12) to yield the desired pyrrole derivative (labeled as 13). The Paal-Knorr cyclization reaction has long been recognized as one of the most valuable traditional techniques for pyrrole synthesis (method 15).



Scheme-15: N-substituted pyrroles synthesised by One pot two component

Conclusion

Nitrogen-based heterocyclic chemistry stands as a distinct and significant realm within organic chemistry, garnering considerable attention in recent times. The exploration of novel structures within this molecular class has become a focal point of research. Insight into the pharmacological attributes of N-heterocyclic compounds has also been documented. This survey delves into the realm of assembling an array of heterocycles, showcasing the pivotal role of modified mixed oxides as carriers and catalysts. Utilizing mixed oxides as reusable catalysts presents a compelling avenue for advancing the sustainable development of the chemical industry, due to their intriguing and customizable surface properties. The notable acid-base characteristics of active sites, the capacity of metal cations to engage in redox reactions, and related factors collectively contribute to enhancing reaction speed and selectivity. Mixed oxides hold a vital position across various domains, including organic processes, green chemistry, the

petroleum sector, and the synthesis of fine chemicals, encompassing over 30% of all heterogeneous catalysts employed in industrial contexts.

Heterocycles containing nitrogen within their ring structure find applications across diverse fields, ranging from medicinal to agricultural domains, necessitating efficient synthetic pathways. Traditionally, a range of metal oxides has been scrutinized and harnessed to facilitate C-C bond formation in substrate molecules, enabling the synthesis of intricate heterocyclic derivatives through multi-component reactions. The adoption of a one-pot green approach, facilitated by an array of mixed oxide catalysts, furnishes a broad platform for designing and generating novel heterocyclic compounds with promising characteristics.

While strides have been made in comprehending reaction mechanisms occurring on catalyst surfaces, there remains a significant scope for refining and adapting heterocyclic compounds. Continued exploration is required to unravel the intricacies of ongoing reaction processes and to unlock avenues for enhancing and tailoring the properties of heterocyclic compounds.

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