Educational Administration: Theory and Practice
2024, 30(5), 1983-1988
ISSN: 2148-2403
https://kuey.net/

Research Article

Systematic Review On Thiazole And Its Applications

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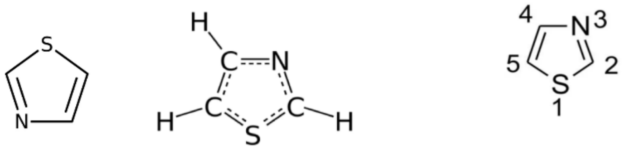
Citation: Manish Pathak, et al (2024), Systematic Review On Thiazole And Its Applications, *Educational Administration: Theory and Practice*, *30*(5), 1983-1988, Doi: 10.53555/kuey.v30i5.3209

ARTICLE INFO	ABSTRACT
	Thiazole is a group of heterocyclic compounds, have garnered significant attention in the field of medicinal chemistry due to their diverse pharmacological effects. This systematic review aims to provide a comprehensive analysis of thiazole compounds, covering their synthesis methods, properties, and recent advancements in medical uses. Furthermore, the paper highlights the potential of thiazole derivatives in pharmaceutical uses of thiazole. Additionally, the paper explores the possibilities and forthcoming research directions in thiazole chemistry.

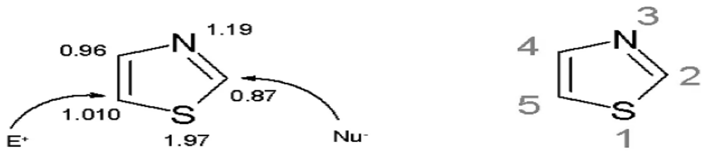
Keywords: Thiazole, Synthetic methods, Applications

INTRODUCTION

Thiazole, a pentagonal heterocyclic compound composed of three carbon atoms, one nitrogen atom, and one sulphur atom, has attracted considerable interest across multiple disciplines because of its diverse characteristics[1].



Thiazole rings exhibit planarity and aromaticity due to their larger π electron delocalization compared to the corresponding oxazole, resulting in a significant level of aromatic character. The intense diamagnetic ring current is clearly indicated by the chemical shift of the ring protons in proton NMR spectroscopy, which falls between 7.27 and 8.77 ppm. This reveals the aromaticity of the compound. Additionally, the calculated π electron consistency identifies C5 as the preferred site for electrophilic substitution and C2 as the favoured site for nucleophilic substitution[2].



Synthetic methods for the preparation of thiazole:

A range of synthetic routes are utilized in the production of thiazole and its derivatives[3]. A prevalent technique entails the combination of 2-aminothiophenol with α-haloketones or α-haloesters, which is then followed by cyclization to yield thiazole. Alternative methods involve the condensation of α-haloketones with thioamides or the reaction of α-haloketones with thioureas[4]. Moreover, thiazole can be synthesized from α-halocarbonyl compounds and thioamides under alkaline conditions.

i. Gabriel synthesis

The acylamino-carbonyl compound undergoes condensation in the presence of Phosphorus pentasulfide[5].

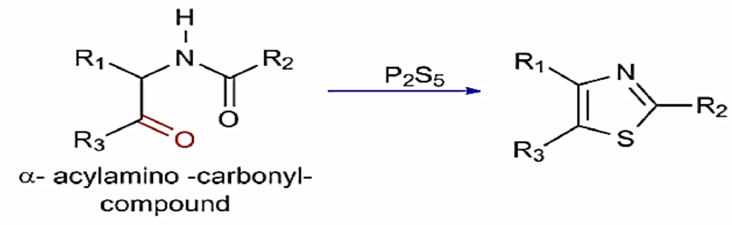


Fig.1.Reaction Scheme of gabriel synthesis

Mechanism: Solid-phase adaptation of the Robinson-Gabriel synthesis[6]. In this method, trifluoroacetic anhydride is employed as the cyclodehydrating agent within an ethereal solvent, while the 2-acylamidoketone is connected to a benzhydrylic-type linker through its nitrogen atom[7].

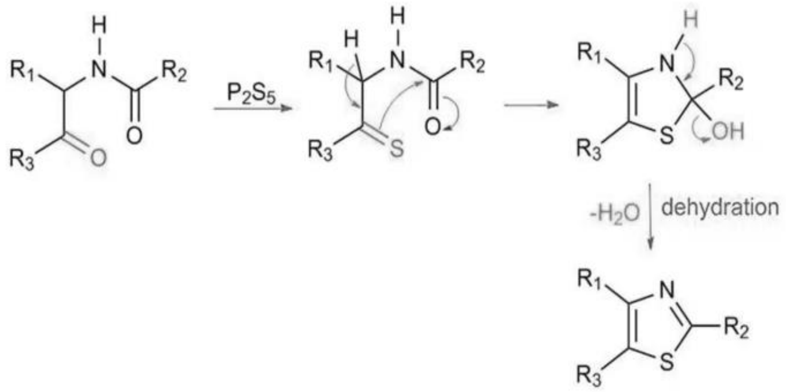


Fig.2.Mechanism of gabriel synthesis

ii. From an α- hydroxy-Carbonyl Component

The Hantzsch thiazole synthesis method is considered to be highly dependable for the production of thiazoles. This process involves the condensation of α-haloaldehydes or ketones with thioureas in neutral, anhydrous solvents, resulting in the formation of 2-aminothiazoles[8]. As an illustration, the reaction between N-phenylthiourea and chloroacetone in anhydrous acetone, with 1 hour of stirring under reflux, yields 2-(phenylamino)-4-methylthiazole. Remarkably, a substantial percentage yield of 96% is achieved in this particular reaction[9].

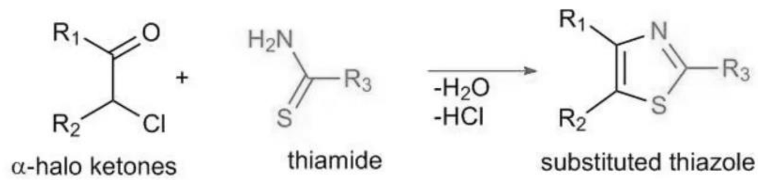


Fig.3. Hantzsch Thiazole Synthesis

iii. From a thiocyanate salt

The efficient synthesis of 4,5-disubstituted thiazoles can be achieved through the base-induced cyclization of active methylene isocyanides, including tosylmethyl isocyanide, ethyl isocyanoacetate, and arylmethyl isocyanides, with methyl arene- and hetarenecarbodithioates[10]. This synthetic method offers simplicity, rapidity, and frequently eliminates the need for purification steps.

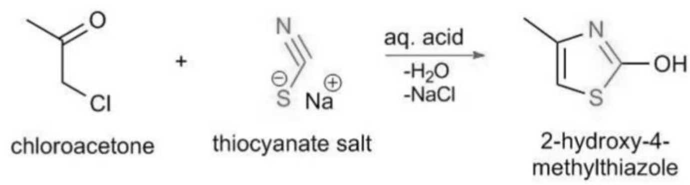


Fig.4. Thiazole Synthesis using thiocyanate salt

APPLICATIONS:

Thiazole, a heterocyclic compound containing both sulfur and nitrogen atoms in its five-membered ring structure, and its derivatives have found extensive applications in various industries[11]. The unique properties and versatile nature of thiazole make it a valuable building block for the synthesis of numerous compounds with diverse functionalities. In the pharmaceutical industry, thiazole derivatives have shown significant potential as therapeutic agents. These compounds exhibit a wide range of biological activities, including antimicrobial, antiviral, anticancer, anti-inflammatory, and antidiabetic properties[12]. Thiazole-based drugs have been developed to treat various diseases, such as tuberculosis, malaria, HIV/AIDS, and cancer. The presence of thiazole moiety in these drugs enhances their efficacy and target specificity, making them valuable tools in the fight against numerous ailments[13]. Thiazole derivatives also play a crucial role in the agrochemical industry[14]. They are used as active ingredients in pesticides, herbicides, and fungicides to protect crops from pests, weeds, and diseases. These compounds possess potent insecticidal, herbicidal, and fungicidal activities, making them effective tools for crop protection and enhancing agricultural productivity[15]. Thiazole-based agrochemicals have contributed significantly to sustainable agriculture practices by reducing crop losses and minimizing environmental impact[16]. Furthermore, thiazole and its derivatives have found applications in materials science. Their unique electronic and optical properties make them suitable for the development of advanced materials. Thiazole-based polymers and copolymers have been utilized in the fabrication of organic electronic devices, such as organic light-emitting diodes (OLEDs), organic photovoltaics (OPVs), and organic field-effect transistors (OFETs). These materials exhibit excellent charge transport properties, high stability, and tunable energy levels, making them promising candidates for next-generation electronic devices[17]. In addition to their applications in pharmaceuticals, agrochemicals, and materials science, thiazole derivatives also find use in other industries. They are employed as dyes and pigments in the textile and cosmetic industries, as flavor and fragrance compounds in the food and beverage industry, and as intermediates in the synthesis of various organic compounds. Overall, the wide-ranging applications of thiazole and its derivatives in diverse industries highlight their significance and potential in various fields[18]. The continuous exploration and development of new thiazole-based compounds are expected to lead to further advancements and innovations in pharmaceuticals, agrochemicals, materials science, and beyond. Thiazole molecules used as an intermediate, chemical in synthetic drugs, fungicides and dyes in industries. A thiazole ring present naturally in the essential vitamin B1 thaimin[19].

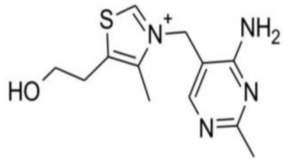


Fig.5. Structure of thiamine (Vitamin-B)

Various derivatives of thiazole nucleus is the aim of research due to their importance in various applications[20]. Derivatives of thiazole heteroatom used as reactants, intermediaries in the various industries like agrochemical, pharmaceutical and the pesticides industry. Most of the derivatives of thiazole were synthesized to achieve the industrial, biological, and medicinal target by numerous research scholar and scientist in R&D laboratories.

Uses of thiazole in pharmaceuticals:

Thiazole derivatives have garnered attention for their extensive range of pharmacological effects, making them crucial structures in the quest for new drugs. These compounds have been extensively investigated for their potential as antimicrobial agents, capable of combating various types of infections [21]. Additionally, they have shown promise as antiviral agents, with the ability to inhibit the replication of viruses and potentially treat viral diseases. Thiazole derivatives have also demonstrated anticancer properties, exhibiting the ability to inhibit tumor growth and induce cancer cell death. Furthermore, these compounds have shown anti-inflammatory effects, reducing inflammation and providing relief for inflammatory conditions. In the field of diabetes research, thiazole derivatives have been explored as potential antidiabetic agents, with the ability to regulate blood sugar levels and improve insulin sensitivity. Thiamine, a well-known thiazole derivative, is an essential nutrient that plays a vital role in cellular metabolism[22]. It is involved in various metabolic processes, including the conversion of carbohydrates into energy. In the pharmaceutical industry, thiazole derivatives have been utilized in the development of drugs such as riluzole, which is used to treat amyotrophic lateral sclerosis, a progressive neurodegenerative disease. Another notable example is rufinamide, an antiepileptic medication that is used to control seizures in patients with epilepsy. Overall, the wide range of pharmacological effects exhibited by thiazole derivatives highlights their significance in the development of novel therapeutic agents[23].

Uses of thiazole agrochemicals:
Thiazole derivatives play a significant role in the advancement of agrochemicals, including pesticides, herbicides, and fungicides. Their effectiveness in controlling various pests enhances their importance in the formulation of crop protection solutions. Moreover, compounds containing thiazole have been investigated for their ability to act as growth regulators and agents for safeguarding plants[24].
Uses of thiazole materials science:
Thiazole-based compounds possess fascinating characteristics that render them suitable for diverse applications in materials science. They have been employed in the production of fluorescent dyes, optical brighteners, and conductive polymers[25]. Polymers containing thiazole display promising features for applications in organic electronics, photovoltaics, and light-emitting diodes (LEDs).
Biological activities and pharmacological potential:
Thiazole have been widely studied for their diverse biological activities, making them promising candidates for drug development. One of the notable characteristics of thiazole derivatives is their antimicrobial properties. They have been shown to be effective against a variety of pathogenic bacteria, fungi, and viruses, making them valuable in the treatment of infectious diseases[26]. Additionally, thiazole compounds have demonstrated potent anti-inflammatory effects, which can be beneficial in managing inflammatory conditions such as arthritis and asthma. In recent years, research has focused on the anticancer potential of thiazole derivatives. These compounds have shown promising results in inhibiting tumor growth and metastasis by targeting key signalling pathways involved in cancer progression. For example, some thiazole derivatives have been found to inhibit angiogenesis, which is crucial for the growth and spread of cancer cells. The mechanisms of action of thiazole derivatives in different disease models are varied and complex. Some compounds work by interfering with DNA replication or protein synthesis, while others modulate specific molecular targets involved in disease pathways. Understanding these mechanisms is essential for designing more potent and selective thiazole-based therapies. Overall, thiazole derivatives offer a wide range of pharmacological activities that make them valuable in the treatment of various diseases[27]. Further research into the therapeutic potential of these compounds is needed to fully exploit their benefits in the development of novel drugs[28].

RECENT ADVANCES AND RESEARCH GAPS:

In recent years, the field of thiazole chemistry has experienced remarkable advancements, leading to the discovery of novel compounds with enhanced therapeutic efficacy and reduced toxicity. Thiazole derivatives, which are organic compounds containing a five-membered ring with a sulfur and nitrogen atom, have shown great potential in various therapeutic applications[29]. One of the key areas that require further investigation in thiazole chemistry understands the structure-activity relationships (SAR). SAR studies aim to establish the relationship between the chemical structure of a compound and its biological activity[30]. By systematically modifying the structure of thiazole derivatives and evaluating their biological properties, researchers can gain insights into the specific features that contribute to their therapeutic effectiveness[31]. This knowledge can then be utilized to design and develop more potent and selective thiazole-based drugs. Another important aspect that needs to be elucidated is the safety profile of thiazole compounds. While significant progress has been made in improving their therapeutic efficacy, it is crucial to thoroughly investigate their potential toxicity and side effects. This involves conducting comprehensive preclinical and clinical studies to assess the compound's pharmacokinetics, pharmacodynamics, and potential adverse reactions. Understanding the safety profile of thiazole derivatives is essential for their successful translation into clinical practice[32]. Furthermore, exploring the potential of thiazole compounds in combination therapy is an area of great interest. Combination therapy involves the simultaneous use of multiple drugs to enhance therapeutic outcomes. Thiazole derivatives have shown promise in combination with other classes of drugs, such as antibiotics, anticancer agents, and antiviral drugs. Investigating the synergistic effects and potential mechanisms of action of thiazole compounds in combination with other therapeutic agents can lead to the development of more effective treatment strategies[33]. In summary, the field of thiazole chemistry has made significant progress in recent times, resulting in the discovery of innovative compounds with improved therapeutic effectiveness and decreased toxicity. However, there are still several areas within this field that require further investigation, including understanding the structure-activity relationships, elucidating the safety profiles, and exploring the potential of thiazole compounds in combination therapy[34]. Continued research in these areas will contribute to the development of new and improved drugs centred around thiazole compounds, ultimately benefiting patients and advancing the field of drug discovery.

CONCLUSION

Thiazole compounds are a versatile group of heterocyclic compounds with a wide range of pharmacological activities and therapeutic potential. The creation of new thiazole derivatives, coupled with thorough biological assessments, shows potential for the advancement of effective therapies for different illnesses, such as cancer. Ongoing investigations in thiazole chemistry are crucial to tackle current obstacles and fully exploit the therapeutic capabilities of these compounds.

FUNDING
NONE

CONFLICT OF INTEREST
The authors declare no conflict of interest, financial or otherwise.

DECLARATION
None

ACKNOWLEDGEMENT
Authors would like to express gratitude to Faculty of Pharmacy, Swami Vivekananad Subharti University for their support during work. I am thankfull to Dr. Ganesh Prasad Mishra, Professor, Department of Pharmaceutical Chemistry, Faculty of Pharmacy, Swami Vivekananad Subharti University for their continuous support.

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