A Review: Important applications of Heterocyclic Compounds

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Abstract

Heterocyclic compounds play a significant role in our daily life. Heterocyclic compounds constitute the vast and diverse family of organic compounds. Number of these compounds is growing quickly due to the advances in synthetic research and also their synthetic utility. Some key structures in medicinal chemistry are heterocycles and also, they are often found in many in biomolecules such as enzymes, vitamins, natural products and biological active substances including antifungal, antibacterial, anti-inflammatory, antioxidant, antiallergic, anticonvulsant, anticarcinogenic, enzyme inhibitors, herbicidal, anti-HIV, antidiabetic and insecticidal agents. Many heterocyclic compounds exhibit optoelectronic properties.

Keywords: Heterocyclic compounds, vitamins, optoelectronic properties.

1. Introduction

Heterocyclic compounds are of prominent importance in everyday life. They play a significant role in the metabolism of all living cells. Most of heterocyclic compounds, synthetic or natural, are pharmacologically active and are found in clinical use. At least one ring structure is present in such a compound and the prefix hetero refers to the non-carbon atoms or heteroatoms, which could be nitrogen, oxygen, sulphur, phosphorus, boron and many others. These ring structured compounds are found as three to eight membered rings with one or more hetero atoms. However, compounds having five or six membered heterocyclic moieties are ubiquitous. Even though heterocyclic compounds can be saturated or unsaturated, unsaturated heterocyclic compounds are of high significance because of their conjugated electron system. Heterocyclic compounds can be found with single or fused ring structure with a heterocyclic ring fused to benzene or another heterocyclic ring. More than fifty percent of the known organic compounds are heterocyclic and large number of the biologically active compounds contain heterocyclic moiety. The presence of heteroatoms provides a wide range of suitability in various applications.

Heterocyclic compounds are widely spread in nature. A lot of them are of fundamental importance to living systems. A vast class of compounds are found as vital components in biological processes. The nucleic acid, which are fundamental units of genetic material, are derivatives of the purine like adenine or guanine and pyrimidine like thymine, cystosine. Some derivatives of purine and pyrimidines are also used as antibiotics which function by affecting the synthesis of DNA. Protein synthesis inhibitor Puromycin is an example of such an antibiotic. The derivatives of porphyrin ring systems like Chlorophyll and heme are key ingredients required for the photosynthesis and also for the transport of oxygen in higher plants and in animals. Necessary diet ingredients such as ascorbic acid (vitamin C) , pyridoxol (vitamin B6), thiamin (vitamin B1), riboflavin (vitamin B2), nicotinamide (vitamin

B3) and are heterocyclic compounds. The properties of heterocyclic compounds are tunable as replacing carbon atoms by various hetero atoms will change the molecular electron density, structure and interaction profile that leads to various application possibilities [1].

Applications of heterocyclic compounds Heterocyclic compounds

More than 90% of novel medications contains heterocyclics, which span the boundary between chemistry and biology [2]. The increasing presence of several heterocycles in drugs is due to progress in synthetic methodologies, such as metal-catalysed cross-coupling and hetero-coupling reactions, allow rapid access to access to a wide variety of functionalized heterocycles. Heterocyclic compounds exhibit various biological activities such as antibacterial, antifungal, and many more [3]. In addition to these biological properties, many heterocyclic compounds show significant biochemi-luminescence, photochromic, and solvatochromic properties. Heterocyclics have found enormous applications such as dyes, fluorescent sensors, brightening agents, plastics, analytical reagents, conjugated polymers and also for information storage. They have been used in technological applications like organic conductors, optical data carriers, organic light-emitting diodes (OLEDs), photovoltaic cells, semiconductors, molecular wires, light harvesting systems, liquid crystalline compounds and chemically controllable switches [4].

Thiophene is one of the significant aromatic compounds having a five membered ring structure with one of the carbons is replaced by sulphur. Thiophene nucleus is an important heterocyclic compound that exhibits remarkable pharmacological activities. Compounds carrying thiophene moiety show remarkable anti-inflammatory activity [5]. Number of thiophene derivatives are used as raw material for herbicides and pesticides [6]. Several thiophene derivatives have been reported as serotonin antagonists and are used to treat Alzheimer's disease.Dyes containing thiophene moiety have also been employed in the formulation of inks for computer printers [7].

Oxadiazoles are five membered rings with one oxygen and two nitrogen atoms.They have been reported to possess anti-tubercular, anti-hypoglycemic, antibacterial, antiviral, antifungal, anti-malarial, diuretic, insecticidal, anti-leishmanial , anticonvulsant, anti-inflammatory, anticancer, anti-histaminic, antihypertensive, and anti-emitic activities [8]. Oxadiazole derivatives have been used as electron-transporting material for OLEDs . Molecules containing oxadiazole moiety have shown interesting thermal, luminescent, electron transporting and hole blocking abilities that make them suitable candidates for efficient optoelectronic applications [9].

Another five membered heterocyclic compounds are thiazoles which are with nitrogen and sulfur atoms separated by a carbon atom. The thiazole ring coupled to a benzene ring results in benzothiazole. Several thiazole and benzothiazole derivatives are used as drugs, biocides, fungicides, dyes and catalysts. Studies on Benzothiazole derivatives shows a broad spectrum of biological properties including antimicrobial, anticancer, antifungal, antitumor, anti-anesthetics antiinflammatory and antimalarial activities [10]. Thiazole derivatives have been reported as accelerators (mercaptobenzothiazole), photographic sensitizers, liquid crystals and sensors [11].

Oxazole is an aromatic heterocyclic compound with an oxygen and a nitrogen separated by a carbon. Several oxazole derivatives have been reported with in vitro

scavenging activity for reactive oxygen and nitrogen species [12]. Oxazole derivatives have also been studied for their antimalarial properties [13]. Significant amyloidogenesis inhibition properties have been reported for several oxazole derivatives [14]. Oxazole derived compounds have also been studied for their liquid crystal properties [15].

Pyridine is a six membered nitrogen bearing heterocyclic compound Pyridines and its derivatives of azo moiety have reported excellent antimicrobial, antiviral, antidiabetic, antimelanogenic, anti-ulcer, anticancer, anti-mycobacterial, anti-inflammatory and DNA binding activities [16]. Pyridine derivatives are widely used in agrochemicals. They are also known for their chemosensing function [17].

Pyrimidine is a heterocyclic aromatic compound. It contains two nitrogen atoms at positions one- and three of a six-member ring. The various substituted pyrimidine derivatives have shown significant anti-microbial, analgesic, antiviral, anti-inflammatory, anti-HIV, antitubercular, anti-tumour, anti-neoplastic, antimalarial, diuretic activities. Some pyrimidine derivatives are used to regulate the cardiovascular system [18].

Several derivatives of coumarin oxazole, pyrazole and pyrrole derivatives. Shows an excellent antimalarial, anticancer, antifungal, antipsychotic and anxiolytic properties [19]. Coumarin is oxygen containing heterocyclic compound with fused benzopyran structure. Various studies on cumarin have confirmed biological activity in the treatment of lymphedema [20]. Coumarins are also used as a precursor reagent in the production of a number of synthetic anticoagulant pharmaceuticals similar to dicoumarol [21]. 4-hydroxycoumarins are a type of vitamin K antagonist that block the regeneration and recycling of vitamin K [22]. Coumarin derivatives are also used in aromatic applications due to their sweet smell. In addition, coumarin dyes are extensively used as gain media in blue-green tuneable organic dye lasers [23]. Coumarin tetramethyl laser dyes offer tunability over a wide frequency range and high laser gain, and they are also used as active medium in coherent OLED emitters [24]. The optoelectronic properties of several coumarin substituted compounds make them suitable for solar cell and laser applications [25]. They have also been reported with tunable photoluminescence properties and fluorescent chemosensors [26].

Conclusion:

Production and analysis of Heterocycles have constituted one of the largest areas of research. They have contributed to the development of society from a biological and industrial point of view. The presence of heterocycles in major organic compounds is of interest in biology, pharmacology, optics, electronics, material sciences and so on. The challenges of discovering new heterocyclic systems and of understanding their properties also continue to stimulate research in this area.

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