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LUMINESCENCE OF BIOLOGICAL COMPOUND 2(-4 THIAZOLY) BENZIMIDAZOLE INCORPORATE WITH ELECTRONIC IMAGE

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Abstract: In this paper, photo degradation of benzimidazole using benzophenone (methyl orange) as a fumigant, 2(-4) thiazolyl and luminescent in an acidic and neutral media is carried out. Photochemical reactions rely on the source of the reaction. For instance, 2-(-4 thiazole) benzimidazole (2 grams of powder) was dissolved in 200 milliliters of dried and distilled ethyl alcohol and 0.01 grams of fumigant under sunlight, ultraviolet light, and visible light. For around 40 to 50 hours, the solution combination was luminescent when exposed to 125-w and 250-w mercury vapor lamps. Every ten hours, the chromatography of the thin layer approach allowed for the regular observation of the reaction mixture's progress. Two fresh spots showed up on TLC plates after 41 and 55 hours.

The final products have a variety of biological qualities, such as being used as a primary treatment for fungal diseases and stomach warm mold. They are also frequently used in anti-parasitic medications to treat roundworms, hookworms, and parasitic worms called Helminthes. Blood vessels are formed from an existing structure (angiogenesis) in vertebrates by genes that are important for the preservation of cell walls in yeast. These genes also function to prevent the creation of blood vessels in human cells and frog embryos. Additionally, it has been demonstrated to be a vascular-disrupting agent that lowers blood flow and promotes tumor development. This paper also presents the electronic image of 2(-4 Thiazoly) Benzimidazole which refers to a visual representation that shows how electrons are distributed within the molecule.

Index Terms **-** Photo degradation-luminescence, Benzimidazole, Thiazolyl, Photochemical reactions, Photodynamic Therapy (PTD).

I. INTRODUCTION

Luminescence of biological compounds (LBC) refers to the light emission from biomolecules (like proteins, enzymes, or pigments) that occurs due to chemical reactions, energy absorption, or interaction with radiation. In medical aspects LBC is broadly divided into three category namely;

1. Bioluminescence

- Produced by living organisms through enzymatic reactions.
- Example: Light from fireflies, deep-sea fishes, or bacteria (Vibrio species).

2. Fluorescence
- Occurs when biological molecules absorb light (usually UV) and emit visible light after a very short time (nanoseconds).
- Example: Tryptophan, NADH, chlorophyll, and fluorescent dyes.
- Commonly used in fluorescence microscopy and biomedical imaging.

3. Phosphorescence
- Similar to fluorescence, but the emitted light lasts longer (milliseconds to minutes) due to delayed energy release.
- Less common in biological compounds.

New chemical reactions are made possible by Medicinal Organic Photochemical Reaction or LBC. Some of these reactions are unique, meaning that photochemical processes are the only known way for them to occur. Etrocyclics exhibit the importance of biological or pharmacological action and make up a significant portion of medicinal organic chemistry. Every species with an abundance of electrons will either absorb light or maybe emit radiation as a result of the chemical reaction of heterocyclic medicinal medicines. In general, photochemical reactions can be induced by electromagnetic radiation in the visible (400–800 nm) and ultraviolet (200–400 nm) wavelength ranges. The direction of the beam's propagation contains electromagnetic radiation, which raises the potential energy when it is absorbed by molecules. Synthetic organic photochemistry has enabled the production of several compounds that cannot be synthesized using dark processes2. Fluorescence
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• Example: Tryptophan, NADH, chlorophyll, and fluorescent dyes.
• Commonly used in fluorescence microscopy and biomedical imaging.
3. Phosphorescence
• Similar to fluorescence, but the emitted light lasts longer (milliseconds to minutes) due to delayed energy release.
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A simple mechanism of LBC is shown in figure 1

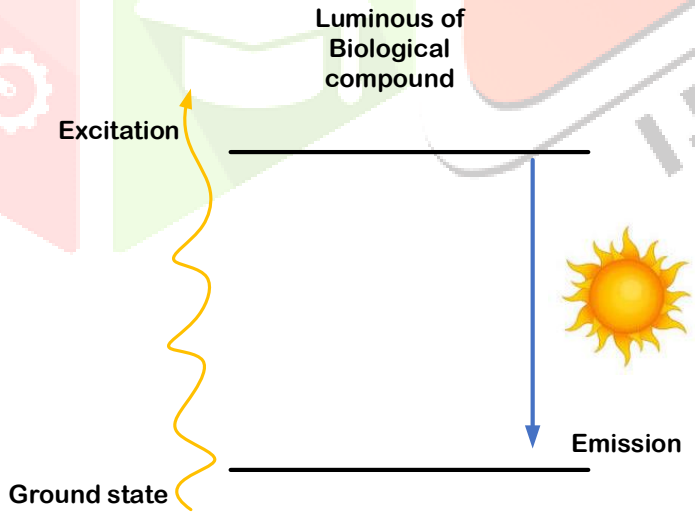

Fig. 1: Mechanism for luminous of biological compound

II. PHOTO-DEGRADATION-IRRADIATION

Photochemistry is the study of chemical transformations initiated by the absorption of light energy, typically ultraviolet (UV), visible, or infrared radiation. When light interacts with matter, it provides energy that can excite molecules to higher energy states, enabling reactions that might not occur under normal (dark) conditions [2].

According to Chapman, [3] The strongest UV radiation comes from high-pressure mercury lamps. For qualitative and semi-quantitative photochemical studies, these lights are great. Mercury lamps with a medium pressure are also employed as UV sources. Short-wavelength UV radiation is abundant in high-intensity noble discharges employing krypton and xenon and low-pressure hydrogen discharges [4, 5].

Foot and Wexlwer [6] and Corey and Taylor [7] uncover singlet oxygen in 1964. Sensitization techniques, such as fluorescence, are employed in the photo-oxidation of proteins, amino acids, alkaloids, and several other organ chemicals [8]. Over the past 40 years, a lot of study has been done on the photolysis or photoirradiation of organic molecules [9].

Albendazole is used as a preventative measure against Dutch elm disease and mainly to combat fungal infections, such as mold and brightness, in fruits and vegetables, including oranges. Thiabendazole, a preservative with E number E233 (INS number 233), is also utilized as a food additive [10, 11]. For instance, it is frequently used as a constituent in waxes applied to citrus fruit skins and is used to guarantee the freshness of bananas. In the EU, Australia, and New Zealand, it is not permitted as a food ingredient [12, 13]. There have been reports of its use in the treatment of aspergillosis [14]. It is often used with azoxystrobin to make antifungal wallboards. Absorption of red (680 nm) light raises an electron to a higher orbital, Sπ. Absorption of blue (430 nm) light elevates an electron to a higher (but still Sπ) energy state because it has more energy per photon than red light.

The molecules contribute electrons to more positive (less negative) molecules and take electrons from less positive (more negative) molecules during electron transfer. Molecules are said to as reduced when they take on electrons and as oxidized when they lose electrons. Thus, a series of oxidation-reduction events are involved in the electron transfer that occurs after chlorophyll absorbs light energy.

Infrared light (photosensitizer) is utilized in photodynamic therapy (PDT), a treatment that looks for illness in ambient molecular oxygen levels. The photosensitizer absorbs light and releases oxygen. The biological system is subsequently harmed by the activated oxygen (mostly singlet oxygen), as in the case of photodynamic elimination of microorganisms and PDT for cancer.

Photosensitizing furocoumarins (psoralens) found in naturally occurring plants have been used to study skin erythema in recent years. When used in combination with exposure to near UV radiation, psoralens have also been shown to have mutagenic and carcinogenic effects. Psoralen combined near UV light therapy (PUVA therapy) causes a number of other harmful biological alterations.

III. THIABENDAZOLE

Thiabendazole is a benzimidazole (C10H7N3S) compound for anti-infective/anthelmintic medication, which is used to treat cutaneous larva migrans, strongyloidiasis, and visceral larva migrans. The structure comprises a benzimidazole ring system with a 4-thiazolyl substituent at the 2-position. Thiabendazole functions by blocking the mitochondrial enzyme fumarate reductase in parasites. It disrupts microtubule dynamics in helminths, resulting in structural alterations. It is usually supplied orally, although it can also be used topically. It can be well absorbed after oral administration and, after being converted to 5-hydroxythiabendazole by cytochrome P450 CYP1A2, the majority of the dose is eliminated in the urine within 24 hours. Anorexia, vomit and nausea are most common side effects of thiabendazole. It is recognized for its ability to diminish oxygen consumption and impede the uptake of glucose and amino acids in some fungus.

It is one of the earliest known nitrogen heterocycles, benzimidazole was initially created by Hoebrecker followed by Ladenberg-Wundt between 1872-1878. However, it wasn't until the early 1960s that a combination of 2-phenylbenzimidazole (1, phenzidole) and phenothiazine was introduced as a sheep anthelmintic that its therapeutic promise in parasite chemotherapy was acknowledged [15]. Thiabendazole's emergence as a treatment for helminth infections in humans and domestic animals can be considered a turning point in the development of a new class of anthelmintics. One of the most significant classes of anthelmintics, benzimidazoles offer a variety of potent medications for intestinal and tissue-dwelling helminths. The structural ring for thiabendazole is shown in figure 2, where R, R1, R2 are the molecular compound whose combinations results in specific drugs as mentioned in table 1.

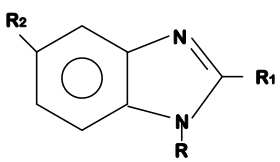

Fig. 2. Benzimidazole ring

Table-1: Some clinical medicines of Benzimidazole drug

Compd. Generic Name No.	R	R_1	R_2
Phenzidole	H	C_6H_5	H
Thiabendazole	H	4-thiazolyl	H
Cambendazole	H	4-thiazolyl	NHCOO*i*-Pr
Carbendazim (antifungal)	H	NHCOOMe	H
Lobendazole	H	NHCOOEt	H
Parbendazole	H	NHCOOMe	*n*-Bu
Albendazole	H	NHCOOMe	S*n*-Pr

IV. Method of Experimentation

In this paper, photo degradation of benzimidazole using benzophenone (methyl orange) as a fumigant, 2(-4) thiazolyl and luminescent in an acidic and neutral media is carried out. 2 (-4 thiazolyl) benzimidazole in neutral and acidic media with benzophenone acting as a fumigant and sensitizer. Dissolve 2 grams of the substrate in 200 milliliters of distilled ethyl alcohol. Two to three drops of distilled hydrochloride acid were added to a 500 ml beaker to make the medium acidic, and 0.01 g of benzophenone was added as a sensitizer. Irradiation-Luminescence was then initiated once the solution was put into the photo-reactor device. Constant water circulation maintained the reaction mixture's temperature. At regular intervals, the reaction's progress was monitored. The irradiation was discontinued after 70–75 hours since no change was seen after around 70 hrs. The identical substrate undergoes a photochemical-irradiation reaction in a neutral media. 200 ml of distilled ethanol were used to dissolve the 2 grams of substrate. As a sensitizer, add 0.01 gms of benzophenone.

After that, this solution was moved to the photo reactor, and a 125 W light was used to begin irradiation. At regular intervals, the reaction mixture's progress was monitored. New spots started to show up on the thin layer chromatography plate after 41–45 hours. Following the reaction, the reaction mixture was concentrated, and preoperative thin layer chromatography (TLC) was used to separate products I and II. The result comparison for the two products is shown in Table-II.

Table 2: Result comparison

Chart	PRODUCT –I	PRODUCT –II
Yield	0.8 gm	0.7gm
Melting point	170 0c	2230c
Nitrogen Test	Positive	Positive
Sulfur Test	Negative	Positive

V. Compound Discussion and Structure

When 2(-4 thialyl) benzimidazole was Luminescent by UV light in a neutral medium with a pH of 7, the compounds' photo-degradation, irradiation, or luminescence was performed using benzophenone as a sensitizing fumigant under a 125w ultraviolet lamp as shown in figure 3. It provides the product shown in figure 4 and figure 5, and the IR, 1HNMR, and 13CNMR have verified the product's structure.

1. The infrared (IR) spectrum of the product shows peaks at 3369.3(NH stretching),1596.4(CN stretching), 1274.9 (C-N bending), 1086.5 (C-O & C-N stretching), 933.5(O-O stretching), 831.8Cm-1(aromatic CH bending).

2. The nuclear resonance (1HNMR) spectrum of products shows peaks at 7.5-7.5(aromatic protons), 6.2.(NH protons), 4.7-4.5(CH2 proton of 5-member ring).

3. The (13CNMR) spectrum of the product shows peaks at 155.0(C1 & C2), 141(C3 carbon), 138(C4 carbon atom),124-131(aromatic carbon atoms).

Mass Spectrum of the product at m/z 233 which correspond to the to the molecular weight of the product. Other important peaks are as follows;217,201,199,117,102,91,83,76 etc. as shown in figure 6.

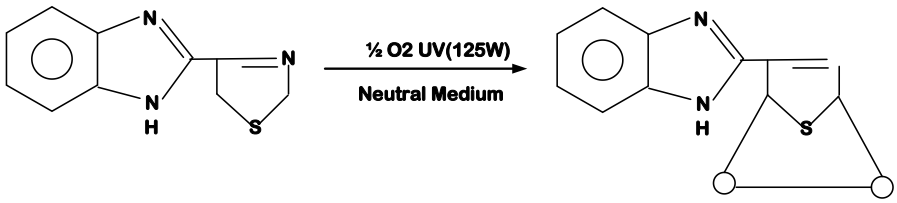

Fig. 3: Luminescent by UV light of 2(-4 thialyl) benzimidazole

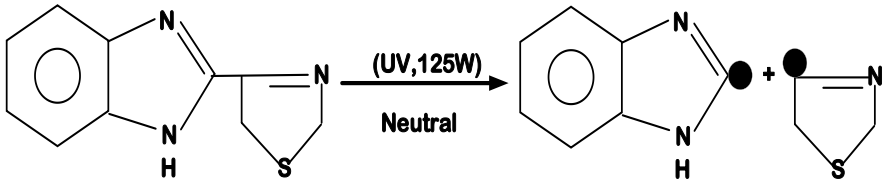

Fig. 4:. Product I

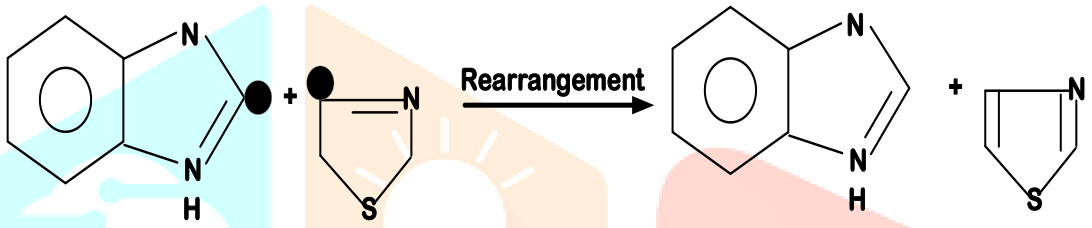

Fig. 5:. Product II

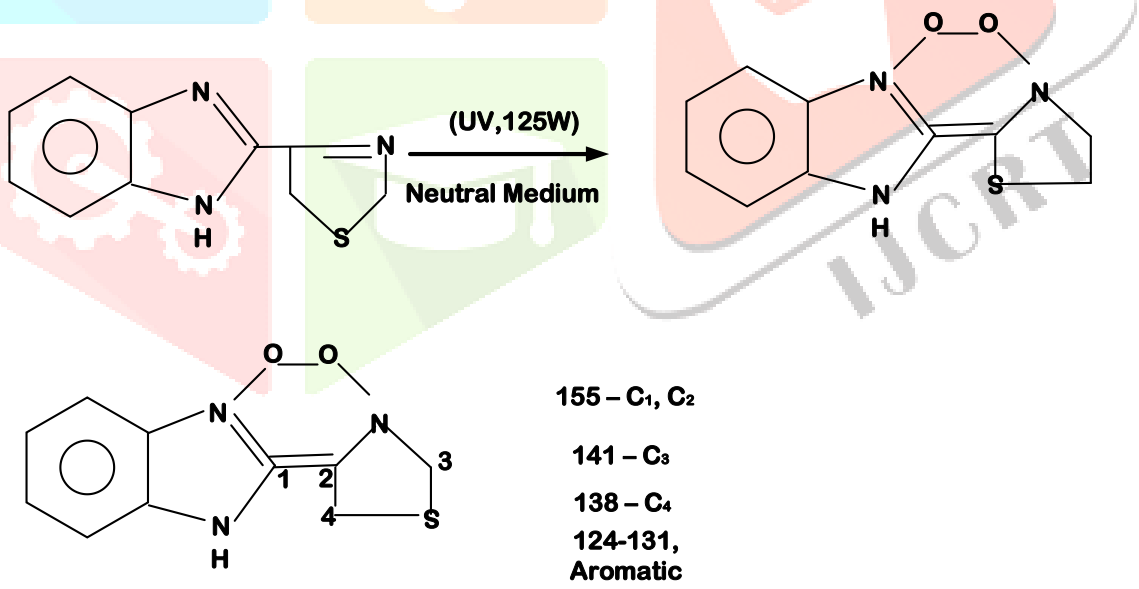

Fig. 6: Structure of the drug thialyl-benzimidazole

VI. MECHANISM OF COMPOUND

Benzimidazole is a heterocyclic aromatic compound consisting of a benzene ring fused to an imidazole ring. It is a biologically active scaffold widely used in pharmaceutical chemistry because it exhibits a broad range of therapeutic properties such as;

A. Antimicrobial Activity

Benzimidazole derivatives are effective against bacteria, fungi, and viruses. Examples:

- *Mebendazole, Albendazole* – act as anthelmintic (anti-worm) agents.
- *Carbendazim* – used as an antifungal compound.

Mechanism: Interfere with microtubule synthesis or inhibit nucleic acid metabolism in microbes.

B. Anthelmintic (Anti-Parasitic) Activity

One of the most important medicinal uses. Drugs like Albendazole, Mebendazole, and Thiabendazole are used to treat intestinal worm infections.

Mechanism: Inhibit tubulin polymerization → disrupt glucose uptake in parasites → cause energy depletion and death.

C. Antiviral Activity

Some benzimidazole derivatives show activity against HIV, Hepatitis B, and Herpes viruses. They act by inhibiting viral DNA replication or enzyme activity required for viral growth.

D. Anticancer Activity

Benzimidazole compounds can inhibit cell division, disrupt microtubule formation, and induce apoptosis in cancer cells.

Examples: Certain derivatives target topoisomerase, tyrosine kinases, or tubulin polymerization.

E. Anti-inflammatory and Analgesic Activity

Benzimidazole analogs act as COX inhibitors, reducing the production of prostaglandins that cause inflammation and pain.

They have effects similar to NSAIDs (Non-Steroidal Anti-Inflammatory Drugs).

F. Antihypertensive and Cardioprotective Activity

Some derivatives act on the angiotensin receptor and help in lowering blood pressure.

Example: *Telmisartan* (a benzimidazole derivative) – an angiotensin II receptor blocker (ARB).

G. Antidepressant and Anticonvulsant Activity

Certain benzimidazole derivatives affect CNS neurotransmitters, showing antidepressant, anticonvulsant, and anxiolytic effects.

H. Antioxidant Activity

Benzimidazoles scavenge free radicals and reduce oxidative stress, which contributes to aging and many diseases.

Edwara and George have researched the photolysis of benzimidazole and its 2-alkyl derivatives. Crank and Ahamad have studied the photolysis of different 2-substitute benzimidazole. Its derivatives have a wide range of pharmaceutical applications, including anticancer, antihypertensive, antiviral, antifungal, anti-HIV, anti-convulsive, and anti-diabetic properties. Posadaz11 has investigated the kinetics and microbiological implications of this sort of compound's riboflavin and rose bengal-sensitized photooxidation. Recently, thiabendazole—which the FDA has approved for oral use since 1967 as an antifungal and anthelminthic medication—was repurposed as a vascular disruptor. The lead compound's moderately inhibitive cell-proliferation activity was confirmed to be anti-angiogenesis and vascular by optimizing its structure. In 1962, substituted benzimidazole was first made available. It is the preferred medication for strong oxidases and effective against a range of nematodes. It has the potential to be hepatotoxic and to cause CNS side effects. According to Smith and Reynard's 1992 Textbook of Pharmacology, thiabendazole is a parasite and fungicide. In cases of metal poisoning, such as lead, mercury, or antimony poisoning, thiabendazole is used medicinally to bind metals because it is also a chelating agent.

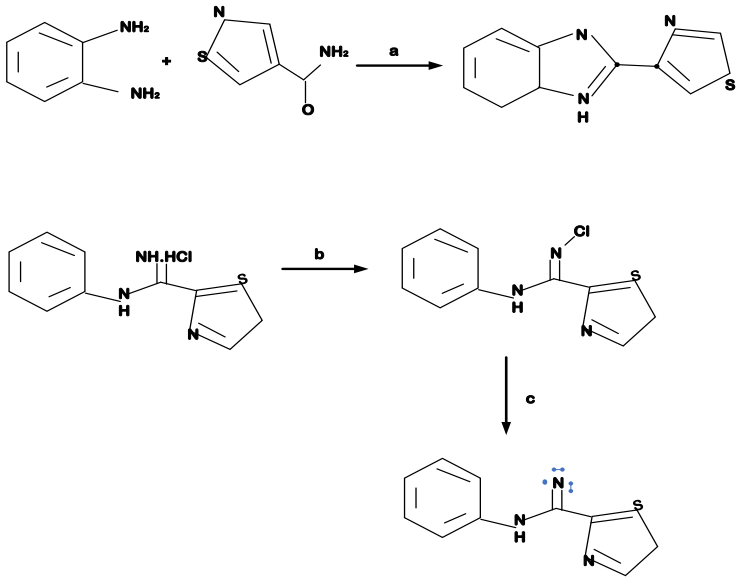

Fig. 7. Reagents and condition of the drug

Ascarislumbricoides (common roundworm), Strongyloides stercoralis (threadworm), Necator-americanus, and Ancylostoma-duodenal (hookworm) are all susceptible to its vermicide and/or vermifugal properties. In reaction to certain stimuli, substituted benzimidazoles can stop the release of stomach acid because they are strong inhibitors of the Na+/K+ ATPase and the parietal cell proton pump. Methylene groups containing heterocyclic bonds are crucial for the activation of sulfoxide groups. The Reagents and condition of the drug discussed in shown in figure 7.

VII. ELECTRONIC IMAGE OF 2(-4 THIAZOLY) BENZIMIDAZOLE

The electronic image of 2-(4-thiazolyl) benzimidazole is a graphical depiction of how electrons move, concentrate, and interact within the molecule, highlighting electron-rich zones (N and S atoms) and electron-deficient areas across its aromatic system. It illustrates the molecule's electronic structure as shown in figure 8. It explains the chemical reactivity, optical behavior, and interaction with light or biological systems. the electronic image may include:

1. **Electron Density Map;** which shows regions of high and low electron concentration. The high electron density appears around Nitrogen (N) atoms in benzimidazole Sulfur (S) atom in the thiazole ring.

2. **Electrostatic Potential Surface (ESP)** which is a color-coded surface indicating charge distribution. If colour is red, then the molecule is electron rich or negatively charged. If blue coloured, then Electron-poor or having positive potential. And atlast is yellow coloured then the region is neutral.

3. **Molecular Orbital Image (HOMO–LUMO)** which displays the highest occupied and lowest unoccupied molecular orbitals.

4. **Resonance and π-electron delocalization** which demonstrates conjugation between benzimidazole and thiazole rings.

The comparative summary of the work done is presented in table-III

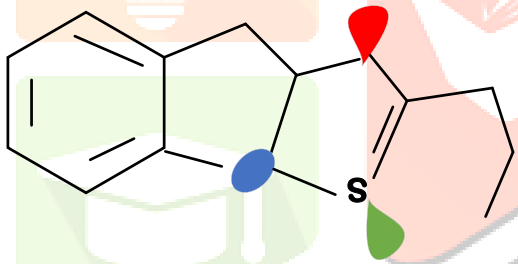

Fig. 8. Electronic Image of 2(-4 Thiazoly) Benzimidazole

Table-3: Comparative summary

Chart	**LBC**	**Luminescence**
Process type	Light-induced chemical breakdown	Light emission after excitation
Outcome	Loss of structure, formation of degraded products	Emission of visible-UV lights
Key transition	Excited state → chemical reaction	Excited state → photon emission
Effect on compound	Decreases stability	Used for detection or imaging
Applications	Drug stability, phototoxicity testing	Fluorescent sensors, bioimaging

VII. CONCLUSION

2-(4-Thiazolyl) benzimidazole is a heterocyclic compound that combines two biologically active moieties: Benzimidazole ring which is known for antimicrobial, anticancer, and antioxidant properties and Thiazole ring which contributes to electronic conjugation and biological reactivity. Because of its conjugated π-electron system, the compound interacts strongly with light (UV–visible radiation), making it relevant in both photo-degradation and luminescence studies. This paper presents the photo-chemical reaction of benzimidazole and the properties under infrared and UV rays are studied. The compound structure with medicinal properties are also presented in this paper. The compound discussed in this paper can undergo

photo-degradation under high-intensity or prolonged irradiation. It also possesses luminescent properties, making it valuable for bioanalytical and photophysical applications.

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