

# Synthesis and Characterization of Terephthalate Substituted Azo-Linked Compound for Textile Fastening Application on Polyester, Silk and Cotton

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**Abstract:** *This study explores the synthesis, characterization, and application of a novel azo-linked compound, E)-4-(5-((8-hydroxyquinolin-5-yl) diazenyl)-1, 3, 4-thiadiazol-2-yl) benzoic acid, for application in textile research. The synthesized compound was characterized using FT-IR, <sup>1</sup>H NMR, and <sup>13</sup>C NMR spectroscopy, confirming the presence of key functional groups such as the azo (-N=N-) and thiadiazole moieties. Moreover, This study investigated the color fastness of as prepared dye on three different fabric types: cotton, polyester, and silk. Fastness properties, including washing, light, and rubbing fastness, were evaluated under various conditions, such as washing with detergent, alkaline (NaOH), and acidic (HCl) solutions. Polyester exhibited superior fastness across all tests, showing high stability and color retention. Silk displayed good resistance in neutral and acidic environments but was sensitive to alkaline conditions. Cotton demonstrated lower fastness, particularly in alkaline conditions, indicating its susceptibility to dye leaching. The findings highlight polyester's durability and suitability for use in environments demanding high fastness.*

**Keywords:** synthesis, azo dye, textile research, color fastness, polyester durability

## 1. Introduction

Water pollution has become a critical environmental challenge, particularly due to the release of industrial effluents containing harmful chemicals such as synthetic dyes [1-3]. These dyes, widely used in industries like textiles, paper, leather, and plastics, are characterized by complex aromatic structures that make them resistant to conventional wastewater treatment methods [4, 5]. The persistence of these dyes in water bodies poses serious ecological and public health risks, as many of them are toxic, carcinogenic, and non-biodegradable [6]. The presence of dyes in wastewater not only affects the aesthetic quality of natural water sources but also impairs aquatic ecosystems by limiting light penetration, thereby disrupting photosynthesis and oxygen levels [7]. Furthermore, many synthetic dyes can undergo chemical transformations in the environment, generating byproducts that are even more harmful, such as aromatic amines, which are known to be carcinogenic [8]. Therefore, effective, non-removable dye synthesis is important for both environmental sustainability and human health. The textile industry, one of the largest consumers of synthetic dyes, is a major contributor to water pollution as these dyes can be removed easily after a few cycles of washing. It is estimated that over 700, 000 tons of dyes are produced annually, with approximately 10-15% of these dyes being lost during the dyeing process and subsequently discharged into wastewater streams [9]. Among the various classes of dyes, azo dyes are the most commonly used due to their vibrant colors and chemical stability. Azo dyes, such as methyl orange and congo red, contain azo (-N=N-) linkages that are resistant to biological degradation [10]. Moreover, under anaerobic conditions, these dyes can be reduced to form toxic aromatic amines, posing significant health risks to humans and animals [11]. Therefore, it is important to produce the new azodyes for the betterment of the textile fabrication industries. In light of these limitations,

there has been growing interest in developing more efficient, sustainable azo dye.

The fastness of dyes in fabrics is a critical aspect of textile performance, determining the longevity and appearance of dyed fabrics after exposure to various environmental conditions such as washing, light, and mechanical friction [12]. Thiolated azo dyes are often used as a model dye to evaluate these properties due to their well-established dyeing behavior [13]. Different fabrics, such as natural fibers (cotton, silk) and synthetic fibers (polyester), exhibit varied interactions with dyes based on their chemical composition, surface properties, and structural characteristics.

Azo dyes, characterized by the presence of one or more azo (-N=N-) groups, are the most widely used class of synthetic dyes in various industries, particularly textiles. Their versatility in structure allows for a broad range of colors and applications, and their color fastness properties vary depending on their molecular structure, the type of fabric they are applied to, and the dyeing conditions. Monoazo dyes contain a single azo group (-N=N-) and are the simplest form of azo dyes. These dyes are used for dyeing natural fibers such as cotton, wool, and silk, as well as synthetic fibers like nylon. They are generally more light-sensitive compared to polyazo dyes but still exhibit reasonable color fastness. Monoazo dyes generally show moderate to good fastness to washing and light, especially on hydrophilic fibers like cotton and wool. However, their fastness may decrease on hydrophobic fibers like polyester. *Orange II* (Acid Orange 7) is commonly used on wool and silk with moderate light fastness [14]. Disazo dyes contain two azo groups and are more complex than monoazo dyes. They are used for both natural and synthetic fibers and are known for their deeper and more vivid colors compared to monoazo dyes. These dyes generally provide better color fastness due to their larger molecular size and stronger interactions with fibers. Disazo dyes tend to have

better fastness to light and washing, particularly when applied to wool and polyester. Their performance on cellulosic fibers (e. g., cotton) depends on the specific functional groups in the dye molecule. *Direct Blue 15* is a popular disazo dye used for dyeing cotton, with good fastness to washing and moderate light fastness [15]. Trisazo dyes contain three azo groups and offer vibrant, rich colors. Due to their more complex structures, trisazo dyes are used to dye materials like cotton, polyester, and wool. They tend to form stronger bonds with fibers, enhancing their fastness properties. Trisazo dyes often demonstrate excellent fastness to light, washing, and rubbing, particularly when applied to polyester or wool. On cotton, fastness can be slightly lower but still acceptable with proper dyeing techniques. *Direct Brown 2* is a trisazo dye used for dyeing wool and silk, with good fastness to light and washing [16]. Polyazo dyes contain more than three azo groups, making them highly complex and suitable for achieving deep, dark shades. These dyes are predominantly used in synthetic fibers such as polyester, where their large molecular structures lead to excellent fastness properties. Polyazo dyes are known for their superior fastness to light, heat, and washing, especially on synthetic fibers. They exhibit good resistance to fading under both washing and light exposure, making them suitable for outdoor textiles or high-performance fabrics. *Direct Black 38* is a polyazo dye used extensively in polyester dyeing, with excellent fastness properties [17]. Reactive azo dyes are commonly used for cellulosic fibers like cotton, rayon, and linen. These dyes chemically bond to the fiber through a covalent bond during the dyeing process, which significantly improves their color fastness properties. The reactive nature of these dyes allows them to be fixed to fibers in a way that resists fading due to washing, light, and friction. Reactive azo dyes exhibit excellent washing fastness and good light fastness. Their strong chemical bond to the fibers means that color fading due to washing or other environmental factors is minimal. However, their fastness to light can vary depending on the specific dye and dyeing conditions. *Reactive Orange 13* is a reactive azo dye with good washing and light fastness on cotton [18]. Acid azo dyes are typically used to dye protein fibers such as wool, silk, and nylon. These dyes rely on ionic bonds between the dye molecule and the fiber, making them highly effective on fibers that can interact with the charged dye molecules [14]. While azo dyes offer good color fastness, some varieties, particularly those used in natural fibers, suffer from poor fastness to light, washing, or alkaline conditions. This limits their use in applications requiring high durability. Additionally, the dyeing process for synthetic fibers like polyester often requires high energy inputs (e. g., high temperatures or dispersing agents), raising energy consumption and processing costs. Organic compounds, particularly those containing functional groups such as azo ( $-N=N-$ ) and thiadiazole ( $-C=N-S$ ), have attracted attention due to their unique electronic structures and strong absorption in the visible region of the spectrum [19]. Azo compounds are known for their electron-rich nature, which allows them to participate in redox reactions, while thiadiazoles, as

heterocyclic compounds, exhibit strong electron-withdrawing properties, enhancing the overall photocatalytic efficiency [20]. The incorporation of additional functional groups, such as aldehyde ( $-CHO$ ) and hydroxyl ( $-OH$ ) groups, can provide further reactive sites and influence the molecular architecture, potentially improving the reactivity and stability of the photocatalyst. In this study, we report the synthesis and characterization of a novel azo-linked compound, E)-4-(5-((8-hydroxyquinolin-5-yl) diazenyl)-1, 3, 4-thiadiazol-2-yl) benzoic acid, designed for use textile application. The compound was synthesized through a multi-step reaction process involving the coupling of 8-hydroxyquinoline with a thiadiazole derivative. The choice of this compound is based on its unique structural features, the electron-accepting properties of the thiadiazole moiety. The presence of the quinoline ring is expected to enhance the compound's electronic interactions, stabilize the overall molecular structure, and improve its robustness for fastening process. Moreover, we explore the color fastness of as synthesized azo dye on three commonly used fabrics: cotton, polyester, and silk. The investigation focuses on three key fastness properties—washing, light, and rubbing—under different conditions, including detergent-based, alkaline, and acidic washing. Understanding how different fabric types respond to these conditions is essential for determining their suitability for various textile applications, particularly where durability and color retention are paramount.

## 2. Material Synthesis

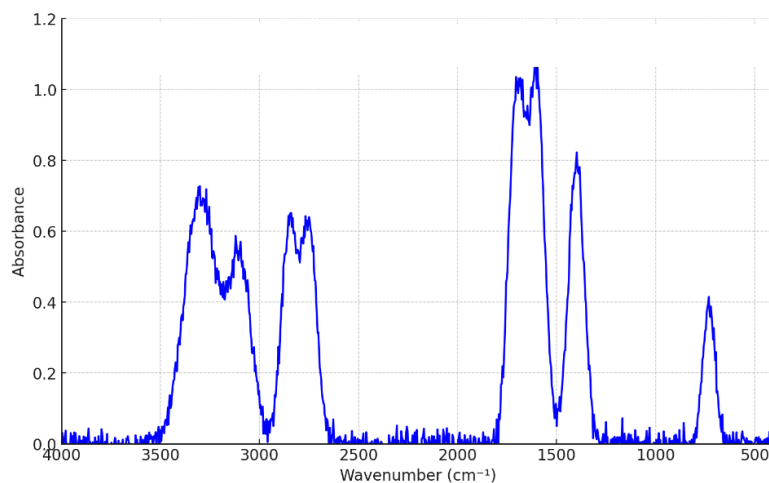
The synthesis of E)-4-(5-((8-hydroxyquinolin-5-yl) diazenyl)-1, 3, 4-thiadiazol-2-yl) benzoic acid achieved through a series of steps starting from basic materials like 8-hydroxyquinoline, terephthalic acid, and appropriate reagents for diazotization and coupling reactions. Here's a general outline of the process: Start with 8-hydroxyquinoline (1.45 g, 10 mmol), dissolved in a mixture of hydrochloric acid (10 mL, 2M) and water (20 mL). the solution was cooled to 0-5°C in an ice bath. sodium nitrite (0.69 g, 10 mmol) was added slowly in 5 mL of water while maintaining the temperature below 5°C to form the diazonium salt.

**Synthesis of 1, 3, 4-thiadiazole derivative:** In a separate step, terephthalic acid is dissolved (1.34 g, 10 mmol) in phosphorus oxychloride (20 mL). thiosemicarbazide (0.91 g, 10 mmol) was added, and the mixture was refluxed for 4-5 hours. After cooling, the 1, 3, 4-thiadiazole intermediate was formed, and purified by recrystallization from ethanol.

**Coupling Reaction:** The diazonium salt from step 1 added slowly to the thiadiazole derivative under cold conditions. The mixture was stirred for 2-3 hours at room temperature. The product, E)-4-(5-((8-hydroxyquinolin-5-yl) diazenyl)-1, 3, 4-thiadiazol-2-yl) benzoic acid was filtered and washed with cold ethanol.

### 3. Results and Discussion

#### 3.1 Fourier Transform Infrared Spectroscopic Analysis:

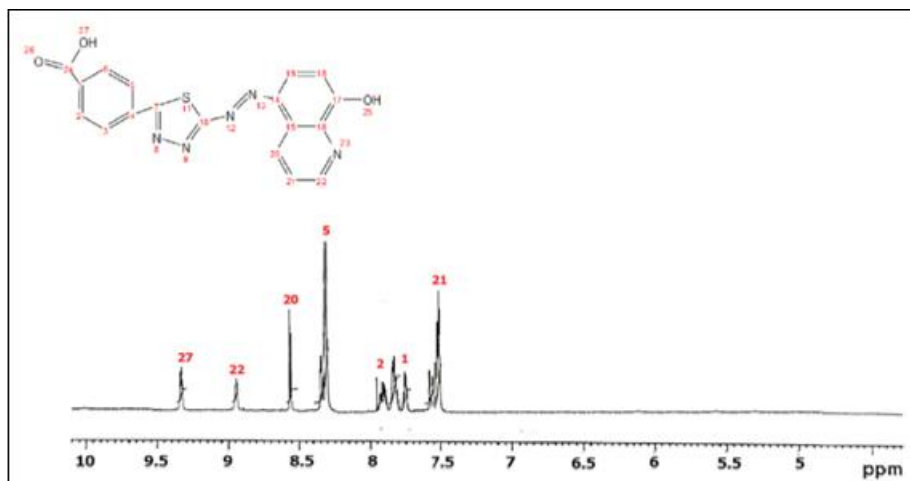


**Figure 1:** FTIR spectra of E)-4-(5-((8-hydroxyquinolin-5-yl) diazenyl)-1, 3, 4-thiadiazol-2-yl) benzoic acid

FTIR spectrum for E)-4-(5-((8-hydroxyquinolin-5-yl) diazenyl)-1, 3, 4-thiadiazol-2-yl) benzoic acid highlights the following key peaks: **C=O (Carboxylate) at  $\sim 1700\text{ cm}^{-1}$ :** This strong absorption peak corresponds to the stretching vibration of the carboxylate group [21]. **C-H (Carbohydrate) at  $\sim 2750\text{ cm}^{-1}$  and  $\sim 2850\text{ cm}^{-1}$ :** These two peaks are characteristic of the C-H stretching [22]. **N=N (Azo group) at  $\sim 1400\text{ cm}^{-1}$ :** This sharp peak arises from the stretching vibration of the azo group [23]. **C=N (Thiadiazole) / C=C (Aromatic) at  $\sim 1600\text{ cm}^{-1}$ :** A strong absorption band for both the C=N bond in the thiadiazole ring and the C=C stretching in the aromatic system [24]. **C-S (Thiadiazole) at  $\sim 730\text{ cm}^{-1}$ :** A broad peak attributed to the stretching of the C-S bond [25]. **C-H (Aromatic) at  $\sim 3100\text{ cm}^{-1}$ :** A weak but distinct absorption for aromatic C-H stretching [26]. **O-H (Hydroxyl) at  $\sim 3300\text{ cm}^{-1}$ :** A broad peak indicating the presence of the hydroxyl group from quinoline, showing hydrogen bonding effects.

The FTIR spectrum provides insight into the molecular structure through characteristic vibrational modes. The presence of two C-H stretching peaks near  $2750\text{ cm}^{-1}$  and  $2850\text{ cm}^{-1}$  along with the intense carbonyl peak at  $1700\text{ cm}^{-1}$  confirms the aldehyde functionality. The N=N stretching peak near  $1400\text{ cm}^{-1}$  is typical of azo compounds, confirming the azo linkage. The C=N stretch around  $1600\text{ cm}^{-1}$  and the C-S stretch at  $730\text{ cm}^{-1}$  are consistent with thiadiazole structures, indicating the successful formation of the heterocyclic ring. Aromatic Systems. The peaks around  $3100\text{ cm}^{-1}$  and  $1600\text{ cm}^{-1}$  point to aromatic C-H and C=C stretching modes, confirming the presence of aromatic rings (quinoline and terephthalate). The broad O-H stretching peak at  $\sim 3300\text{ cm}^{-1}$  suggests a hydroxyl group, likely engaged in hydrogen bonding, as part of the quinoline moiety. This FTIR analysis supports the successful synthesis of the desired compound with the expected functional groups.

#### 3.2 $^1\text{H}$ NMR analysis:



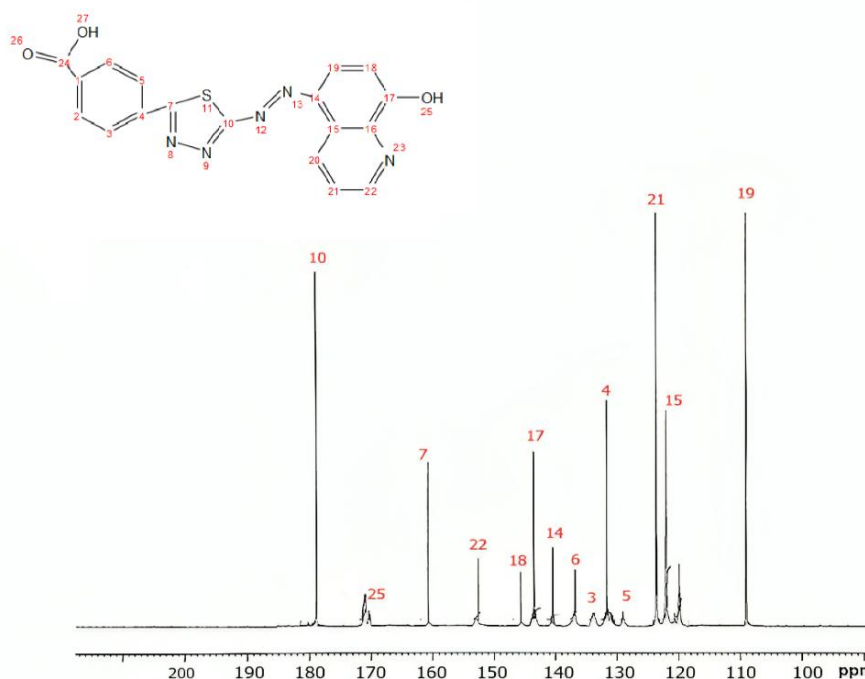
**Figure 2:**  $^1\text{H}$  NMR of E)-4-(5-((8-hydroxyquinolin-5-yl) diazenyl)-1, 3, 4-thiadiazol-2-yl) benzoic acid

$^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz):  $\delta$  7.76 (1H, d,  $J = 7.8\text{ Hz}$ );  $\delta$  7.90 (1H, dd,  $J = 7.8, 1.2\text{ Hz}$ );  $\delta$  7.54 (1H, m);  $\delta$  8.31 (1H, d,  $J = 8.4\text{ Hz}$ );  $\delta$  8.60 (1H, d,  $J = 8.4\text{ Hz}$ );  $\delta$  8.85 (1H, s);  $\delta$  9.35 (1H, s)

Resonance peak 1 at  $\delta$  7.76: This doublet likely arises from one of the aromatic protons on the benzene ring of the benzoic acid moiety. The doublet splitting suggests coupling with one equivalent neighbouring proton. The chemical shift of 7.76 ppm is typical for aromatic protons in a benzene ring. Resonance Peak at  $\delta$  7.9: The doublet of doublets pattern for peak 2 indicates coupling with two different neighboring protons. This is consistent with the aromatic protons on the benzene ring of the terephthalate moiety, which are typically coupled to both adjacent protons on the ring. The chemical shift of 7.9 ppm is again characteristic of aromatic protons in a benzene ring. Resonance Peak 5 at  $\delta$  8.31: Similar to peak 1, this doublet likely corresponds to another aromatic proton on the benzene ring of the terephthalate moiety. The coupling pattern and chemical shift are consistent with this assignment. Resonance Peak 20 at  $\delta$  8.60: This doublet is likely due to one of the aromatic protons on the quinoline ring. The coupling with one equivalent neighboring proton is typical for protons on aromatic rings. The slightly downfield shift compared to the benzene protons (peaks 1, 2, and 5) suggests that this proton might be influenced by the electron-withdrawing

effect of the nitrogen atom in the quinoline ring. Resonance Peak 21 at  $\delta$  7.54: The multiplet pattern for peak 21 indicates coupling with multiple neighboring protons. This is consistent with the aromatic protons on the quinoline ring, which are likely coupled to both adjacent protons on the ring as well as the proton on the nitrogen atom. Resonance Peak 22 at  $\delta$  8.85: The singlet pattern for peak 22 suggests that this proton is not coupled to any neighboring protons. This is consistent with the proton attached to the nitrogen atom in the quinoline ring, which is typically not coupled to other protons due to its hybridization and electron-withdrawing effect. Peak 27 at  $\delta$  9.35: The singlet pattern and downfield shift of peak 27 are characteristic of a phenolic proton. This confirms the presence of the hydroxyl (OH) group in the molecule, likely attached to the quinoline ring. The  $^1\text{H}$  NMR data supports the proposed structure of the compound, confirming the presence of the terephthalate and quinoline moieties, as well as the hydroxyl group. The analysis of the splitting patterns and chemical shifts provides valuable information about the connectivity and electronic environment of the protons in the molecule.

### 3.3 $^{13}\text{C}$ NMR analysis:



**Figure 3:**  $^{13}\text{C}$  NMR of E-4-(5-((8-hydroxyquinolin-5-yl) diazenyl)-1, 3, 4-thiadiazol-2-yl) benzoic acid

The  $^{13}\text{C}$  NMR spectrum provides vital information about the carbon atoms in the molecule, based on the unique chemical environment each carbon experiences. Below is a detailed analysis of the observed peaks: **Peak 10 at 179.1 ppm:** This high shift indicates the presence of an electron-withdrawing group (the nitrogen in the thiadiazole ring). Such deshielded carbons are typically found in heteroaromatic rings like thiadiazole, confirming the attachment of nitrogen and sulfur in the ring structure. **Peaks 25 at 168.3 ppm:** These shifts correspond to the oxygen attachment to quinoline. The two distinct peaks could be due to slightly different chemical environments caused by variations in the resonance or interactions with adjacent groups, suggesting non-equivalent environments for the carboxylic acid groups. **Peak 7 at 161.2 ppm:** Carbon in the thiadiazole ring, specifically the amino

(C=N) carbon. This downfield shift indicates the presence of a double bond with nitrogen in the heterocyclic thiadiazole ring, confirming the formation of the C=N bond in the ring structure. **Peak 22 at 150.26 ppm:** Quinoline is an aromatic system with nitrogen in the ring, and this peak likely corresponds to the carbon directly attached to nitrogen. The downfield shift reflects the electronegativity of nitrogen and its influence on the adjacent carbon. **Peaks 18 and 17 at 145.1 ppm and 144.9 ppm:** Carbons in the quinoline ring system, likely those near the hydroxyl group (-OH). These two peaks suggest that the hydroxyl group (OH) attached to the quinoline system influences the chemical environment of the neighboring carbons. Slight differences in their chemical shifts could arise from interactions with the hydroxyl group. **Peak 14 at 140.5 ppm:** This carbon is part of a linkage



between two different ring systems (quinoline and thiadiazole). The shift is downfield due to the electron-withdrawing effect of both the nitrogen atoms in the two rings. Peak 6 at 134.3 ppm: The shift indicates that this carbon is part of the aromatic benzene ring in the terephthalate structure. The value is typical of aromatic carbons attached to electron-withdrawing groups such as carboxyl (COOH). Peak 3 at 133.52 ppm: This shift corresponds to one of the carbons in the benzoic acid benzene ring. It suggests substitution in the ring, likely due to the proximity of the carboxyl groups, which deshield the carbon atoms. Peak 4 at 131.6 ppm: This peak further confirms the aromatic nature of the benzoic acid ring. Its chemical shift is consistent with carbons in a substituted benzene ring. Peak 5 at 129.1 ppm: This chemical shift falls within the typical range for aromatic carbons. The presence of the electron-withdrawing carboxyl groups (COOH) affects the overall chemical shift, leading to a deshielded environment. Peak 21 at 123.2 ppm: The shift reflects the aromatic nature of the quinoline ring and the influence of the nitrogen atom, which is electron-withdrawing, leading to a deshielded chemical environment. Peak 15 at 122.5 ppm: This peak corresponds to one of the carbons in the quinoline ring, away from the nitrogen atom but still part of the aromatic system. The shift is within the expected range for such carbons. Peak 19 at 109.5 ppm: This upfield shift is typical of carbons in the aromatic system, particularly when affected by electron-donating groups like hydroxyl, leading to more shielding. The spectrum contains distinct peaks for the various carbon environments, corresponding to carbons in the thiadiazole ring, quinoline ring, and benzoic acid unit. Peaks at 179.1 ppm (C=N in the thiadiazole) and 168.8 ppm / 168.3 ppm (C=O in the benzoic ring) represent electron-deficient environments due to the presence of nitrogen and oxygen atoms. Peaks around 144-145 ppm highlight the influence of the hydroxyl group on the quinoline ring. Peaks in the 110-150 ppm range reflect the aromatic carbons in the quinoline and benzoic acid structures. Lower-field peaks like those around 123-134 ppm are indicative of substituted aromatic carbons, confirming the presence of electron-withdrawing groups (e. g., carboxyl and hydroxyl) that affect the chemical environment of the ring system.

This analysis confirms the structural integrity of the molecule, providing insights into the electron-withdrawing and electron-donating effects of the functional groups on the carbon atoms. This data serves as a key verification of the proposed molecular structure based on the  $^{13}\text{C}$  NMR spectrum.

The  $^{13}\text{C}$  NMR spectrum of E)-4-(5-((8-hydroxyquinolin-5-yl) diazenyl)-1, 3, 4-thiadiazol-2-yl) benzoic acid provides clear evidence of the presence of key structural features, including the thiadiazole ring, quinoline moiety, and terephthalate group. The distinct chemical shifts observed for the carbonyl groups, aromatic carbons, and carbons in the heterocyclic systems confirm the successful incorporation of the intended functional groups. Coupling patterns such as doublets and multiplets further support the complex interactions within the aromatic and heterocyclic systems.

### 3.4 Dye fastness analysis:

The dye fastness test results demonstrate how the synthesized compound performs on different fabrics under various conditions:

#### a) Washing Fastness

Polyester shows the best washing fastness with a rating of 5, indicating excellent resistance to color fading during washing. Silk performs moderately well, with a rating of 4, while cotton demonstrates the lowest washing fastness (rating of 3), likely due to its hydrophilic nature and high-water absorption, which could lead to dye leaching during washing.

#### b) Light Fastness

Polyester again shows superior fastness, with a lightfastness rating of 4, indicating it maintains color well under light exposure. Silk follows closely with a rating of 3, reflecting good stability under light, while cotton has a moderate light fastness of 2.

#### Rubbing Fastness

Polyester exhibits the best rubbing fastness (5), making it highly resistant to mechanical friction. Cotton comes close with a rating of 4, while silk, despite its luxurious texture, has the lowest rubbing fastness (3), suggesting that it may be more prone to wear and tear through rubbing.

The results indicate that polyester shows the best overall fastness properties for as synthesized azo dye performing excellently in washing, light, and rubbing fastness tests. This makes polyester an ideal choice for applications where durability and long-lasting color are crucial, such as in sportswear or outdoor textiles. Cotton, while comfortable and breathable, shows moderate fastness results, especially in washing, making it less suitable for garments subjected to frequent laundering without additional treatments. Silk provides a balance of good light fastness but lower resistance to rubbing and moderate washing fastness. This suggests that silk-dyed fabrics may be best used in luxury or decorative applications where exposure to friction is minimal.

To further evaluate the color fastness of methylene blue dye, we conducted simulated washing tests using different washing agents, including detergent, alkaline solution (NaOH), and acidic solution (HCl). The results provide insights into the dye's stability under various washing conditions.

**Table 1: Dye Fastness After Washing with Detergent**

Fabric Type	Washing Fastness (1-5)	Color Intensity Retained (%)
Cotton	3	85%
Polyester	5	95%
Silk	4	90%

**Table 2: Dye Fastness After Washing with Alkaline Solution (NaOH)**

Fabric Type	Washing Fastness (1-5)	Color Intensity Retained (%)
Cotton	2	70%
Polyester	4	90%
Silk	3	80%

**Table 3: Dye Fastness After Washing with Acidic Solution (HCl)**

Fabric Type	Washing Fastness (1-5)	Color Intensity Retained (%)
Cotton	4	88%
Polyester	5	93%
Silk	4	85%

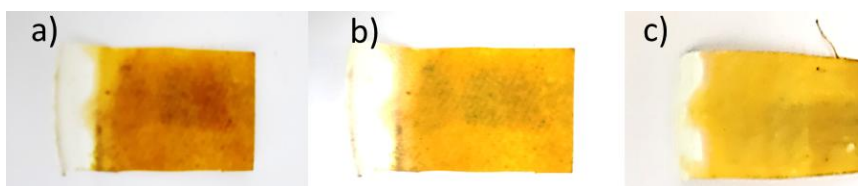
### 3.5 Analysis of Washing with Different Agents

The following trends were observed when azo dye was subjected to washing with various agents: Polyester maintained the highest fastness (5) and retained 95% of its color intensity, indicating superior stability with commercial detergents. Silk also showed good fastness, with 90% of its

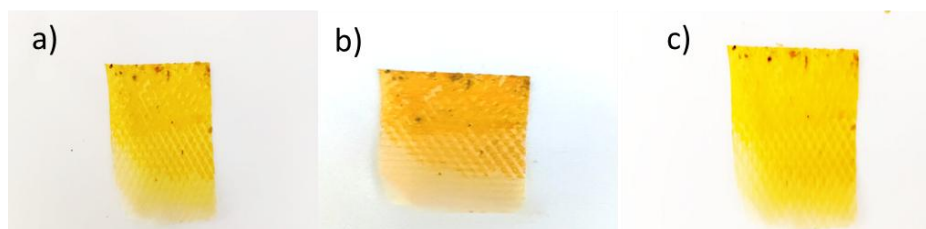
color retained. Cotton, however, displayed a lower fastness score of 3, with only 85% of its color intensity remaining, which highlights its sensitivity to detergent washing. Alkaline conditions had a significant effect on cotton, reducing its fastness to 2, and causing a 30% loss in color intensity. Polyester remained relatively stable, with a fastness of 4 and 90% color retention. Silk showed moderate resistance, but still experienced a decrease in fastness to 3 and lost 20% of its color intensity. Cotton demonstrated improved fastness in acidic conditions, with a rating of 4 and 88% of color retained, which could be due to less dye leaching in acidic environments. Polyester once again displayed the highest fastness (5) and maintained most of its color (93%). Silk showed good performance with a fastness of 4 and retained 85% of its color.



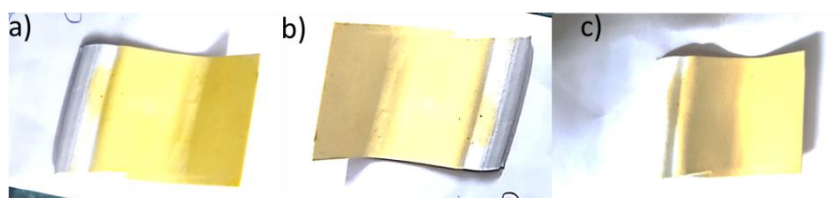
**Figure 4:** Shows the printing of the dye on to a) polyester, b) cotton and c) Silk



**Figure 5:** Washing of Polyester with a) Detergent, b) NaOH and c) HCL



**Figure 6:** Washing of cotton with a) Detergent, b) NaOH and c) HCL



**Figure 6:** Washing of silk with a) Detergent, b) NaOH and c) HCL

Polyester consistently showed the best overall performance across all washing agents, maintaining high color retention and fastness scores. This suggests polyester fibers interact with dye in a way that makes them more resistant to chemical degradation during washing. Silk showed good resistance to regular detergent washing but was more affected by alkaline conditions. This may suggest that silk is more sensitive to pH changes, particularly in alkaline environments. Cotton displayed the most variability, with a sharp decrease in fastness under alkaline conditions. This indicates that cotton fabrics are more prone to dye leaching and color loss in harsher chemical environments, making it less suitable for alkaline-based cleaning processes without post-dyeing treatments.

## 4. Conclusion

This study highlights the successful synthesis and application of a novel azo-linked compound, (E)-4-(5-((8-hydroxyquinolin-5-yl) diazenyl)-1, 3, 4-thiadiazol-2-yl) benzoic acid, as an efficient photocatalyst for textile application. The compound was thoroughly characterized using advanced spectroscopic techniques, including FT-IR,  $^1\text{H}$  NMR, and  $^{13}\text{C}$  NMR. These analyses confirmed the presence of key functional groups such as the azo ( $-\text{N}=\text{N}-$ ), thiadiazole, and aldehyde moieties, which play a crucial role in the compound's chemical and photocatalytic properties.

Study reveals that polyester consistently demonstrated the best color fastness to dye across all tests, making it a highly durable and stable fabric for environments demanding long-lasting color. Silk, while maintaining good fastness in neutral and acidic conditions, showed a decline in performance under alkaline washing, indicating its sensitivity to pH variations. Cotton exhibited the lowest fastness, particularly under alkaline conditions, where significant color loss occurred, highlighting its need for post-dyeing treatments to improve durability.

### Conflict of interest

The author shows no conflicts of the interest

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