Al-Nahrain Journal of Science
ANJS, Vol. 26 (4), December, 2023, pp. 28-32

Laser and Scanning Electron Spectroscopy of Benzyl Hydrogen-4-(Dimethylamino) Benzylidene Hydroxycarbon Hydrazodithiate Schiff's Base

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Article's Information

Received: 20.09.2023
Accepted:03.10.2023
Published: 10.12.2023

Keywords:
Schiff base
Laser
SEM
EDX
BHDBHH

Abstract

The Schiff base compound, benzyl hydrogen-4-(dimethylamino) benzylidene hydroxycarbon hydrazodithiate (BHDBHH), was investigated under continuous wave laser beam irradiation (30 mW), and its chemical properties were analyzed. The material's chemical properties were found to be affected during laser processing. We examined the chemical properties of the Schiff base using a Scanning Electron Microscope (SEM) and energy-dispersive X-ray (EDX) Spectroscopy. By varying the exposure time, we discovered that longer exposure times resulted in a darker colouration of the compound, even at a low power of 30 mW. This finding led us to conclude that the compound is highly sensitive to laser exposure and can be easily diffused with a more powerful laser. The EDX test revealed a significant reduction in the sulfur element, with more than 50% of it being burned during the exposure.

DOI: 10.22401/ANJS.26.4.04

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1. Introduction

Despite significant advancements in the field of chemistry over the past century, the fundamental principles governing industrial chemical practices have remained unchanged. Traditionally, the manipulation of temperature, pressure, and catalysts has been relied upon to break and reform chemical bonds [1]. However, researchers have recently developed novel methods that utilize lasers to illuminate chemical compounds, potentially allowing for precise control over reaction pathways [2]. The procedure of using lasers to influence reactions is not entirely new, as attempts to do so began approximately 35 years after the invention of the first laser. These devices emit radiation with a specific frequency, or color, enabling them to transfer well-defined amounts of energy to targeted substances [3]. Chemical bonds were perceived as individual springs with varying strengths, which vibrated when supplied with specific energy levels. The goal was to tune lasers to selectively disrupt or weaken a particular bond, thereby favoring the formation of one product over others [4].

Schiff bases are a group of compounds that possess some characteristics that make them particularly interesting and valuable in various branches of chemistry [5]. These compounds contain imine or azomethine nitrogen (C=N) groups, which fulfil a specific requirement [5]. Schiff-based compounds can have multiple substituents with electron-donor/acceptor groups, which can modify the hyperpolarizabilities of conjugated systems within these molecules. This property gives Schiff bases the potential for nonlinear behaviour [6]. The medical, anticancer, antibacterial, antifungal, and pharmacological activities of Schiff bases, as well as their optoelectronic properties, have been extensively studied [6]. In this study, a Schiff base was synthesized, and its response to a low-power visible continuous wave laser beam was characterized through separate diffraction measurements [7].

The present study aimed to investigate the effects of laser irradiation at varying power levels and exposure times on chemical materials, particularly Schiff base materials (BHDBHH in this study). The structure and composition of the resulting material were analyzed using scanning electron microscopy (SEM) at room temperature. This technique allowed for the identification of any non-uniformities or local changes in chemical composition on a micrometric scale. Additionally, the energy-dispersive X-ray spectroscopy (EDX) technique is employed to qualitatively determine the elemental composition and assess changes in atomic fractions within the prepared samples [8].

2. Materials and Methods

2.1. Material

All the chemicals and solvents were analytical grade (Fluka and Sigma-Aldrich) and weren't further purified before usage.

2.2. Schiff 's base

BHDBHH has been synthesized, characterized, and prepared in previous research [9]. Figure 1 shows the chemical structure of the Schiff base.

2.3. Circuit of Laser

The components of the laser circuit include a power supply with a voltage range of 0-30V, an LM317 voltage regulator, a diode, resistors (1 ohm, 1K ohm, 3K ohm), a capacitor with a value of 10uF, a Class III laser diode (650nm), and a breadboard. The circuit is designed to handle up to 20 volts from a function generator, and it ~~has been~~ tested with a laser diode output power of 30mW. The circuit is capable of sustaining the heat for a few minutes to allow for the application of the laser diode on the chemical compound. We have designed the laser circuit ourselves, with the assistance of Figure 2 as a reference. We divided the chemical compound into three samples for testing purposes. We positioned the laser at a distance of approximately 35-40 cm from the chemical compound to apply the laser light. We conducted the tests using different time exposures and laser power levels set at 30 mW, as outlined in Table 1.

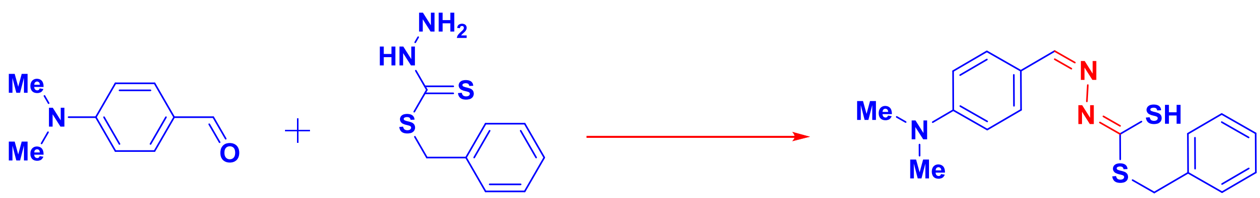


Figure 1. Synthesis of Schiff base.

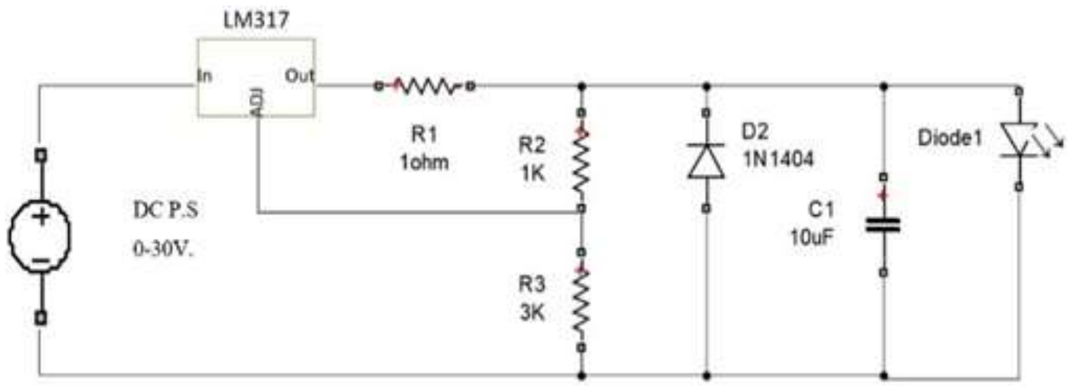
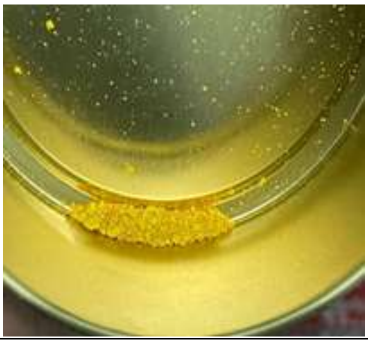


Figure 2. The Laser Circuit

Table 1. Experiment Conditions

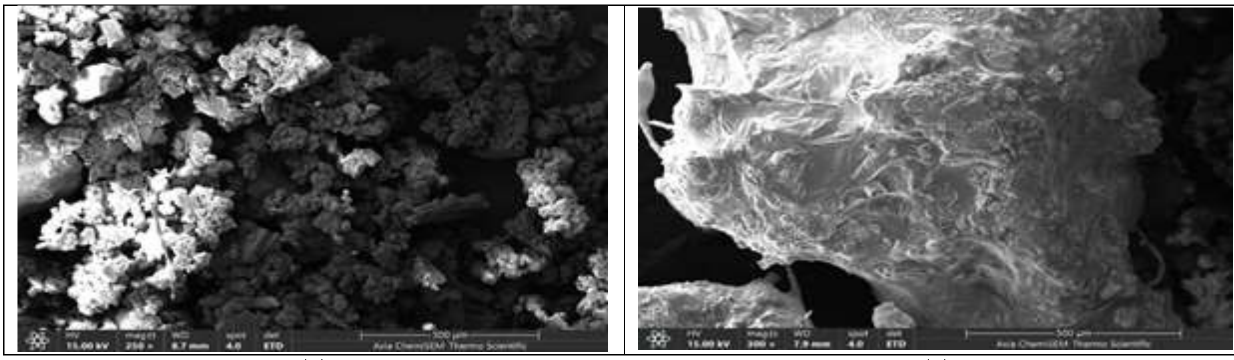
Time of Exposure		
5 minutes	10 minutes	15 minutes
		

3. Results and Discussion

After exposing the Schiff base (BHDBHH) to the laser, it underwent significant changes. The BHDBHH transformed into a dark red color and experienced a size reduction. During the experiment, the BHDBHH started to vaporize, emitting grey smoke with a distinct and potent odour reminiscent of burning organic compounds with sulfur. The physical appearance of the BHDBHH changed from fine particles resembling a powder to a few conglomerates due to fusion.

3.1 Scanning electron microscopy (SEM)

Microscopic examination of the laser-exposed surface provides valuable information about the regularity, absence of roughness, and crystallization of materials. Furthermore, it allows for ~~the~~ identification of indicators such as the absence of spots, cracks, and darkness on the surface of irradiated materials. SEM images of the Schiff base compound indicated a tendency to form a smooth, uniform, and homogeneous surface after exposure [10]. Additionally, the absence of spots, cracks, and darkness, ~~along~~ with the presence of regular and non-rough areas, were observed. The utilization of Scanning Electron Microscope (SEM) technology enables the acquisition of clear, undistorted, and high-resolution images of the Schiff base compound's surface, providing insights into its homogeneity and regularity [11]. Comparative analysis of pre-and post-exposure SEM images (Figures 3 a and b) revealed that the damage inflicted by the laser was superficial [12]. The surface of BHDBHH exhibited a notably smoother and more uniform appearance compared to its pre-exposure state, which exhibited numerous holes and irregularities [13].



(a) (b)

Figure 3. SEM image of BHDBHH surface (a) before and (b) after laser exposure.

3.2 Energy dispersive X-ray (EDX)

To determine the elemental composition of the BHDBHH, energy dispersive X-ray (EDX) mapping was performed in conjunction with SEM. The results of the EDX analysis indicated a notable increase in surface oxygen content, accompanied by a decrease in the percentage of carbon and sulfur in comparison to the raw Schiff base [14, 15]. The EDX graphs depicting the Schiff base before and after laser exposure can be observed in Figures 3 and 4, while the corresponding data is provided in Tables 2 and 3.

Table 2. EXD test results before laser exposure

Element	Atomic %	Weight %
C	71.9	58.9
N	14.6	13.9
S	11.3	24.8
O	2.2	2.4

Table 3. EXD test results after laser exposure

Element	Atomic %	Weight %
C	60.0	51.5
N	20.5	20.5
S	5.0	11.4
O	14.5	16.5

Figure (4): EDX graph for BHDBHH before laser exposure

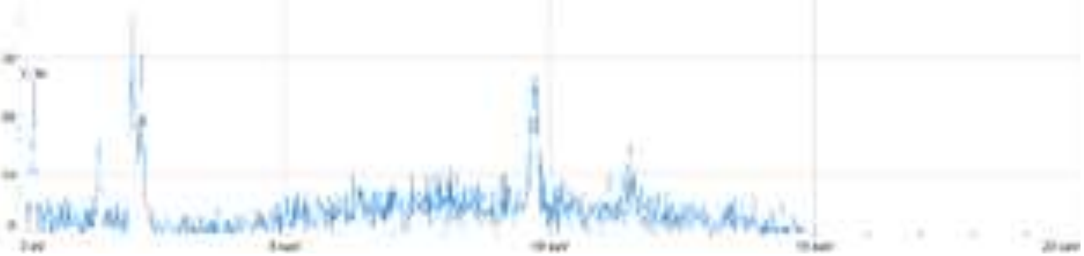


Figure (5): EDX graph for BHDBHH after laser exposure.

4. Conclusions

After exposing three samples of the BHDBHH to a laser with power output 30mW and at different exposure time we discovered that the BHDBHH is sensitive to such low power of laser, and its color turns red the more we expose it to the laser and it gets darker into dark crimson red until it turns into almost black particles. The SEM test showed visually how tiny particles were the BHDBHH, and after laser exposure it fused together to make few conglomerates. ~~And t~~The EDX test showed significant drop of the Sulphur element in the BHDBHH's chemical composition after the laser exposure which ~~leads~~ that Sulphur was the most sensitive element in the BHDBHH, and ~~big~~ percentage of Oxygen ~~in~~ result of BHDBHH burning. ■

Acknowledgments: The authors like to thank their affiliations.

Conflicts of Interest: The authors declare no conflict of interest.

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