IOP Publishing Phys. Scr. 99 (2024) 065525 https://doi.org/10.1088/1402-4896/ad42e8

Physica Scripta

RECEIVED
16 February 2024
REVISED
14 April 2024
ACCEPTED FOR PUBLICATION
24 April 2024
PUBLISHED
9 May 2024

PAPER

Studies of the nonlinear optical properties of a synthesized Schiff base ligand using visible cw laser beams

Zahraa Salman Fadhil[1], Qusay M A Hassan[2,*], Kawkab Ali Hussein[1], H A Sultan[2], Jasim M S Al Shawi[1] and C A Emshary[2]

[1] Department of Chemistry, College of Education for Pure Sciences, University of Basrah, 61001, Iraq
[2] Department of Physics, College of Education for Pure Sciences, University of Basrah, Basrah 61001, Iraq
[*] Author to whom any correspondence should be addressed.

E-mail: qusayali64@yahoo.co.in

Keywords: Schiff base ligand, DPs, Z-scan, AOS.

Abstract

The synthesized Schiff base ligand (compound Z1) is analyzed by IR, mass, ^{1}HNMR, and ^{13}CNMR spectroscopies. Computational chemical modeling is performed to examine the geometry optimization and molecular structure of compound Z1 by using the DFT/ WB97XD/6-31+G(d,p) method. The parameters HOMO–LUMO energies with nonlinear optical (NLO) properties are computed. The results indicate good agreement between experimental and theoretical data, so that compound Z1 to have good NLO properties. The NLO properties of the compound Z1 are examined under excitation with a 473 nm, cw, low power laser beam via two techniques, viz., diffraction patterns (DPs) and the standard Z-scan techniques. As high as 3.03×10^{-11} m^2 W^{-1} of the compound Z1 of the nonlinear refractive index (NLRI), n_2, is obtained via the DPs. Both static and dynamic all –optical switching (SAOS and DAOS) are tested using 473 nm and 532 nm cw low power laser beams.

1. Introduction

A vast amount of research has been devoted towards the study of organic materials, inorganic materials, etc, nonlinear optical (NLO) properties for the sake of using them in a variety of applications, viz., image processing, optical communications, limiting, 3D data storage, phase conjugation, switching, and bi-stability [1–12]. In these applications the nonlinear refractive index (NLRI), n_2, of materials must be large and their response time must be short. The NLO properties of these materials can be obtained via three techniques viz., diffraction patterns (DPs) [13], thermal lens [14] and Z-scan [15, 16]. DPs technique is based on the generation of DPs where n_2 value usually estimated at highest power input and the change of its refractive index (RI), Δn, can be estimated. The Z-scan, closed and open apertures, can be adopeted for the estimation of the n_2 and the nonlinear absorption coefficient (NLAC). The real and imaginary parts of the 3rd NLO susceptibility sign and values can be estimated too.

The term 'Schiff's base' is due to a German scientist, Hugo Schiff, is characterized in 1864. In a different way, it is the nitrogen analogous to a ketone or aldehyde in which an azomethine or imine group has taken the place of the carbonyl group [17–19]. These have a variety of biological activities and are frequently employed for industrial applications. These are the most often utilized organic chemicals that are employed as catalysts [20], polymer stabilizers [21], dyes [22], and optical chemical sensors [23], alongside pharmacological applications, such as anticancer [24], antibacterial [25], antifungal [26] and antiviral properties [27] and optical properties [28–30]. The capability of Schiff bases to form complexes, particularly very stable ring complexes, and their selectivity toward metal ions are two of their most significant characteristics [31]. Their metal complexes also possess industrial and properties as well as optical data storage and NLO materials [32, 33]. Over the past thirty years, additional research has been conducted to find more affordable and effective materials for organic NLO materials, like Schiff bases, are a class of compounds that have drawn a lot of interest because of their straightforward design, synthetesis flexibility, and π-conjugated framework in the form of a D-π-A push–pull system. This makes them a promising class of NLO materials [34–37].