Study the improving the optical properties of laser day by doped nanomaterials

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ABSTRACT

The present research include studying the structural ,linear and nonlinear optical properties for organic laser dye: doped with (PVA) polymer and (Ag)nano particles for using it in field of nonlinear optics. Many properties of organic laser dyes can be improved and enhanced by doping with polymer and nanoparticles materials, which are favorable for practical applications.Thin films have better linear and non-linear spectral optical properties as compared to solutions. And samples prepared from dyes doped with polymers and nanomaterials have better nonlinear optical properties compared to samples prepared from single dyes .

The results indicate that the optical power limiting threshold is inversely related to the solution concentration the prepared thin films of mixture laser dyes with ratio(4:1) doped with PVA polymer and Ag nano particles give spectral , linear and nonlinear optical parameters high as compared with other mixing ratios.Where the highest value of the quantum efficiency (96%) and the highest value of the nonlinear refractive index and the nonlinear absorption coefficient (12.68×10^{-3} cm^2/mW) and (6.125 cm/mW) were obtained, respectively.

The results indicate that all samples of pure and doped dyes and its mixture (solutions and thin films) could be employed as a suitable medium for a variety of optoelectronic applications, including optical power limiting and active laser medium in liquid lasers.

Keywords: improving, optical properties, laser , doped nanomaterials

1-Introduction

The optical nonlinear properties of nano-materials have been extensively studied for the applications in high power laser devices .Among all these materials, silicon materials have triggered particularly high research interests because of their potential to be integrated with microelectronics. One of the primary arguments in favour of silicon [2]

optical materials is the possibility to build chip-scale photonic devices ,which motivates intensive investigations on optical nonlinear prop -erties of silicon materials in nanoscale. [3-6] ⟨R. Dekker, 2007,p33⟩

Nonlinear optical properties have been the subject of numerous investigations theoretically and experimentally during recent years due to their applications to many branches. The nonlinear optical properties are important parameters in characterizing and determining

the applicability of any material to nonlinear optical device. There are several techniques for measuring these parameters like Z- Scan technique.

Organic compounds have been the subject of intense theoretical and experimental study due to their promising applications in different life science fields. The organic compounds are defined as hydrocarbons and their derivatives. They can be subdivided into saturated and unsaturated compounds. Organic dyes are fluorescent molecules with large molecular weights, characterized by a strong absorption band in the visible region of the electromagnetic spectrum. Such a property is found only in organic compounds which contain an extended system of conjugated bonds alternating single and double bonds. In a dye laser, these molecules are dissolved in an organic solvent or incorporated in to a solid matrix. Although dyes have been demonstrated to laser in the solid, liquid, or gas phase, it is in the liquid and solid phases that dyes have made a significant impact as laser media. [7,8](R. Intartaglia, 2012,p6)

Organic dyes are one of the materials which optics field, because of play an important role in the nonlinear the large variety of these compounds at high intensities, fast response, large nonlinear properties, and easy to process integrated into optical devices. The organic materials such as organic dyes have compatibility with other materials, mainly related to the need of employing large volumes of organic solutions of dyes that are both toxic and expensive. So the dye has to be changed for different wavelength regions, so attempts were made to overcome the problems posed by dye solutions by incorporating dye molecules into solid matrices. This has resulted in significant advances towards the development of practical tunable solid-state lasers. (Semaltianos ,2010,p12)

Dye doped polymers find applications in similar fields of modern photonic technology, optical amplifiers, fiber optics, and optical limiting which is used for protecting the human eye and the sensors by handling the laser output. Polyvinyl Alcohol (PVA) is synthetic polymer utilized from the early 1930 in a wide range of industrial, commercial, medical and food applications, and has numerous properties like being effectively fabricated, with relatively a minimal cost, and dielectric material.

Nanotechnology represents one of the major breakthroughs of modern science, enabling materials of distinctive size, structure and composition to be formed. For the smaller particles the percentage of surface atoms increases, leading to changes in physical and chemical properties of the materials. PVA polymers are modulated and improved by addition of Ag nanoparticles and those properties can be applied in the fields of optics and electronics .The nonlinear properties of dyes solutions, dyes doped polymer thin films and Ag nanoparticles composite can be studied by using a simple technique called Z-Scan. It is a sensitive and popular experimental method to measure intensity dependent of nonlinear optical (NLO) properties of materials which can rapidly measure both nonlinear absorption (NLA) and nonlinear refraction (NLR) in solids, liquids and then studying the optical limiting behavior. [3,9,14]

2- Literature Survey

Several researches on using Z-scan for study nonlinear properties of organic dyes.

In (2000) S.Sinha et al. studied nonlinear refraction in rhodamine B (RB) organic dye solution at)510.6 nm(using the Z-scan technique with)40 ns(laser pulses from a copper vapor laser. The observed nonlinear refraction is of thermal origin resulting from nonradiative energy transfer from the dye molecules to the solvent molecules and is therefore strongly dependent on the thermal properties of the solvent, The lowest thermal nonlinearity was observed in an aqueous solution of the dye. This makes water the best choice as a solvent. Comparison of the nonlinear optical properties of an aqueous dye solution with that using water- surfactant mixture as the solvent.

In (2002) S. Venugopal studied the nonlinear absorption and excited state dynamics in Rhodamine B solutions were investigated at (532 nm) and (600 nm), the absorption band's resonance wavelength, the absorption edge

wavelength determined using standard Z-Scan techniques. According to the results of concentration-dependent experiments, reverse saturable absorption exhibits a complex behavior within the context of saturable absorption.

In (2005) N. Hussein studied the absorption spectra for organic compounds Laser dyes; Rhodamine 6G, Rhodamine B, Fluorescin and Phenolphthalein. It is about fundamental vibrations modes, calculation of vibrated frequencies, diagnosing the fundamental and overtone beams within Fermy's resonance in the (Mid-Infrared) about (4000 – 200) cm-1. It was noticed during the calculation for the beams' intensity of absorption for (Mid-Infrared), that there was an approximated approaching between the theoretical results and the practical ones.

In (2006) D.Yan et al. studied the of the composite PMMA films containing Ag nanoparticles and rhodamine 6G are prepared .Investigate the fluorescence characteristics and nonlinear optical characteristics of the R6G/PMMA film influenced by Ag nanoparticles. the fluorescence enhancement . The corresponding nonlinear refractive index is meastured by Z-scan technique, which is much enhanced compared with the R6G/PMMA film.

In (2007) A.Chouket et al. studied the optical properties of rhodamine B dye molecules confined in porous silica are reported. Porous silica–laser dye composite is obtained by simple impregnation of porous silica (PS) in rhodamine B (RB) solution. The FTIR spectroscopy shows penetration of rhodamine molecules in the matrix. A nonradiative excitation transfer due to dipolar

interaction is evidenced from the effect of the RB concentration on the PL emission and confirmed by FTIR spectrosc.

2 2 Laser Dyes

Organic dyes are known as hydrocarbons, Organic dyes are composed, of large molecules that have a complex structure, and have a wide absorption, and fluorescence spectrum in the visible, and ultraviolet regions of the electromagnetic, spectrum, with a large molecular, weight. Because it contains, conjugate chains composed, of carbon atoms linked by, alternating single and double bonds, which is, called the chromophore system. The chromophore, is characterized by absorbing light in ,the ultraviolet and visible region, which makes the dye colorful because the, absorption transitions (S0 to S1) occur, in the visible region. The chromophores, are the responsible group ,for giving the colouring character to ,the molecule, so the dye molecule ,appears a certain colour for some pigments ,that absorb the wavelength that falls, within the range (400 nm -800 nm).

Polymers emerged in the, 1920s amid prolonged, controversy, and its ,acceptance that is closely, associated ,with the name of H. Staudinger ,who received the Nobel, Prize in 1953. Many examples, of synthetic, polymers, can be mentioned some are, used every day, like polyesters, others less known, as the ones used,, for medical applications for organs, and ,degradable sutures, etc. On the other hand, some metals have been, ,replaced by polymers in,, many uses due to the, possession of these polymers similar, ,properties to metals, in particular electrical

,properties. It was found, that some organic, polymers, have high electrical properties, and have conductivity values, returning from, semiconductors, to metals. ﴾Zollinger, 2003﴿

Laser Ablation in Liquid Phase ,,nanostructures such as ,particles, wires, and nanotubes are the focus of ,intensive research due to their ,unparalleled applications in microphysics, chemistry, and the fabrication ,of devices at the nanoscale.

The laser ablation in, liquid has ,opened, up unique horizons for, manufacturing nanostructures, and as a result of this, there has been a, rapid growth of studies in the, formation, of nanostructures, with this ,new technology recently. By comparing the, traditional physical, method such ,as chemical vapor deposition, Vapor Phase Transport, and vacuum laser ablation, and other ,methods , The liquid phase laser ablation has,, advantages, including, the nanoparticles are somewhat crystalline ,and can, be obtained, easily ,by one, step, without any

subsequent heat treatment, due to the high ,efficiency, of the removed parts, and pure colloidal solutions of nanoparticles can form, a product. It collects in the colloidal solution.

"Nano is a Greek word derived, from nano- meaning, (dwarf). This prefix is, used in the metric, system to mean 10-9 or one billionth, of a meter. In comparing, of the DNA, double-helix has, a diameter around, (2 nm), typical carbon-carbon bond ,lengths, or the spacing, between these atoms, in the molecule are, in the range (0.12–0.15) nm. Additionally, the smallest, cellular life-forms, which is, bacteria of the genus Microplasma, are around (200 nm) in length, and the comparative, size of a nanometer to, a meter is the same, as that of a marble, to the size of the earth,. Nanoparticles have, been around for a, long time. The first reported,technical use of nanoparticles, is date back to the ,middle age where they ,were used for their, optical ,properties in ,some, ,representation. One of the, first, record of nanoparticles, in the scientific, literature dating, back to the middle, of the 19th century when, Michael Faraday was studying gold, colloids in the, nanometer, range. The possible, shapes, and structures, of nano-objects, are vast and fascinating, spanning for, example, dots, pillars, ,spirals, flowers, cups. (Schäfer,

F. P. "Dye lasers and laser dyes in physical chemistry." Dye lasers: 25 years: 19- 36 (1992).

3-2-1-Laser Types by Mode of Operation

All types of lasers can operate using one of two methods: their laser beams can either be pulsed or continuous. This is what we call their mode of operation.

- With continuous-wave lasers, there is a constant flow of energy, meaning that the laser continuously shoots a single, uninterrupted laser beam. The most common example of this is a laser pointer's uninterrupted beam. Continuous-wave lasers are commonly used for laser cutting and laser welding.
- With pulsed lasers, the laser beam is interrupted at regular intervals to allow the energy to build up and reach a higher peak power than continuous-wave lasers. The laser beam is released as pulses that have a specific duration called the pulsed duration. These high energy densities are required for many applications like spot welding and engraving.

Continuous-wave lasers may seem more powerful than pulsed lasers because the advertised laser power is typically much higher, but this can be misleading. This is because lasers are named according to their average laser

3-2- Types of laser dyes

power, and the average power of pulsed lasers is usually lower even if they reach higher peaks of power.

For example, a 6,000W continuous-wave laser continuously releases 6,000W of laser power. Conversely, a 100W pulsed laser can release pulses of 10,000W each.

3-2-2-Laser Types by Pulse Duration

Pulsed lasers are divided into several categories based on the duration of their pulses.

A modulator is used to control the number of pulses per second. As a result, each pulse has a precise duration, called pulse duration, pulse length, or pulse width. The pulse duration is the time between the beginning and the end of a pulse.

Several modulating methods are used to pulse laser beams: q-switching, gain- switching, and mode-locking are some examples. The shorter the pulse, the higher the energy peaks. Here are the most common units used to express pulse duration.

- Milliseconds (one thousandth of a second) are the longest time units used to express pulse duration and have hence the lowest energy peaks. For example, laser hair removal pulses may vary between 5 ms and 60 ms depending on the hair thickness.
- Microseconds (one millionth of a second) are probably the least common pulse durations They can be used for material processing applications, but the following pulse durations are more commonly used, as they offer more precision. Microsecond lasers can also be used for applications like spectroscopy and hair removal.
- Nanoseconds (one billionth of a second) are very common pulse durations used for applications like laser material processing, distance measurements, and remote sensing. Laserax, for example, uses nanosecond fiber lasers to perform laser marking, cleaning, texturing, and engraving.

- Picoseconds (one trillionth of a second) and femtoseconds (one quadrillionth of a second) are the shortest pulse durations, which is why the terms ultrashort pulses and ultrafast lasers are used. These lasers offer the most precise results and have

the lowest heat affected zones. This prevents undesirable melting and allows for very precise engravings. They are used in material processing, medicine (such as eye surgery), microscopy, measurements, and telecommunications.

3-2-3-More Types of Lasers

As you can see, there are many ways to categorize lasers. Another way is by the laser wavelength, where you have infrared, near-infrared, visible, ultraviolet, and X-ray lasers.

Laser experts keep pushing the limits of laser technology, with new developments being made every year. As a result, the types of lasers are constantly evolving, and to a wide range of newly developed, low-cost materials on an ongoing basis.

Conclusions

1. The linear optical properties (n_o and α_o) of solution of laser dye doped with polymer PVA with nanoparticles Ag are higher than thin films without nanoparticles Ag.
2. The nonlinear optical properties of thin films of laser dye laser dyes doped with polymer PVA with nanoparticles Ag are higher than thin films without nanoparticles Ag.
3. The nonlinear refractive index for all samples shows the behavior self- defocusing, and two photon absorption in nonlinear absorption coefficient and The nonlinear absorption coefficient for all thin films of laser dyes and their mixtures show saturable absorption phenomena

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