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Synthesis, characterization, and study of the nonlinear optical properties of two new organic compounds

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ABSTRACT

Two new compounds, viz., Octaphenyl Tetrapyrazino Porphrazine Nickel (OpTpPzNi (II)) and Phthalocyaninato Aluminum Chloride (PcAlCl) with two different central metal atoms nickel and aluminum are prepared and identified respectively. Self-diffraction ring patterns were observed, as the solution of OpTpPzNi(11) in the solvent dimethyformamide was illuminated with continuous wave low power laser beams of 473 nm and 532 nm, respectively. It was found that the diffraction ring patterns depend critically on wavelengths and intensities of laser beams. Simulation results of the experimental diffraction ring patterns using Fresnel-Kirchhoff integral are obtained. The theoretical findings are in good accord with the experimental ones. The nonlinear refractive index, n_2, of OpTpPzNi(II) solution is determined by diffraction ring patterns and the Z-scan techniques, while the nonlinear refractive index, n_2, of PcAlCl solution is estimated by Z-scan technique only.

1. Introduction

The study of nonlinear optical properties of materials have attracted considerable attention in recent years due to potential photonic applications [1–11] such as high density optical data storage [12–15], optical phase conjugation [16], optical signal processing [17], all-optical switching [18–20], optical bi-stability [21–24], optical limiting devices [25–43] etc. To date, so many materials have been studied, showing good nonlinear optical properties and proven efficient in various photonic applications. Organic materials can be considered as the most important class of materials with good nonlinear optical properties since they exhibit large nonlinearities, fast response times, easy molecular design and good process ability to form optical devices. Porphyrins and phthalocyanine can be classified as organic materials, have attracted special attention among several new organic materials, not only because they can be used as drugs in photodynamic therapy for bacterial reduction and cancer treatment [44–47], but due to their use in photonic devices such as optical limiters [48,49].

The tetrapyrrole macromolecules have four ring systems contains four unicarbon or uninitrogen linkages to link the four pyrrolic rings to form porphyrins or porphrazines respectively. The porphrazines four pyrrolic rings link to four benzene rings to form phthalocyanine compounds (Pc) or link to four pyrazine rings to form semi-phthalocyanines(Pz) which are also called tetrapyrazino porphrazine compounds [50,51]. The four central nitrogen atoms of the phthalocyanies and semi-phthalocyanies can be linked to many transition, non-transition, lanthanides, and actinides elements to form metallic phthalocyanies or semi-phthalocyanies. The phthalocyanies or semi-phthalocyanies can be linked together in different ways and can be linked to different peripheral groups. The different central metal atoms and different peripheral groups have large effect on electrical and spectroscopic properties [52,53].

Two different compounds were prepared in the present work, viz., octaphenyl tetrapyrazino porphrazine nickel (OpTpPzNi (II)) and phthalocyaninato aluminum chloride (PcAlCl). The two compounds have two different central metal atoms, aluminum, and nickel respectively. The aluminum atom with the phthalocyanine ring and chloride atom form pyramidal structure and the nickel atom with peripheral phenyl groups to make semi-planar structure. The two compounds were analyzed using elemental analysis, IR and UV–vis spectroscopy and studied by x-ray diffraction to find their structural d-spacings. The passage of two low power Gaussian laser beams at two wavelengths viz., 473 nm and 532 nm have led to the observation of two multiple diffraction ring patterns in a solution of OpTpPzNi. The dependence of

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