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Linear and nonlinear optical properties of potassium dichromate in solution and solid polymer film

C.A. Emshary, Isra M. Ali, Qusay M.A. Hassan *, H.A. Sultan

Department of Physics, College of Education for Pure Sciences, University of Basrah, Basrah, Iraq

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ABSTRACT

A film with polyvinyl alcohol and aqueous solution of potassium dichromate are prepared where various linear optical constants and nonlinear properties are determined via the measurements of the film optical absorbance and transmittance spectra in the wavelength range 312–900 nm and via the diffraction ring patterns by transmitting a visible, 473 nm, continuous wave with single fundamental transverse mode, low power laser beam. As high as 10^{10} sec^{-1} optical conductivity and nonlinear refractive index of 10^{-13} cm^2/W of the film are obtained due to the linear parameters and 10^{-7} cm^2/W of the aqueous solution due to the diffraction ring patterns. Fraunhofer approximations of the Fresnel-Kirchhoff theory are used to simulate the diffraction ring patterns.

1. Introduction

Since the sixties of the last century, much researches have been directed towards the study of the nonlinear optical properties of vast number of nonlinear optical (NLO) materials. These materials should have fast response times, large third order optical nonlinear susceptibilities and nonlinear refractive indexes to fit the requirements needed in the potential applications such as photonic technologies of integrated optics, optical computing, optical signal processing, optical phase conjugation, optical sensing, optical data storage, broad band optical communications, optical bi-stability, refractive index modulation, all optical switching, optical limiting devices and light controlled phase [1–19]. Up to now endless efforts have been made by the many researchers towards exploring the NLO properties of organic materials [20–38], inorganic materials [39], nanomaterials [40], semiconductors [41], polymers [42,43], etc.

During the last fifty years two main routes have been followed by the researchers to obtain different constants of the various media that decided whether the examined media behave nonlinearly via determining the third order optical susceptibility and the nonlinear refractive index. These routes are (i) the use of linear parameters to determine the various constants such as the linear refractive index, extinction coefficient, real and imaginary parts of the media dielectric constants, nonlinear refractive index, etc., by the measurements of both the media absorbances and transmittances and the use of known simple relations and the Wemple and DiDomenico theory. (ii) The other route is the use of the well-established techniques viz., the diffraction ring patterns, the thermal lens and the Z-scan open and closed apertures [44–46]. When comparing the Z-scan method with the diffraction ring patterns method, we find that the Z-scan method is an easy method, the devices required to conduct it are simple, require a low incident intensity laser beam to calculate the nonlinear absorption coefficient and the nonlinear refractive index, while the diffraction ring patterns method is also easy, almost requires the same devices that are used in the Z-scan method, requires a laser beam of intensity higher than the one used by the Z-scan method and it can be used to calculate the nonlinear refractive index.

Potassium dichromate is a solid ionic crystalline of orange – red color mainly used in various labrotaries and industrial applications as an oxidizing agent. From the chemical point of view it is used in the initiated polymerization of aniline [47], chemical polymerization kinetics of poly-o- phenylenediamine and characterization of polymers in aqueous hydrochloric acid solutions [48], and oxidative chemical polymerization of the ortho-tolidine in acid medium [49]. It's physico chemical studies were carried out at different temperatures [50] and the only available studies of its nonlinear optical properties using the Z-scan technique were conducted seven years ago by Thilak et al. [51], and lately by Zarif et al., [52]. To the best of our knowledge no results available for the potassium dichromate based on the first route mentioned earlier.

In this work the linear and nonlinear optical constants of the potassium dichromate polyvinyl alcohol (PVA) mixture film are studied in details based on the measurements of the absorbance and transmittance at room temperature. The nonlinear refractive index of an aqueous

* Corresponding author.
E-mail address: qusayali64@yahoo.co.in (Q.M.A. Hassan).

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