ABSTRACT

Research of new optical materials which have a great potential for use in nonlinear optical devices is one of the current interesting subject of investigations. Due to their efficiency, chemical flexibility, and high conjugated framework, organic compounds have received considerable attention as possible materials for nonlinear optics.

In the present work, four different nonlinear studies are carried out. In the first study, two dyes namely, basic green 1 and acid green 5 from triphenylmethane family and two dyes namely, nile blue chloride and nile blue A from oxazine family are chosen and investigated for their nonlinear optical properties using Z-scan technique. In the second study, basic green 1 and acid green 5 doped gelatin films are prepared and optical phase conjugation using four-wave mixing concept are investigated in these films. In the third one, azo dye soaked gelatin films are prepared and the characterization of these films are done by forming self-diffraction gratings. In the fourth study, sudan (dye) based poly (methacrylates) are prepared and are characterized by forming holographic gratings. Characterization of the media is done by the formation of holographic grating.

The nonlinear optical properties of triphenylmethane and oxazine dyes are investigated using Z-scan technique. Since these dyes show absorption at 625 nm and 639 nm, He-Ne laser at 632.8 nm is used in this study. Self-defocusing i.e. negative nonlinearity is observed in these dyes. It is also observed that the nonlinear absorption coefficient for solution of
triphenylmethane dye can be attributed to a saturation absorption process, and that for oxazine dye can be attributed to two-photon absorption process. The nonlinear refractive index and nonlinear absorption coefficient are found to depend on the concentration of dye and incident beam intensity. The nonlinear refractive index, nonlinear absorption coefficient and magnitude of the third-order nonlinear susceptibility $\chi^{(3)}$ are calculated for all these dyes.

Optical phase conjugation using four-wave mixing is carried out in triphenylmethane dye doped gelatin films. The phase conjugate reflectivity is found to depend on (1) the time of exposure (2) the concentration of the dye in the gelatin film (3) the intensity of the probe beam (4) the intensity of backward pump beam (5) the intensity of forward pump beam and (6) the interbeam angle between the probe and forward pump beams. Maximum reflectivity achieved is 0.12% for acid green 5 dye film.

Since azo dyes, acid orange 6 and acid orange 10, show absorption peak around 495 nm and 480 nm, the radiation from argon ion laser at 514.5 nm is used as the light source for grating formation. Exposure of these dyes soaked gelatin films to interfering beams of argon ion laser results in the formation of transient self-diffraction gratings i.e. two beams which form the grating themselves are diffracted. Intensity of first order diffracted beam is monitored as a function of time using a digital power meter. Investigations are carried out to study the dependence of grating formation on time of exposure, concentration of dye in the gelatin plate, overall incident intensity of each writing beam, the intensity ratio between two writing beams and spatial frequency.
Since all Sudan IV polymers show a strong absorption around 517 ± 1 nm and all Sudan III polymers show a strong absorption around 510 ± 1 nm, argon ion laser is used for the formation of grating. When these polymers are exposed to an interference pattern due to two beams of argon ion laser, a permanent grating is observed. The grating formation is monitored using He-Ne laser at 632.8 nm as probe beam and the intensity of the first order diffracted beam is measured as a function of time using photodetector attached with the power meter. It is found that poly {1-[(2′-methyl-4′-(2′′-methylphenylazo) - phenylazo] - [2-(8-methacryloyloxyalkyloxy)] naphthalene} (called Ib in the thesis) films have higher diffraction efficiency than all other polymers films for same recording parameters. In Ib polymer, a maximum diffraction efficiency of 1% has been recorded. The exposed region of the sample is examined with Atomic Force Microscope (AFM). AFM recording of the exposed interference pattern reveals the creation of surface relief grating with regularly spaced, sinusoidal surface relief structures. The depth of the surface relief pattern is 41.15 nm for the Ib polymer.

High-density optical data storage using Fourier transform holography is carried out in Ib polymer films. One full page of text to be stored is converted into transparent slide using photographic technique and the transmitted light called the object beam is made to interfere with the reference beam at a well defined position in the Ib polymer medium. The resulting interference pattern at the focused spot of size 50 μm produces permanent grating.
When the recording of one page is completed, a different position on the storage medium is addressed for recording of second page. Finally, the entire storage medium is covered by an array of holograms each representing a data page. Since the information is stored in the form of Fourier transform hologram in the focussed spot without binary conversion, the data storage capacity is very large. In a 10 cm dia circular disc $10^5$ pages in the form of text, figures, drawings, etc., can be stored. For read-out of the stored page, the desired hologram is addressed by a reference beam from He-Ne laser. The light diffracted from the hologram is a faithful replica of the signal wavefront from the page recorded.

Thus, this study has resulted in characterizing organic dyes for their optical nonlinearity. Also few dyes in solid matrix form act as very good optical data storage material. Since all these dyes are not expensive and the method of preparation of the dyes in solid matrix form is not very difficult, and also the laser required for the study is of low power, these studies could be carried out in many of the educational/research institutions.