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High Tech Applications of Laser Colorants

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Dr. Alok Ray had joined Bhabha Atomic Research Centre, Mumbai as a Scientific Officer in 1983 after successful completion of one-year orientation course in Chemistry at BARC training school and his M.Sc. degree in Chemistry from University of Calcutta. He received his PhD degree from University of Mumbai in 1992 for his work on laser spectroscopy of atoms and molecules and was an EEC post-doctoral fellow at CNRS labs, France during the period 1994-1995. In the early part of his career, he had carried out extensive investigations on high-lying excited levels, such as Rydberg and autoionization levels of atomic uranium, using laser photo ionization spectroscopy techniques based on home built time-of-flight mass spectrometer. He investigated kinetics and rate constants of several volatile organic radicals with atmospheric pollutants such as NO, NO_2, So_2 using discharge flow-LIF-QMS technique. During the last 10 years, he was engaged in characterization, installation and qualification of nigh-average power dye laser systems at BARC facility for strategic applications. He has initiated several important activities such as design and development of new dye molecules, indigenous synthesis of high purity and high-performance laser dyes in collaboration with MUICT, their photo-physical and laser characterization, photo-degradation analysis of dye solutions and improvement in photostability of laser dyes.Dr. Alok Ray is presently working as scientific Officer (H) in Laser & Plasma Technology Division, BARC and also a professor of Homi Bhabha National Institute (Deemed University). He has published more than 150 papers in international journals and symposiums. He is a reviewer of papers submitted to Applied Physics B journal. He has been serving as a visiting lecturer for M. tech students at DIAT, DRDO, Pune, M.Sc. students at Univ. of Pune. He has national collaboration with MUICT, Anna University, Chennai, University of Pune, CGCRI, Kolkata, as well as, international collaboration with labs at Spain and Russia.

Abstract

Colorants were developed and synthesized by chemists, but their applications have been extended to high tech areas such as dye lasers, NLO materials in physics, luminescence and fluorescence imaging for vital stains and live cell tracking in biology, photonics and opto-electronics in electronics etc. Laser colorants are used as active materials in dye lasers, which are the most versatile class of lasers with diverse applications in core areas such as energy, health-care, environment and industry, as well as, in basic and applied sciences. Motivated by the enormous impact of lasers on modern science & technology, there is an ongoing search for advanced laser colorants, and, in particular, for novel solid-state dye laser media, which has opened up possibility of compact tunable lasers for remote and portable applications. For an organic approach to solid-state dye lasers, one can either utilize dilute systems of organic dyes incorporated in host matrices, or alternatively employ films of highly luminescent π conjugated polymers as lasing materials. Recently, it has been proposed that efficient laser dyes may be found among the so-called quasi-aromatic compounds, belong to syn-bimanes, pyrromethene and the dipyrrinone. These are five-and six-membered heterocyclic chromophores in which vibrational-spin orbit interactions reduce triplet-triplet absorptions in emission spectral region. We have indigenously synthesized xanthene and pyrromethene class dyes in collaboration with Department of Dyestuff Technology of MUICT and fabricated disc type solid-state dye laser materials using dyes incorporated in tailored PMMA hosts. Photophysical and optical characterization of these active materials helped us to develop methodology for fabrication of superior SSDL materials. Semiconductor research has led to a multitude of advances over the past few decades. In the past decade, attention was diverted to organic molecules, which showed electroluminescent properties. High efficiency lasers, light emitting diodes, photo-detectors, and solar cells are only a few of these developments. Also, for synthetic chemists, an equally stimulating endeavor is to develop methodologies suitable for preparation ofπ conjugated polymeric materials with precision and high purity. The talk will describe our systematic investigations on the performance characteristics of a high-repetition-rate narrow band dye laser in oscillator-preamplifier-amplifier configuration using ethanol and binary water solvents. Photo thermal deflection and Z-scan techniques were set up to evaluate thermo-optic properties of dye solutions. An interesting observation was improvement in photostability of laser colorant solutions with increase in rate of stimulated emission.