4

Colorants for Nonlinear Optics

4.1. INTRODUCTION

As the name implies, nonlinear optics\textsuperscript{1-3} is concerned with the interaction of electromagnetic radiation with various media to produce new radiation which is altered in phase, frequency, amplitude, etc., from the incident radiation. The rapid growth of laser technology (nonlinear optic effects are only observed with laser light) coupled with the telecommunications industry's need for sophisticated optical switching devices required for data transmission in this computer age has prompted an enormous interest in nonlinear optical materials.

4.2. NONLINEAR OPTICAL EFFECTS AND APPLICATIONS

Equation (4.1) is the basic equation governing optical effects in \textit{molecular systems}:

\[ P = aE + \beta E^2 + \gamma E^3 + \ldots \]  

Equation (4.2) applies. It is the same as Eq. (4.1) except the coefficients are different.

\[ P = \chi^{(1)}E + \chi^{(2)}E + \chi^{(3)}E + \ldots \]  

The first term represents the \textit{linear} effects and is associated with the refractive index. It is the second and higher terms which represent the \textit{nonlinear} effects. Of these, the most important for practical applications is the second-order
There are several nonlinear optical effects (Table 4.1) but the phenomenon known as frequency doubling is potentially the most important.

The frequency doubling effect whereby the incident radiation is converted to radiation of double the frequency is especially useful in both telecommunications and optical data storage. For example, in telecommunications the most efficient way to transmit data is by using infrared laser radiation, for example, 1200 nm, produced by an indium-phosphorus laser diode, along optical fibers. However, detection of this long wavelength radiation is inefficient. In contrast, visible radiation is much easier to detect but is an inefficient transmitter of data. Consequently, an important use of nonlinear optical materials would be to convert the infrared radiation to visible radiation by frequency doubling, thus enabling easier detection of the signals (Fig. 4.1).

![Figure 4.1. Frequency doubling effect for optical communications.](image-url)