CONVENTIONAL DYES FOR HIGH TECHNOLOGY APPLICATIONS

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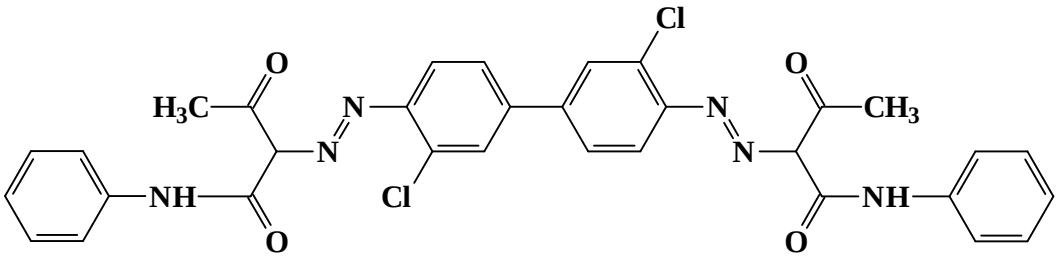
The traditional use of organic colourants is to impart colour to substrates such as textiles, paper and leather or natural substrates. These include azo dyes and metal complex azo dyes, carbonyl dyes, phthalocyanines, polymethine dyes, di- and triarylmethine dyes and sulphur dyes. However, the last decade, has witnessed a phenomenal rise in the growth of dyes for high technology applications. These applications include a wide range of electronic applications including liquid crystal displays, organic light emitting devices, microfilters, organic semiconductors, solar energy conversion, lasers and optical data storage, some of the more recently developed reprographic techniques, such as electrophotography and ink-jet printing and a range of biomedical uses. For some of these applications, many highly purified conventional dyes or tailor made conventional colourants can be employed. These dyes are designed to interact with electromagnetic radiation, pH, electricity, heat, pressure and frictional forces.

Electrophotography

Electrophotography involves the interaction of light energy with (static) electricity to produce an image. This comprises two technologies of photocopying and laser / LED (light emitting diode) printing. This technique uses photoconductors and toners to produce an image. Colour copier uses subtractive colour mixing and uses three primary colours yellow, magenta and cyan.

Two factors will fuel the increased use of coloured toners. (1) The increasing use of colour in the graphic arts and computer aided design and computer aided modelling (2) The increasing number of primary applications using colour. The colourants used in coloured toners may be either pigments or dyes. Pigments are preferred due to their higher fastness to light and heat than dyes. Various pigments that can be used as colour toner is depicted in Figure 1 and include Pigment Yellow 12 **1**, Pigment Red 122 **2** and Pigment Blue 15 **3**.



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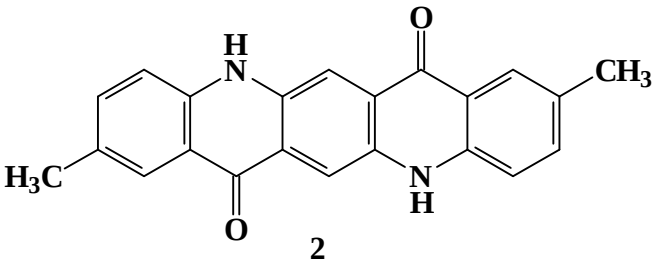

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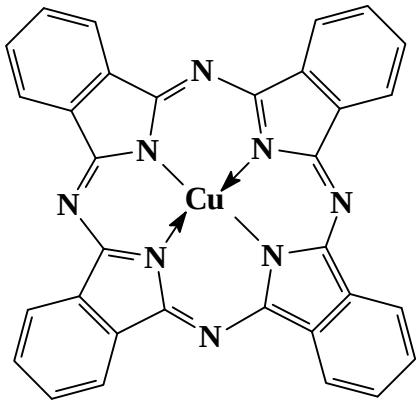

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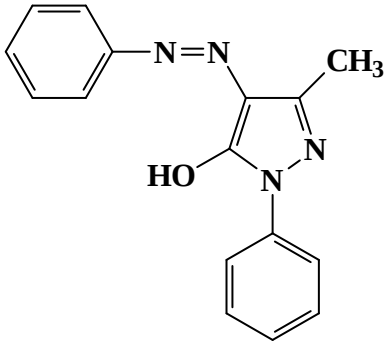
Figure 1: Pigments used as coloured toner

An advantage that dyes possess over pigments is that they dissolve in the toner resins to give highly coloured, transparent toner particles. The various dyes that can be used as the colour toner are Solvent Yellow 16 **4**, Solvent Red 49 **5**, Solvent Red 52 **6** and Solvent Blue 111 **7**, **Figure 2**.



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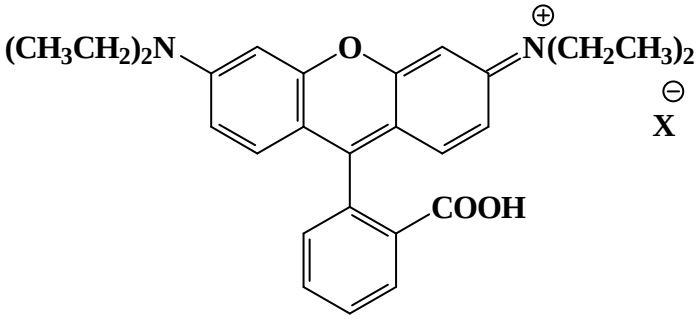

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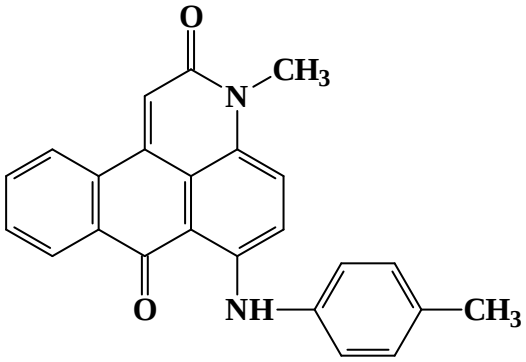

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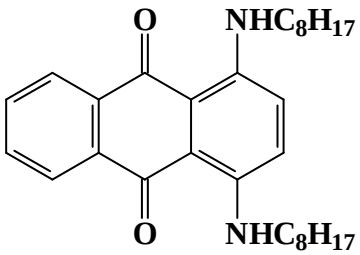

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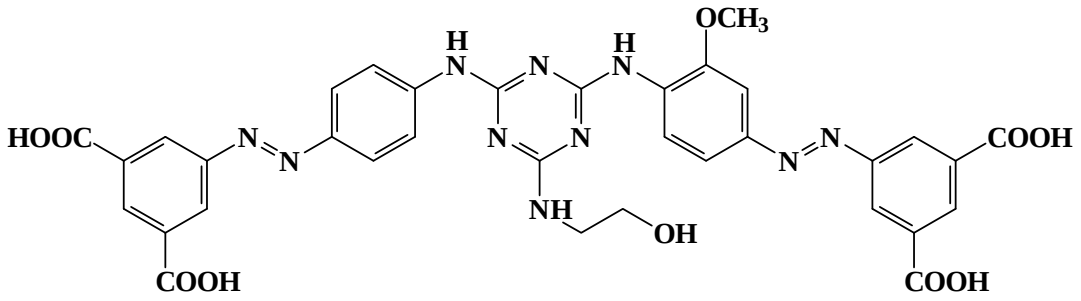
Figure 2: Dyes used as coloured toner

Inkjet printing

Inkjet printing is a truly noncontact, versatile, direct imaging method and is ideally suited to either monochrome printing or full colour printing onto plain paper. Basically there are three basic types of inks; aqueous, solvent and hot-melt. Of the two major classes of colourants, namely dyes and pigments, dyes are used almost exclusively in ink-jet inks.

Pigments, being insoluble have a much greater tendency to clog the nozzles. All ink-jet dyes have to satisfy a number of stringent criteria. The dyes should be pure and bright devoid of any unwanted impurities, high colour strength to produce high quality prints having high optical density, increased flexibility for the addition of additives, high solubility to minimize the crystallisation of the dye which causes nozzle blockage, free from insoluble matter and salts which will clog the nozzles, free from electrolytes and metals which will corrode the metal print heads, accomplished by dialysis and ultra filtration, high fastness properties like light fastness, water fastness and smear fastness, the dye should have high water solubility for the preparation of the ink and water insolubility is required once the dye is on the paper. This is achieved by using dyes containing groups like carboxylic or hydroxyl which have high water solubility in an alkaline ink and relatively low water solubility on the acidic paper (second generation ink jet colourants). The hue should appear same irrespective of the substrate (papers with various texture, adsorption, additives and pH), the dyes should be noncarcinogenic and nonmutagenic (Use of food colours) and it should posess high thermal stability.

Various dyes used in ink-jet printing are CI Food Black 2, CI Direct Black 195, CI Direct Black 154, CI Direct Black 171, CI Direct Black 19, CI Direct Black 168, CI Acid Black 1, CI Acid Black 191, CI Solvent Black 5, CI Solvent Black 7, CI Solvent Black 27, CI Solvent Black 29, CI Solvent Black 35, CI Acid Yellow 17, CI Acid Yellow 23, CI Direct Yellow 86, Direct Yellow 132, CI Acid Red 52, CI Acid Red 149, CI Reactive Red 180, CI Reactive Red 23, CI Direct Red 75, CI Acid Blue 9, CI Direct Blue 199, CI Solvent Yellow 83.1, CI Solvent Red 52, CI Solvent Red 91, CI Disperse Red 60, CI Solvent Blue 44, CI Solvent Blue 45 and Modified CI Direct Yellow 86 **8.**



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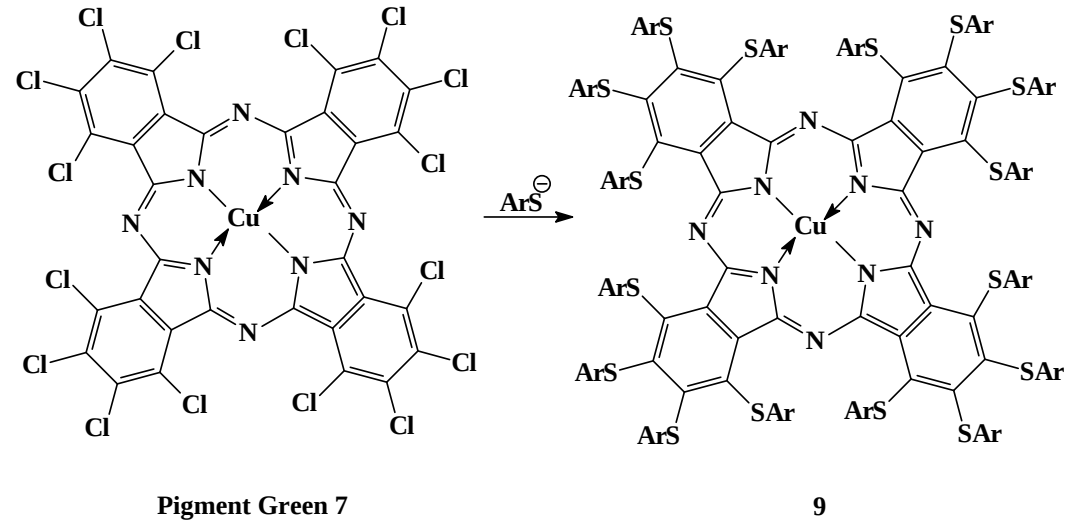
Optical data storage

Environmentally friendly high density optical data disks, which can store large amounts of information, replaced magnetic disks. Various kinds of optical disks used are CDROM-Compact Disc Read Only Memory, DRAW-Direct Reading After Writing, WORM-Write Once Read Many, RW-Rewritable and DVD-Digital Versatile Disc. The dyes used for the optical data storage should possess high absorption at the appropriate wavelength, high reflectivity, high solubility in solvents suitable for spin coating, low thermal conductivity, good oxidative and hydrolytic stability and low toxicity **9**.



Pigment Green 7 **9**

Liquid Crystal Displays

In recent times, liquid crystals have made a significant impact commercially as a result of their application in electro-optical devices such as digital watches,

calculators, and instrument display panels such as in cars and airplanes. The main reason for the success of these liquid crystal displays are their visual appeal and more importantly, their extremely low power consumption.

The molecules in liquid crystalline state are able to align with specially prepared surfaces and electric fields. Liquid crystal displays devoid of dyes are defective in many ways (colour contrast is only grey on dark grey, angle of vision is limited & polarizers are required). The dyes used in liquid crystal displays must be non-ionic, soluble in liquid crystals, highly pure, have a high order parameter and produce the correct viscosity for a rapid response rate. Various dyes and pigments are used for liquid crystal displays are given in **Figure 3** & **Figure 4,** such as CI solvent yellow 189 **10**, CI solvent red 207 **11**, Algol orange RF **12**, CI Pigment violet 37 **13**, CI Pigment red 254 **14**, CI Pigment red 209 **15** and CI Pigment red 177 **16.**

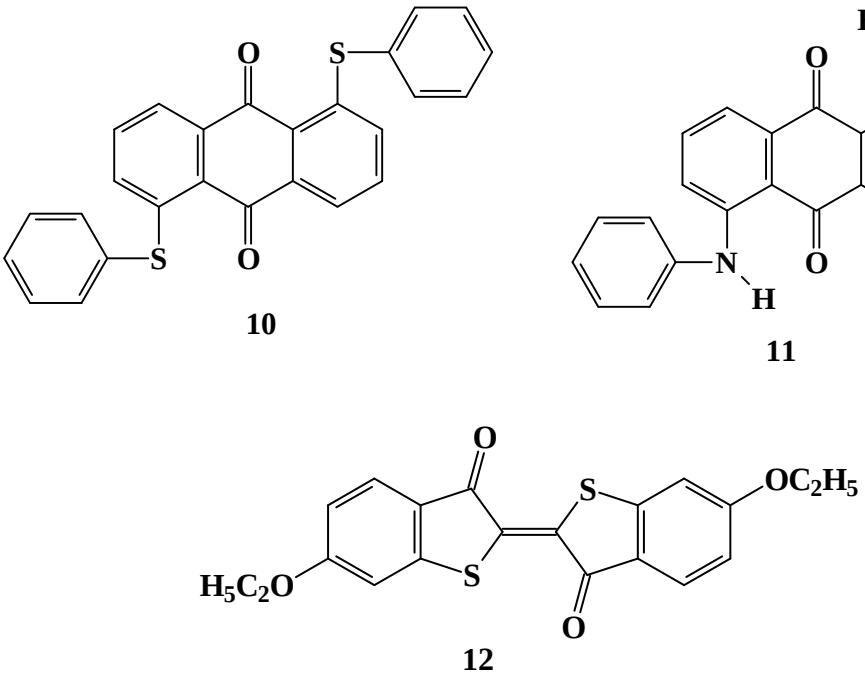


Figure 3: Dyes used in liquid crystal displays

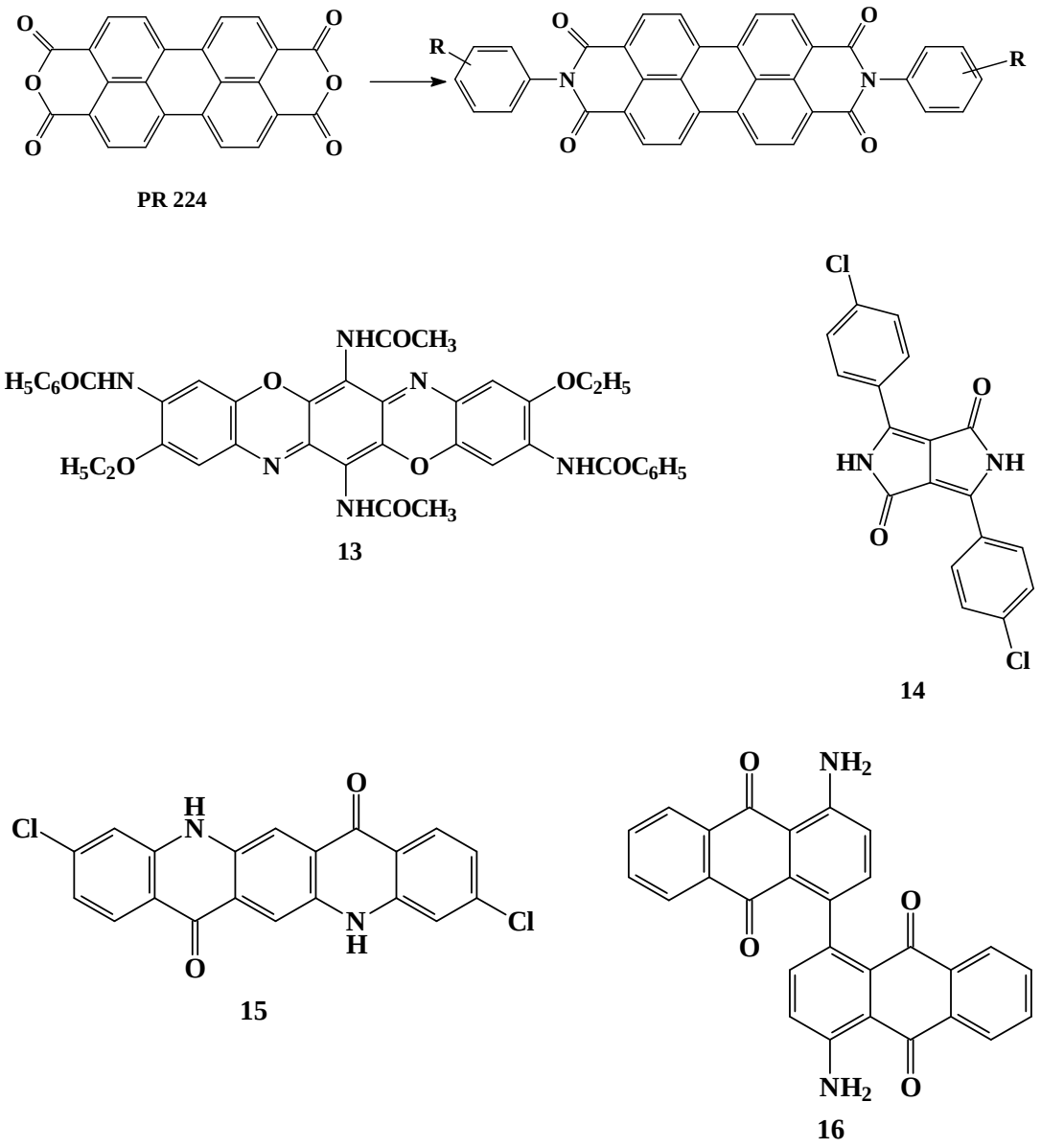
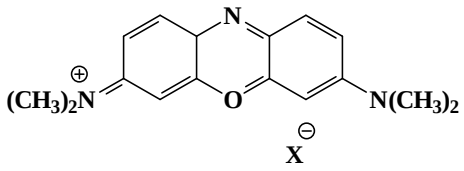


Figure 4: Pigments used in liquid crystal displays

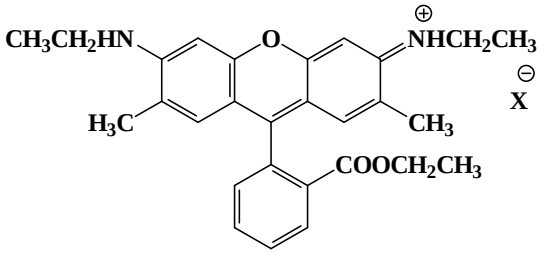
Laser Dyes

Inorganic Lasers emit only at very few Specific wavelengths, but dye lasers cover the entire Visible and near Infra Red spectrum from <400nm to 1000m and have greater tunability than inorganic lasers which, emits narrow bands. Dye lasers should be efficient fluorescer and must not lose a significant amount of energy by alternative

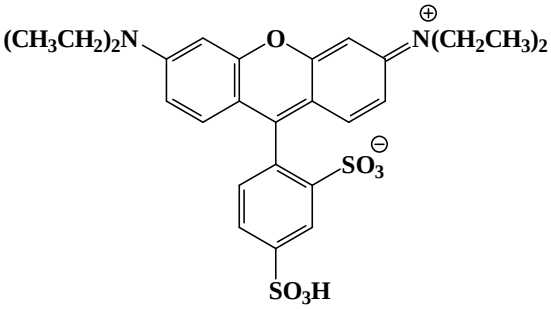
processes such as nonradiative decay and intersystem crossing. Research is on to synthesize new laser dyes which have increased stability and increased tunability of lasing wavelengths. The dyes used as laser dyes require High fluorescence yield, Good photostability and Low excited state losses. The various laser dyes are given in **Figure 5.**



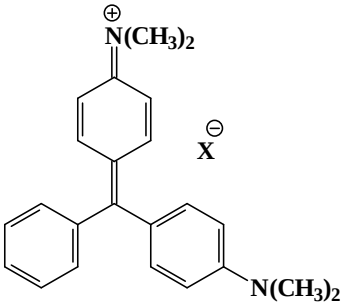
Oxazine 1



Rhodamine 6G



Sulpho Rhodamine B

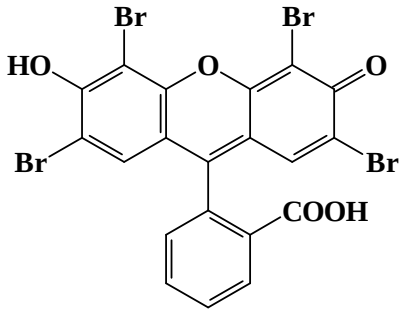


Malachite Green

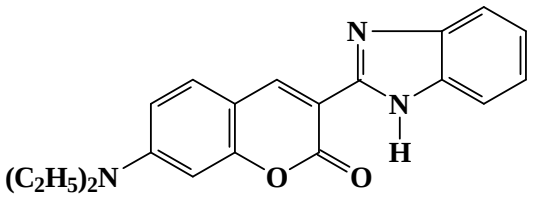
Figure 5: Laser dyes

Dyes in Solar Cells

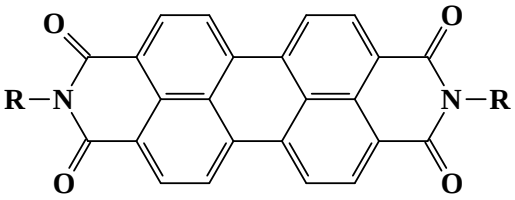
Typical uses of solar cells are powering low energy devices such as liquid crystal displays and traffic lights, future uses could include the large scale generation of electricity using ground-based solar cells. Conventional photovoltaic devices are replaced by more efficient dye-sensitized nanocrystalline solar cells. Light is absorbed by the dye and charge carrier transport is carried out by the semiconductor. The dyes used are given in **Figure 6.**



Eosin



Solvent yellow 185



Perylene tetracarboxydiimides

Figure 6: Dyes in Solar cells

Dyes in Photodynamic therapy

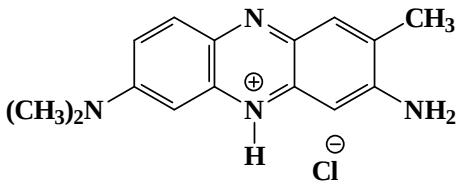
Photodynamic therapy is the combination of three components; light, photosensitizing drug (dye) and molecular oxygen to obtain a therapeutic effect in the treatment of cancer, skin tumours and non-oncological applications such as age related macular degeneration, prolonged uterine bleeding, psoriasis.

Age related macular degeneration is a major cause of blindness in the elderly. Thermal laser treatment can be used in select cases, further damages eye. Photosensitising dye localises in the corneal neovasculature, causing lack of sight and destroys it upon subsequent illumination of light, thus stabilising the loss of sight. In Prolonged Uterine bleeding, PDT is an effective alternative to hysterectomy without the post-operative sequelae associated with surgery.

Photosensitsing dyes target non-economic cells such as tumour cells, pathogenic viruses, bacteria etc. The excitational energy is utilised for photochemical reaction. Photosensitsing dye is administered, kept for 48 hours, dye becomes optimally located in any tumour tissue, predetermined dose of laser light is delivered which produces highly reactive singlet oxygen that kill the tumour. The dye requirements are high

efficiency of singlet oxygen generation, strong absorption in the red and near-IR (600-800nm) region, preferential affinity for tumour and rapid clearance from the body.

The dyes include neutral red **17** used as an effective photosensitizing antiviral agent against herpes simplex infection, sulphur analogue of Nile Blue A **18** that posess many advantages, absorbs at 652nm, accumulates rapidly and destruction occurs with minimal effects to the vasculature and Methylene Blue **19**, used in many therapeutic purposes like treatment of local bacterial infection, tuberculosis, trypanosomiasis, rickettsial illness and cancer and is a weak mutagen and can be used for inactivation of blood viruses such as Hepatitis B, HIV type I.



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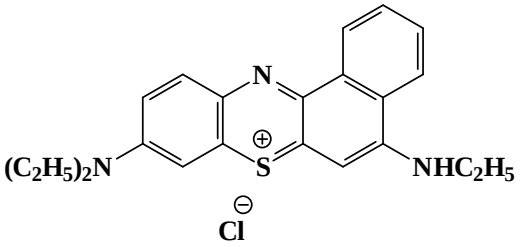

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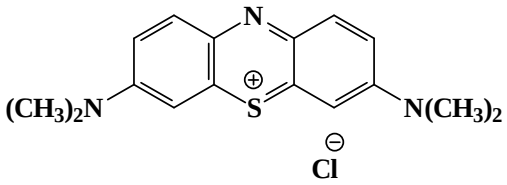

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