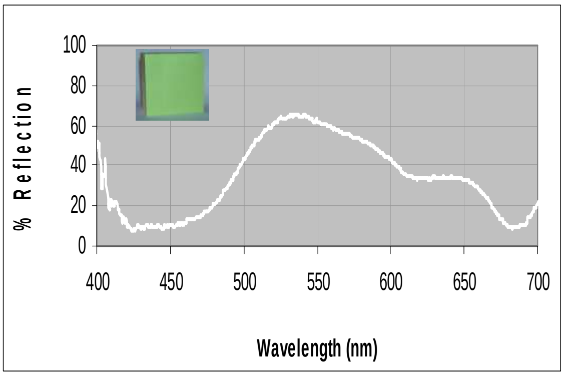
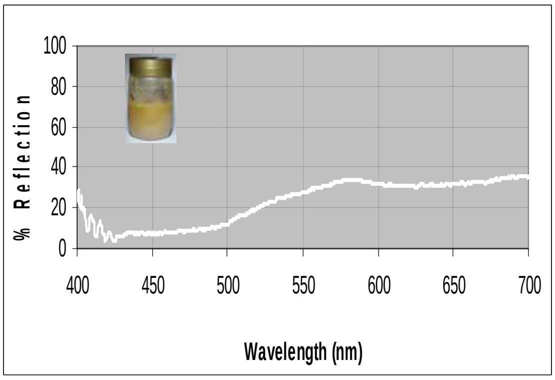
The colors of objects and the need for full spectrum illumination

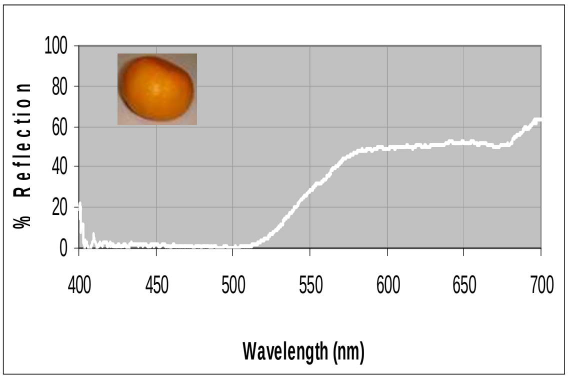
Ordinary objects around us may appear to have distinct colors described as red, blue, green, yellow etc but the fact of the matter is that most objects actually reflect complex combinations of elementary colors. In fact, it will be extremely difficult to find everyday objects that reflect only pure colors. Typical surfaces reflect all wavelengths in varying amounts. Their spectral signature is their reflection spectrum which depicts the percentage of incident light reflected at different wavelengths. Reddish objects will typically show high reflection in the red-orange region and relatively less reflection in the green and blue regions. Objects with hard to describe colors may show very complex reflection spectra. As the reflection spectra of four everyday objects reproduced below show, perceived color can be actually quite complex in spectral detail.



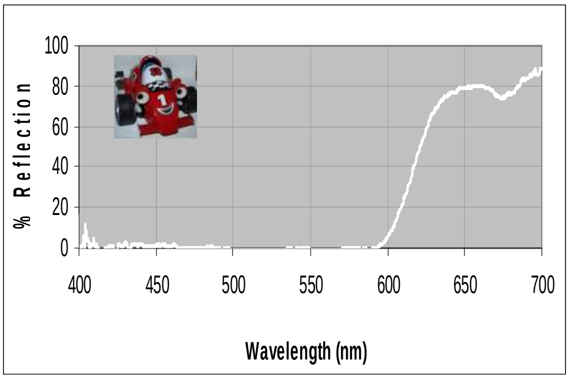
Green Post-it Notes



Honey Pot



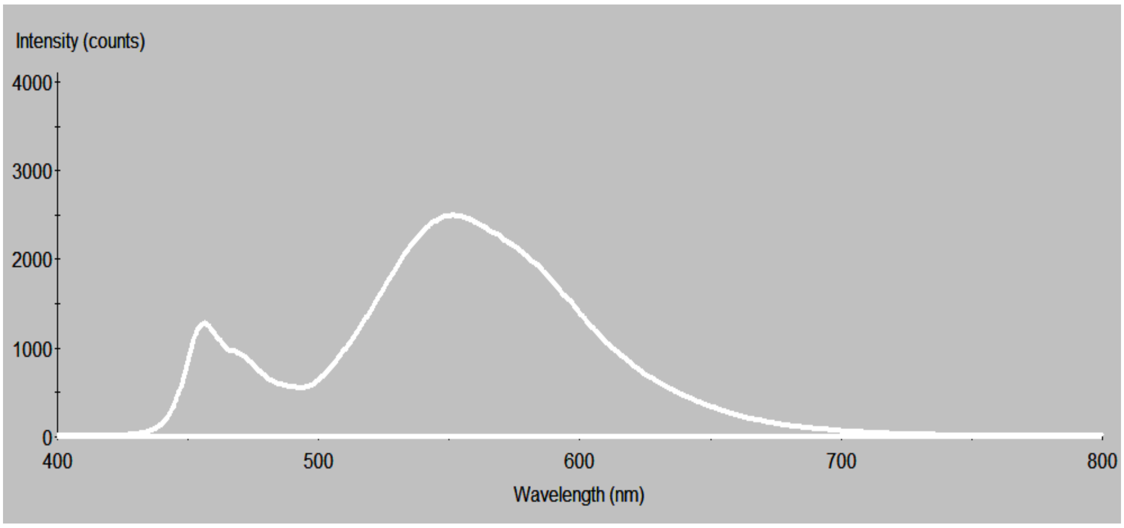
Orange



Red Car

Observing the true color of an object, therefore, of necessity, requires a light source that can provide all the color shades that the object is capable of reflecting. For general purpose illumination applications this means that the light source should ideally contain all wavelengths i.e. color shades from the deep red to the deep violet in roughly equal amounts. Such 'polychromatic' light, containing all visible colors with approximately equal intensities, can render objects faithfully in their true colors. An object seen in artificial full-spectrum light will appear almost exactly the same as seen in outdoor daylight. As natural daylight is the best readily available source for faithful color illumination so little wonder it is used as a reference for comparing other sources of illumination. In this context, daylight is given a color rendering index (CRI) of 100. Other illuminants are then assigned their respective CRIs by comparing their ability to daylight for accurate color reproduction. The closer the CRI of a light source is to 100%, the better it is considered for reproducing apparent visual color. Incandescent lamps have high CRIs because they are sources of thermal radiation just like the sun. However, other – more modern – light sources, such as fluorescent lamps and light-emitting diodes (LEDs) are characterized by lower CRI values. Recently, with the gradual disappearance of incandescent tungsten lamps and the increased availability of fluorescent and LED lighting, there has been a push towards increasing the CRI of these newer light sources.

There are two ways of creating white light from LEDs: use of phosphor-converted 'white' LEDs and the use of a combination of colored LEDs providing different colors. The first approach uses blue LEDs exciting special phosphor materials that convert some of the light to yellow which in combination with residual blue light from the LED chip appears white to the human eye. A typical spectrum from such a white LED is shown below.

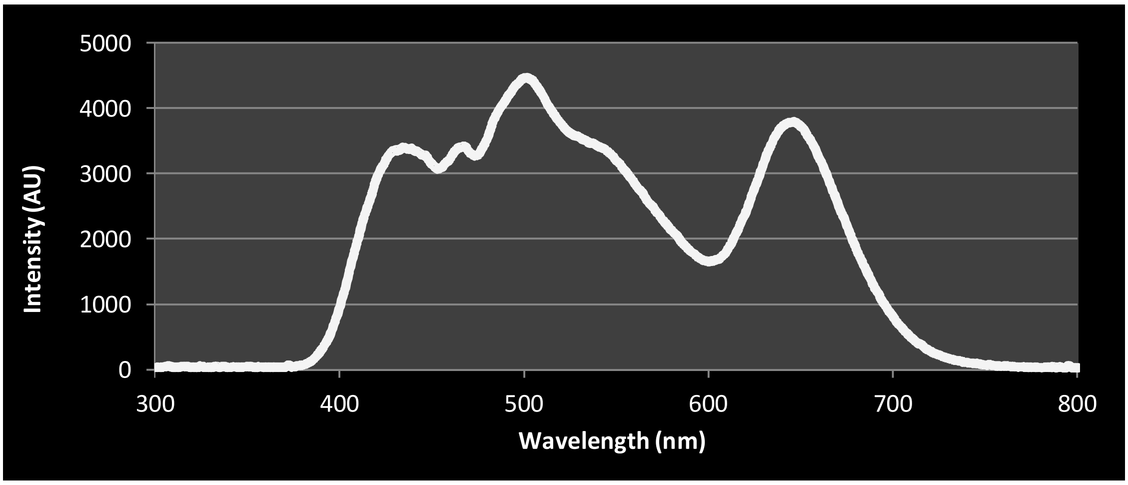


There has been further progress with white LEDs and now LEDs with various colour temperatures such as cool white and warm white are available from several LED manufacturers. The un-even distribution of light intensity in the emission spectrum of white LEDs makes them unattractive for high-quality color illumination applications.

Solid-state white light sources made from separate red, green and blue diodes do better but here the limited spectral width of these LEDs creates problems. The light from RGB LED white lamps has many missing color shades greatly reducing their effectiveness for faithfully rendering colored objects.

Shortcomings in the spectral distribution of LED light have somewhat limited the penetration of solid-state lighting in such areas as photography, video and film production, art illumination and machine vision, among others. For further progress, LEDs emitting broadband light are needed. Wide-spectrum diode emitters can be used to synthesize light with balanced spectra. Such light is extremely useful for illuminating colored objects as it can reproduce colors faithfully, bringing out even subtle changes in color tones. Spectrafill LEDs from Electrospell are true broadband light emitters. These devices produce wide-spectrum red, green and blue light that can be combined to create white light of almost any CRI value. Their availability opens up many attractive prospects for LED-based illumination systems. Light can now be tuned to create most shades of single colors and whites – opening up new possibilities. It is now possible to create high-quality lamps for retail lighting, museum illumination, photography, cine film production, mood lighting and any other application where small, energy-efficient, full-spectrum lights are needed.

Spectrafill red, green and blue LEDs, individually produce broadband light in three regions of the visible spectrum. When combined together, the resulting light covers the entire visible region with no gaps. This means that the light contains all possible color shades and can thus render colored objects in rich chromatic detail. The spectrum from combining the lights from red, green and blue Spectrafill LEDs is shown below. Except for somewhat reduced intensity in the orange region, the power is quite uniformly distributed throughout the visible spectrum – making it by far the best choice for high color definition illumination applications.



These LEDs are easy to drive with either analog or digital control. Typically, each LED can be controlled with a simple current source chip and a resistor, making system design extremely straightforward. All of these advantages translate to low-cost, high-quality, lighting systems which can truly show objects in their true color.