sun strokes

Lying almost totally naked on a tropical beach typically does not trigger deep thoughts regarding the constitution of solar radiation but most of us will slap on a dollop of sunscreen. The message is pretty much 'out there' that our life-giving, life-dependent sun can give off some damaging radiation. While I prefer the imagery of the beach, my boss tells me that there are some misunderstandings around regarding the interactions between the sun rays and paint and asked me to "please explain!" – so here goes!

The sun emits an enormous spectrum of energy referred to as electromagnetic radiation. This radiation is emitted in wavelengths from a few nanometres in length to several tens of metres. The longest waves are radio waves while the very shortest include gamma and x-rays.

The biggest 'chunk' of energy that the sun pours out is in the visible region, that is, in the range in which the human eye operates. Some commentators report this as being from as low as 380 nanometres up to 710 nanometres but the majority report the visible range as 400 (violet) to 700 (red). The amount of radiation in this range varies according to where you are in the world and what time of day it is. However, an average would appear to be about 52% of the total sun's energy is in the visible wavelengths.

The next biggest packet of radiation falls in the infra-red region which, for most purposes, lies between 700-2,500 nanometres. These are the wavelengths that we feel as heat and, with the same strictures as above, represent about 45% of the sun's energy.

An order of magnitude less, coming in at about 3%, is U.V. light, but this feisty little customer is not to be taken lightly (sorry for the pun). U.V. is subdivided into three categories, UV-C; UV-B and UV-A. UV-C, which has wavelengths ranging from 100-280 nanometres, never reaches the earth's surface as it, along with the even higher energy gamma and x-rays, interact with our upper atmosphere and are extinguished.

UV-B is a tricky customer, with a wavelength range of 280-320 nanometres. At the lower, more damaging end, the 'ozone layer' absorbs significant amounts of the energy. This 'ozone layer' should not be considered in isolation to UV-C and B. The ozone layer is created and destroyed by this irradiation in a dynamic relationship that reduces the energy of these rays. UV-B represents about 0.8% of the sun's energy reaching the earth's surface and is the most damaging.

UV-A represents the larger amount of U.V. energy hitting the earth's surface and it is a two-edged sword. The wavelengths between 320-400 nanometres are essential for the creation of vitamin D within the skin but are also of high enough energy to damage the skin and cause premature thickening of it.

The reason why U.V. radiation is of concern, even though there is not a helluva lot of it, is because of the very high energy of this short-wave radiation. To describe it chemically, U.V. light has the ability to enter and break down many organic molecules; visible light generally does not break down individual molecules but can break down the connections joining molecules while infra-red simply gets the molecules 'jiggling around' faster.

Imagine you are sitting in a military tank that is designed to withstand standard velocity munitions (viz visible light). Your tank could withstand bombardment by dozens of these missiles, unless, perhaps, several hit the same spot.

Let one, high velocity, armour-penetrating projectile (viz U.V. light) come along and that single projectile can do more damage than all of the lower energy missiles put together.

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U.V. light is the main degrader of paint binders. These high energy rays, often assisted by the ubiquitous white pigment titanium di-oxide and atmospheric moisture, can split the polymer chains of the binder into smaller and smaller fragments until they simply 'disappear'. This degradation of the binder eventually results in the loss of gloss and the release of free pigment on the paint surface – commonly known as chalking.

Different binders have different abilities to resist U.V. Fluorocarbons and silicones are excellent; pure acrylics are pretty good; aromatic epoxies are shocking as is polystyrene; aromatic alkyd urethanes are poor while aliphatic acrylic urethanes are very, very good.

One can retard the onset of gloss loss and chalking not only by choosing U.V. resistant binders but also by ensuring that there is more of the binder at the top of the film where it is required. 'Clear over base' systems have increased the durability of coatings dramatically.

U.V. light can also degrade certain pigments, leading to fading and colour change. The bonds between the crystals of inorganic pigments, such as red, yellow and green oxides, as well as carbon black, are so strong that even high energy U.V. cannot disrupt them. There are many bright, organic pigments however that are quite U.V. sensitive. The application of simple clear coats over such paints will not protect such sensitive pigments unless the clear contains special U.V. absorbers (see Architects memo 71).

Visible light can also break down certain colours – more typically the dyes used in the colouring of fabrics but also some of the cheaper organic pigments. It has virtually no effect on the binders used and paints do not 'chalk' even in the most well lit rooms. Paints either absorb all visible light (black); absorb and reflect selectively (colours); or reflect it (white).

The light that is absorbed (and in the case of black paint, this is over 50% of the sun's total output) decays into heat.

Infra-red radiation is also absorbed or reflected selectively depending on the nature and colour of the surface, and the wavelength of the infra-red. White paints reflect most of these rays while a black paint, based on carbon black, will absorb them all. The heat absorbed in this range adds to the heat formed due to the absorption of the visible rays and contributes to the total surface temperature of the paint.

The effect of increased surface temperature depends on the type of paint and the nature of the substrate. As a rule of thumb, the rate of chemical reaction doubles for every 10ºC increase in temperature. For paints that cure by chemical reaction (thermosetting systems), higher surface temperatures ensure good curing. However, in air-drying, oil-based systems, overcuring occurs, which leads to embrittlement.

Thermoplastic coatings, however, (which includes almost all of the decorative acrylics) simply soften somewhat. This can lead to the surface becoming softer and somewhat stickier but normal hardness is regained on cooling. The expected increase in the rate of degradation does not occur, thought to be because the hotter surface is free from moisture, which is an important element in degradation.

The other important effect of heat is on substrates that are perfectly stable when cool but unstable when hot. UPVC is one obvious substrate but old oil and alkyd painted surfaces is a less obvious and more abundant one. Mitigation of surface temperature using 'Cool Colour' technology has been covered in Architects memo 78.

So there it is – a short, radiant primer on sunshine – I hope the boss is satisfied – and pass the sunscreen please!

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