The biological dosimetry of solar UV-radiations

The principle of biological dosimetry of UV-radiations

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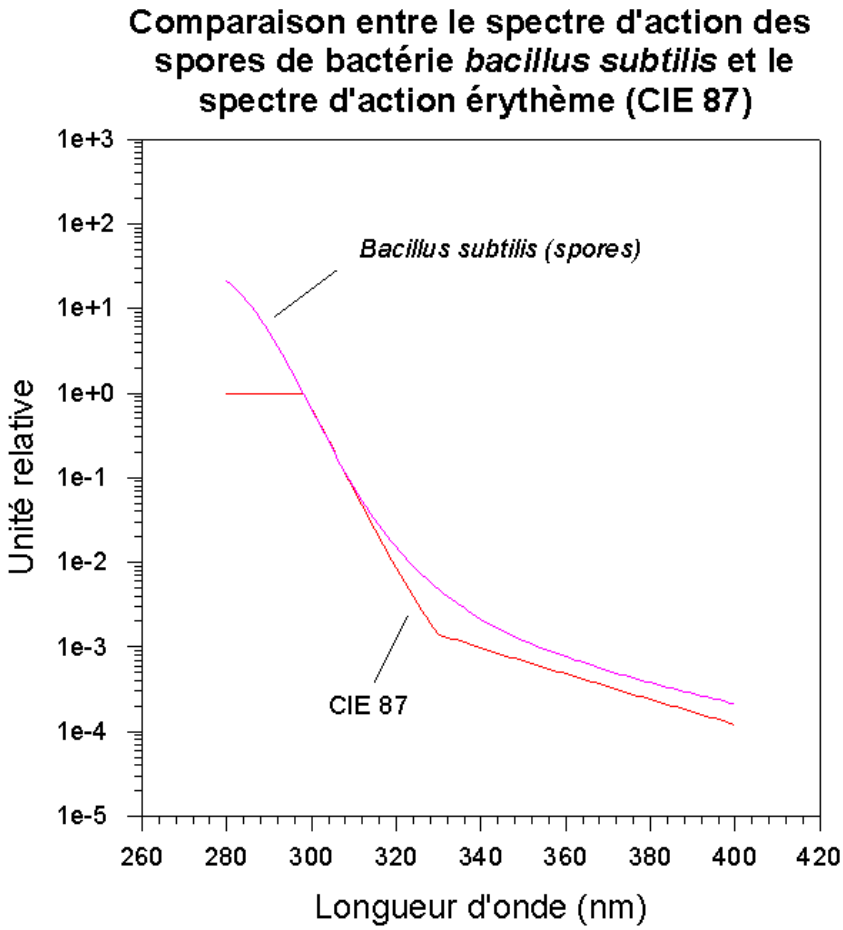
Functioning principle of a biological dosimeter

A biological dosimeter, that measures the total amount of UV-radiations during a particular period of time, uses as sensitive surface a biological material (e.g. spores of bacteria). The selective spectral response of the material (action spectrum) provides the biological response automatically. The effective biological 'dose' should be derived univocally from the irreversible changes occurring during exposure of the photosensitive surface. Therefore the ideal dosimeter has to fulfil several conditions. The spectral sensitivity (action spectrum) has to copy as good as possible the biological process under investigation (human skin response, etc.). The dosimeter has to be handy in usage like for example small sized and insensitive to overheating. If not, any bias has to be analysed and quantified correctly. The dosimeter also needs to be insensitive to rain and be able to cope with long stocking periods. To conclude the optical performances should be characterised radiometrically to avoid wrong interpretation of the results.

Example of a dosimeter in development

As an example it might be interesting to take a look at an advanced prototype of a biological dosimeter: the "biofilm", developed in Germany (DLR, Köln). The functioning of this prototype can be compared with a photographic film. The film emulsion here exists of a gel in which spores of the bacteria Bacillus Subtilis are mixed and fixed on a plastic bottom layer.

The action spectrum of this detector lies close to the standard spectrum CIE 87 as the following figure proves.



This prototype has the necessary characteristics of a reliable, personal dosimeter. Exposure of the biofilm to the UV-radiations causes a partial or total inactivity of the spores of bacteries. The biofilm however needs to be developed and this development requires an incubation process for the "surviving" spores in a nutritious bath and the colouring of the generated biomass. Determination of the received biological effective dose of UV-radiations comes afterwards by comparing the colouring of the biofilm (blue colours) to a standard radiometric colour range.

Other models of dosimeters already exist as prototypes in Europe and Japan. They are made up of biomolecules (vitamin D, bacteriophages) or cellular systems (E.coli-bacilles, Bacillus subtilis) sensitive to UV-radiations.

Ideally, the future dosimeters should take into account the difference between photo types of the skin of certain populations, and therefore exist in models with different sensitivity (in analogy with for example the ASA-category of photographic films).

On top of that, the present development time, necessary to determine the received dose of UV-radiations, reduces the actual usability. This inadequacy is nowadays corrected by adding a small quantity of a chemical indicator that is calibrated approximately, but reacts almost immediately to UV-radiations. Biological dosimeters can be very useful to complete those monitoring stations for UV-radiations that are equipped with physical radiometers, and to increase that way on a national scale the density of measuring points and the number of measurements. Such measuring networks based on the study of radiations climatology do not demand real time measuring results.

The role of the Belgian Institute for Space Aeronomy

A complete radiometric calibration of a biological dosimeter prototype is absolutely necessary for the determination of suitability for measurement of the biological influence of UV-radiations, like for example reliable outdoor measurements. This calibration is composed of the exact determination of the action spectrum, the measurement of reproducibility and linearity of the biological response during exposure to UV-radiations, the possibility of integrating radiations coming from every direction in the sky (angular dependency) and the absolute calibration that has to compare unambiguously the biological response of the dosimeter to a scale divided into radiometric units.

The European project BIODOS (financed by the European Union DG XII) provided an inventory of existing European dosimeters, to select the most promising ones based on strict criteria and to improve the performance by thorough radiometric calibration, so we can leave the phase of prototype and enter pre-industrialisation. These calibrations were conducted at the BISA. For this purpose a sophisticated calibration facility was built and used frequently in our optic lab during the two-year project.

However, to offer the broad public reliable and generally accepted biological dosimeters, great efforts are still necessary.