ULTRAVIOLET RADIATION SOURCES FOR COSMETIC USE : MEASUREMENT OF INTENSITY AND SPECTRAL DISTRIBUTION

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Introduction

Ultraviolet radiation has been known for many years to be both a benefit and a risk to mankind. During the last few decades a rapid increase in malignant melanoma has been observed probably owing to rising exposure to UV-radiation. This increase in UV-exposure may be attributed to the low protection from sunlight by modern clothing or to the new fashion of tanning either by solar UV-radiation or by artificial UV-sources.

A noxious development concerning UV-induced skin cancer can possibly only be stopped by comprehensively informing the public about the risk of tanning and by supervising the artificial UV-sources for cosmetic purposes. This control of industrially produced UV-radiation emitting devices, may be based on the published standards(1-3) from different national and international organisations dealing with UV-safety and measurement, even though most of those standards are only proposals up to now.

Based on the standard proposed for the Federal Republic of Germany (3) a system for the measurement of UV-radiation was built up and several types of UV-sources were measured and their biological effectiveness calculated.

Materials and Methods

The main part of the measurement device is a spectro-radiometer model 6051 from Roffin Sinar, consisting of a scanning monochromator, a photomultiplier and a wavelength marker unit. The monochromator uses a ruled grating as dispersion element to ensure a constant bandwidth over the whole wavelengths (2.5nm from 200 to 400nm). The radiation is coupled to a fused silica optical fibre by a wide-angle diffusor with nearly cosine response. The other end of the fibre has a rectangular shape, to couple light directly to the entrance slit of the monochromator. The radiometer is linked via an a/d-converter to a small computer (CBM 8032) for data acquisition, manipulation and storage and for the representation of results.

The spectral responsivity of the radiometer, - about which knowledge is necessary to calculate the absolute irradiance values -, is determined by calibration against a UV-standard source described by Rössler (4). For the calibration only the wavelength with high values of radiation (mercury lines) were used. The values of the responsivity at other wavelengths were calculated by an interpolation procedure. The calculations of the biologically effective irradiation and exposure times for threshold doses were based on the data published in "DIN 5031 Teil 10" (3).

The tanning devices which were measured up to now were grouped into different classes representing the different kinds of UV-sources used. Type 1 devices are those using high pressure mercury arcs without a special filter, type 2 devices are equipped with so-called sunlamps which are lamps combining incandescent lamps and high pressure mercury arcs within the same bulb. Sometimes lamps of type 2 are combined with infrared lamps whereas type 1 is always in combination with an IR-emitter. The type 3 solaria use fluorescent lamps for UV generation and type 4 is the sun at a standard sunny day (3).

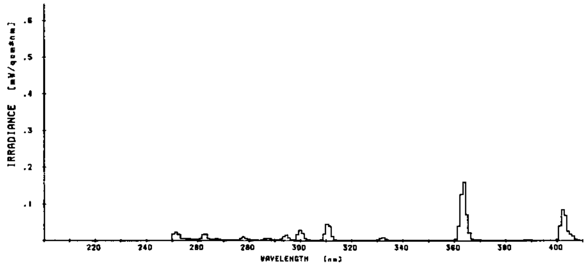
Results

Examples for the spectral irradiance of different UV-sources are shown in Figure 1 a-c. The great differences of the tanning sources shown in this Figure are also reflected in the biological effectiveness shown in Table 1. In this Table the Irradiance effective in producing erythema I(ery) is compared with that effective for the immediate pigment darkening I (ipd). Obviously I(ery) is in part also effective in forming new melanin and therefore in pigmentation (late pigmentation). I(ipd), however, is meant to be the part of the biologically effective irradiance that is responsible for the "safe" pigmentation without a risk for skin cancer. Therefore and because it is tabulated in the standard (3) I(ipd) should only be considered here. Table 1 also gives an idea of the threshold times for one "minimal erythema dose" T(med) and for one "minimal tanning dose" T(mtd).

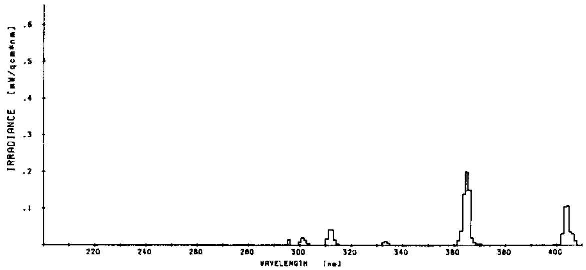
Type	I(ery)	T(med)	I(ipd)	T(mtd)
1	188 $\mu W/cm^2$	3 min	610 $\mu W/cm^2$	280 min
2	60 $\mu W/cm^2$	10 min	655 mW/cm^2	250 min
3	6.4 $\mu W/cm^2$	100 min	19 mW/cm^2	9 min
4	18 $\mu W/cm^2$	30 min	4.2 mW/cm^2	40 min

Table 1 Four different types of tanning sources showing great differences in erythemal - I(ery) - , immediate pigment darkening - I(ipd) - effectiveness, times required for a minimal erythema T (med) and for minimal tanning T(mtd).

a)



b)



c)

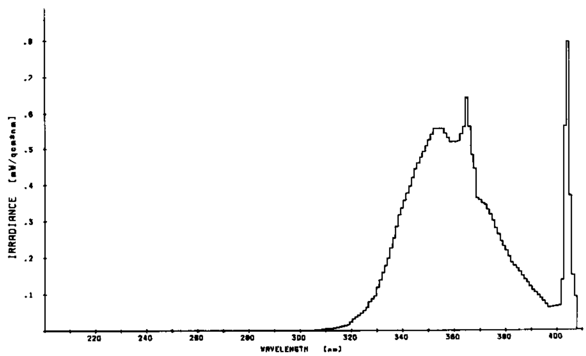


Figure 1

a) Spectral irradiance of an UV-source using high pressure mercury arc, measured at a distance of .7 m from the lamp

b) Spectral irradiance of an UV-solaria using sunlamps at the ceiling of the room at a distance of 1.3 m.

c) Spectral irradiance of a tanning bed using fluorescent tubes, measured directly on the acrylic plate

Conclusions

The type 1 devices which emit a high amount of UV-B (280nm to 320nm) should only be used very cautiously for cosmetic purposes and a therapeutical use should be controled by a physician. Exposure to that kind of radiation is coupled to a very high risk for erythema and long-time exposure may result to a considerable risk for skin cancer.

The type 2 solaria consist of sunlamps mounted together with IR-lamps on the ceiling of the exposure room. This devices want to emulate natural sunlight and, therefore, a considerable amount of UV-B is also emitted. Like the sunlight, this part of the emitted spectrum is also suspected to increase the risk for skin cancer especially in long-time application.

The type 3 devices show little UV-B and therefore they seem to be safe because of nearly no erythemal effectiveness. Furthermore experiments have proven that UV-A alone is not able to produce skin cancer (5). However recent experiments show that large amounts of UV-A in combination with a small amount of UV-B can induce skin tumors in animals (5). Although it is not known wether these results can be applied to man or not, a cancer risk for people using this type of tanning equipment after exposure to sunlight cannot be excluded.

References

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4) F. Rössler, "Strahlungsmessungen an einer Quecksilberhochdrucklampe". Ann Phys 34, 1-20, 1939
5) B. Staberg, H.C. Wulf, T. Poulsen, P. Klemp and H. Brodthagen "Carcinogenic effect of sequential artificial sunlight and UV-A irradiation in hairless mice". Arch Dermatol 119 641-3 1983