ULTRAVIOLET RADIATION LAMPS FOR THE PHOTOTHERAPY OF PSORIASIS

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INTRODUCTION

The first treatment of psoriasis with a source of artificial ultraviolet radiation (UVR) is credited to Sardemann(1) who used a carbon arc lamp of the type developed by Finsen at around the turn of the century. These lamps were unpopular in clinical practice because of their noise, odour and sparks(2), and were superseded by the development of the medium-pressure mercury arc lamp. In the 1960s, a variety of metal halides was added to mercury lamps to improve the emission in certain regions of the ultraviolet and visible spectra(3). Fluorescent lamps were developed in the late 1940s and, since then, a variety of phosphor and envelope materials have been used to produce lamps with different emissions in the ultraviolet region. Today there exists a wide range of different types of lamps which are used for the phototherapy of psoriasis. This chapter will review the physical characteristics of lamps and photoirradiation systems used for so-called UV-B phototherapy of psoriasis. It will not cover sources emitting primarily UV-A radiation which are used in conjunction with photosensitising agents (psoralens) to treat psoriasis.

THE NATURE OF ULTRAVIOLET RADIATION

Ultraviolet radiation covers a small part of the electromagnetic spectrum. Other regions of this spectrum include radiowaves, microwaves, infra-red radiation (heat), visible light, X-rays and gamma radiation. The feature that characterises the properties of any particular region of the spectrum is the wavelength of the radiation.

Ultraviolet radiation spans the wavelength region from 400 to 100 nm. Even in the ultraviolet portion of the spectrum the biological effects of the radiation can vary enormously with wavelength and for this reason the ultraviolet spectrum is further subdivided into three regions.
UV-C (290 to 100 nm). The rays in this wavelength interval do not pass through the Earth's atmosphere and so are not present in terrestrial sunlight. Nevertheless, UV-C is produced by many artificial ultraviolet sources and if present can be particularly damaging to the eyes.

UV-B (320 to 290 nm). It is these rays which are primarily responsible for nearly all of the biological effects following exposure to sunlight. UV-B produces sunburn, suntan, and, following many years of exposure, premature ageing of the skin and skin cancer. Exposure of the eyes to UV-B can produce photokeratitis and conjunctivitis. The only well-established benefit of exposure to UV-B in normal skin is the production of vitamin D.

UV-A (400 to 320 nm). These rays are closest to the visible spectrum, can pass through window glass and are least harmful in humans on a dose-for-dose basis. Nevertheless UV-A radiation can produce erythema, tanning and probably skin cancer, but the doses required are about 1000 times greater than those with UV-B.

THE PRODUCTION OF ULTRAVIOLET RADIATION

Ultraviolet radiation is produced artificially by the passage of an electric current through a gas, usually vapourised mercury. The mercury atoms become excited by collisions with the electrons flowing between the lamp's electrodes. The excited electrons return to particular electronic states in the mercury atom and in doing so release some of the energy they have absorbed in the form of optical radiation, that is, ultraviolet, visible and infra-red radiation.

The spectrum of the radiation emitted consists of a limited number of discrete wavelengths (so-called 'spectral lines') corresponding to electron transitions characteristic of the mercury atom, and the relative intensity of the different wavelengths in the spectrum depends upon the pressure of the mercury vapour. For lamps containing mercury vapour at about atmospheric pressure (so-called medium-pressure mercury arc lamps), radiation is emitted with several different wavelengths in the UV-C, UV-B, UV-A, visible and near infra-red (IR-A) regions. By adding traces of metal halides to mercury vapour lamps, both the power and the width of the spectrum emitted, particularly in the UV-A and visible regions, may be enhanced.

Alternatively ultraviolet radiation can be produced by utilising the phenomenon of fluorescence. A fluorescent tube is a low pressure mercury vapour lamp which has a phosphor coating applied to the inside of the envelope. At low pressures in mercury vapour there is a predominant spectral line at a wavelength of 253.7 nm and radiation of this wavelength is efficiently absorbed by the phosphor on the lamp envelope. This results in the re-emission of longer wavelength fluorescence radiation. The wavelength range of the fluorescence radiation will be a property of the chemical nature of the phosphor material and the composition of the lamp envelope. Phosphors are available which produce their fluorescence radiation mainly in the visible (for artificial lighting purposes), the UV-A, or the UV-B regions.