

LITERATURE REVIEW



Revealing The Unseen: A Review of Wood's Lamp in Dermatology

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ABSTRACT: In use for over a century, the Wood's lamp is a time-tested tool to aid in the diagnosis of certain superficial infections, pigmentary disorders, and metabolic diseases. To achieve its high utility, the Wood's lamp projects ultraviolet light onto the skin which in turn reflects a visible light that a trained eye can use to diagnose and monitor multiple dermatological ailments. Although new alternatives to Wood's lamp have been considered, it still remains a favored method of diagnosis because it is safe, cost-effective, and reliable. In this review, the authors explore the myriad applications of Wood's lamp in the field of dermatology.

KEYWORDS: Wood's lamp, ultraviolet light, fluorescence, phosphor, porphyria, dermatophyte

In 1903, Robert Williams Wood, a well-known American physicist, developed an instrument that produced an apparent paradox: invisible light.¹ This light source, the Wood's lamp, had a special filter comprised of barium silicate with 9% nickel oxide that blocked much of the visible electromagnetic spectrum and allowed transmission of ultraviolet (UV) light.¹⁻² Wood primarily used his invention in UV photography. Later, the Wood's lamp found applications in other scientific fields, including criminal forensics, emergency medicine, ophthalmology, gynecology, and veterinary medicine.³⁻⁹ However, Wood's lamp has arguably gained greatest recognition for its role in dermatology, where it is used to diagnose and monitor an array of fungal and bacterial infections, pigmentary conditions, and metabolic disorders.

A brief discussion of electromagnetic radiation is warranted to contextualize the role of the Wood's lamp. The electromagnetic spectrum comprises a range of energy that radiates, or travels in waves. Arranged within this spectrum are seven energies: radio, microwave, infrared, visible, ultraviolet, X-ray, and gamma. Radio waves have the lowest energy and longest wavelengths, whereas gamma rays have the highest energy and shortest wavelengths. Perceptible by the human retina, visible light has a narrow range from 700nm (red) to 400nm (violet). Slightly more energetic, and invisible, is ultraviolet light. It is in this part of the electromagnetic spectrum that Wood's lamp emits light, from 320nm to 400nm, with a peak wavelength of 365nm.

PHYSICS OF FLUORESCENCE

To understand how Wood's lamp functions, one must take a closer look at what is occurring at a molecular level. When the relatively energetic and short

waves of UV light shine on certain substances, known as phosphors, visible light of lower energy and longer wavelength is produced (Figure 1). This is known as fluorescence. Thus, phosphors essentially convert invisible UV light to visible light. The skin contains natural phosphors, such as collagen and elastin.² To excite other electrons, photons need to have a certain amount of energy. Elastin contains several phosphors, one of which is a crosslinking tricarboxylic amino acid with a pyridinium ring, and collagen's main phosphor is tyrosine, an amino acid.¹⁰⁻¹¹ Both of these phosphors contain electrons that can be excited by UV light. Once excited, almost immediately the electrons become unstable and seek their lower energy ground state.¹² This electronic transition from high to low energy states occurs through vibrational relaxation.¹³ This energy decay process releases photons of visible light.¹³

ALTERNATIVES

A traditional Wood's lamp contains Wood's glass, which is a mixture of barium-sodium-silicate glass and 9% nickel oxide.¹⁻² This glass coats the inside of tubes through which the UV light is transmitted. However, Wood's glass is unique in that it blocks much of the visible light passing through the filter. A recent study has suggested that ordinary blacklights are a less expensive and comparable alternative to Wood's lamp.¹⁴ All blacklights, including light emitting diodes, fluorescent light bulbs, and blacklight blue bulbs, emit UV light, similar to Wood's lamp.¹⁵ However, not all blacklights emit the same intensity and peak wavelength of UV light; each blacklight produces slightly different fluorescence.¹⁶ Wood's lamp produces a peak wavelength of 365nm, whereas commercially available blacklight sources can have peak wavelengths

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TABLE 1. A summary of Wood's lamp findings and associations relevant to dermatology

CONDITION OR USE	ASSOCIATION	WOOD'S LAMP FINDING	SOURCE OF FLUORESCENCE	REFERENCE
Bacterial infections				
Cellulitis after burns, subungual infection, and interdigital infection	<i>Pseudomonas aeruginosa</i>	Green	Pyoverdine	18, 19
Erythrasma	<i>Corynebacterium minutissimum</i>	Coral-red	Coproporphyrin III	20, 21
Trichomycosis axillaris	<i>Corynebacterium tenuis</i> and other diphtheroids	Pale yellow	Unknown, possibly glue-like concretions	23-25
Progressive macular hypomelanosis	<i>Cutibacterium acnes</i>	Orange-red color in pilosebaceous follicles	Coproporphyrin III	26, 27
Fungal infections				
Dermatophytosis*	<i>Microsporum audouinii</i>	Blue-green	Pteridine	2, 28
	<i>Microsporum canis</i>	Yellow-green	Tryptophan metabolites	9
	<i>Microsporum ferrugineum</i>	Yellow-green	Tryptophan metabolites	32
	<i>Trichophyton schoenleinii</i>	Dull blue	—	28
Pityriasis versicolor	<i>Malassezia globosa</i>	Yellow-orange	Pityrialactone	33, 34
Hypopigmented conditions				
Vitiligo	—	Blue-white	Lack of melanin	2, 41
Nevus depigmentosus	—	Dull, off-white	Decrease in melanin	36
Tuberous sclerosis	—	White ash-leaf macule	Decrease in melanin	37
Linear scleroderma/morphea	—	Blue-white	Decrease in melanin	38-40
Melasma	—	Epidermal: Brown or black, Dermal: Grey-blue	Increase in melanin	43, 44
Metabolic disorders				
Congenital erythropoietic porphyria	Uroporphyrinogen III synthase defect	Pink to red	Uroporphyrin I and coproporphyrin I in urine, blood, and enamel	2, 47-48
Porphyria cutanea tarda	Autosomal dominant or acquired uroporphyrinogen decarboxylase defect	Pink to red	Uroporphyrin I and III in urine; few case reports cite fluorescence of skin or enamel	2, 47-48
Hepatoerythropoietic porphyria	Autosomal recessive uroporphyrinogen decarboxylase defect	Pink to red	Uroporphyrin I and III in urine, blood, and enamel	46
Erythropoietic protoporphyria	Ferrochelatase defect	Pink to red	Protoporphyrin IX in blood	49
Miscellaneous conditions				
Solar urticaria	—	Erythema and urticaria	—	50

of 375nm, 385nm, or 395nm.¹⁷ The longer the peak UV wavelength, the more visible light will be produced, which will result in less fluorescence. Blacklights that produce less fluorescence make diagnosing dermatological conditions more difficult. Another difference between a conventional blacklight and Wood's light is that Wood's light can magnify objects by 1.5 times.¹⁸

Interestingly, a second alternative to Wood's lamp can be created by simply generating a blue screen background on a smartphone.^{19,20} Blue light is absorbed well by melanin, however, the luminescence is much harder to see, given the increased levels of visible light.² Digital screens produce short-wavelength visible light, not UV light.²¹ A blue screen on a smartphone is a practical option when in a resource-poor setting where the provider may not have access to Wood's lamp. Clinicians can use an internet search engine to search for "blue image" and download it. Then, the clinician should increase the smartphone screen brightness to the maximum level and turn off the screen timeout setting.¹⁹ The rest of the procedure is identical to using a Wood's lamp; simply darken the room and hold the phone 4 to 5 inches away from the skin. While Wood's lamp is always the superior option, conventional blacklights and even a blue-lit smartphone screen are acceptable alternatives in resource-poor settings.

PERFORMING AN EXAMINATION

To conduct a Wood's lamp examination, the provider will need a light source and a dark room.¹ As per the manual, it is ideal to allow the lamp to warm up for about one minute.²² Other sources say only 20 seconds is needed.¹ It is recommended to hold the Wood's lamp 4 to 5 inches away from the surface of the skin.¹ Many extraneous artifacts could influence the lamp's fluorescence. For example, if the patient has showered or bathed recently, it will decrease the fluorescence.² There are also certain medications, detergents, and fibers that will cause inappropriate fluorescence.² Many substances produce false positives from Wood's lamp, especially in pediatric dermatology. These include colored markers (highlighters), dried soap and laundry detergents with optical brighteners, hyperkeratotic scale, invisible ink, lemon juice, lint, semen, serum, saliva, milk, cosmetics and hair dyes, select sunscreens and ointments, and wet ear wax.²³ When there is unusual fluorescence observed in atypical locations, it is important to consider exposure to these contaminants. Ophthalmologists have indicated that Wood's lamp

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has no harmful effects on the superficial structures of the eye.⁸ However, in pediatric dermatology, the use of UV light protective goggles is recommended to shield the retina, given that children may impulsively look directly into the light.²⁴ Chronic exposure to Wood's lamp may cause cataract formation and ocular aging.²⁴

APPLICATIONS IN DERMATOLOGY

Literature on Wood's lamp use in dermatology is discussed in detail below and summarized in Table 1.

Certain pathogenic bacteria of the skin fluoresce with the use of the Wood's lamp. *Pseudomonas aeruginosa* infections are commonly associated with burns, onycholysis, and interdigital spaces. *Pseudomonas* secretes pyoverdine, a phosphor, which will fluoresce green under Wood's lamp.²⁵ Thus, green fluorescence, in the proper clinical context, insinuates infection with *Pseudomonas* (Figure 2).²⁶⁻²⁸ Similarly, erythrasma is a superficial bacterial infection caused by *Corynebacterium minutissimum*.²⁹ Erythrasma can mimic other intertriginous dermatoses, such as inverse psoriasis or candidiasis, sometimes making diagnosis difficult.³⁰ However, *C. minutissimum* produces coproporphyrin III and fluoresces a coral-red color, which elucidates its diagnosis.³¹ Other causes of intertrigo will not fluoresce similarly.³¹ Trichomycosis axillaris is a superficial bacterial infection in which small concretions form on axillary hair. Trichomycosis is usually associated with *Corynebacterium tenuis* and other diphtheroid species.³² Instead of a coral-red fluorescence like erythrasma, trichomycosis axillaris displays a pale-yellow fluorescence under Wood's lamp.³² Although the precise phosphor in the case of trichomycosis axillaris is unknown, it is postulated to be the actual glue-like concretions, whether bacteriogenic or from apocrine sweat.³³⁻³⁴ Lastly, *Cutibacterium acnes* causes progressive macular hypomelanosis (PMH).³⁵ This hypopigmentation disorder mimics tinea versicolor and post-inflammatory hypopigmentation.³⁰ Under Wood's lamp, *Cutibacterium acnes* fluoresces an orange-red color in pilosebaceous follicles, clinching the diagnosis of PMH (Figure 3).³⁵⁻³⁶

In addition to bacterial infections, Wood's lamp allows for rapid diagnosis of certain fungal infections, especially when compared to the delay associated with fungal cultures. Of the three genera of dermatophytes—*Trichophyton*, *Epidermophyton*, and *Microsporum*—only *Microsporum* and a few *Trichophyton* species will

TABLE 1 continued. A summary of Wood's lamp findings and associations relevant to dermatology

CONDITION OR USE	ASSOCIATION	WOOD'S LAMP FINDING	SOURCE OF FLUORESCENCE	REFERENCE
Milia	—	Bright yellow	Keratin in dermis	51
Annular dermatoses/ neoplasms	Granuloma annulare	Blue-black at the center, red on the edges	Keratin	13
	Lichen planus annulari	Blue-black without a ring structure		
	Porokeratosis	Blue-brown at the center and white on the edge		
Skin cancer margins				
Lentigo maligna melanoma	—	Dark brown and black; Blue-white	Melanin, Loss of melanin in areas of regression	53
Basal cell carcinoma with <i>in-vivo</i> photodiagnosis	—	Coral-red	Methyl aminolevulinate (MAL) cream	54
Cosmetic applications				
Administering chemical peels	Salicylic acid Fluorescein sodium	Green Yellow/orange	Salicylic acid Fluorescein sodium	55
Sunscreen application	—	Blue-white	Sunscreen	56, 57
Tetracycline compliance	—	Yellow	Tetracycline	58
Dihydroxyacetone application	—	Salmon	DHA	59

*Most dermatophytoses do not fluoresce.

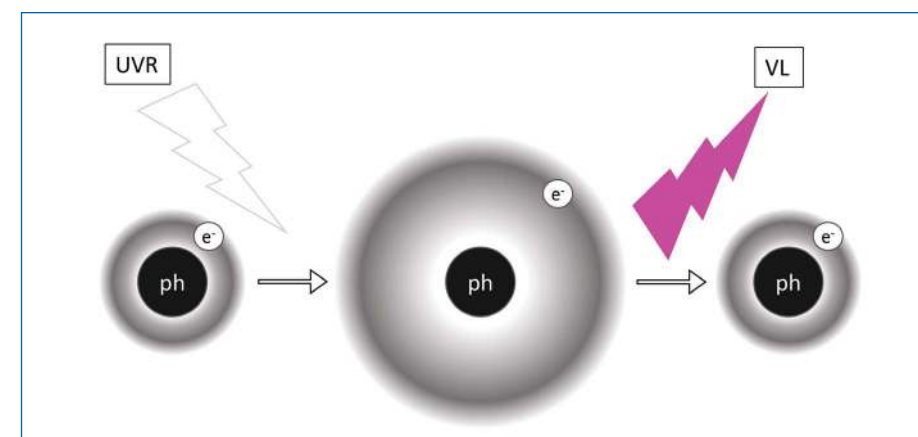


FIGURE 1. Schematic of electronic transitions during fluorescence. When the relatively more energetic and shorter wavelengths of ultraviolet radiation (UVR) shine on a phosphor (ph), its electrons (e-) are moved to excited states. Since such excited states are unstable, electrons soon revert to their ground states. Energy decays in the system via vibrational relaxation and other means, and the remainder is emitted in relatively less energetic and longer wavelengths of visible light (VL).

produce fluorescence.³⁷ Dermatophytes in the genus *Microsporum* will produce a blue-green fluorescence from the porphyrin pteridine; most in genus *Trichophyton* will not produce any fluorescence, although *T. schoenleinii* fluoresces

dull blue and *T. verrucosum* fluoresces in cattle (not humans).^{2,38,39} Historically, most cases of tinea capitis in the United States were caused by *M. audouinii*, and Wood's lamp provided a reliable and quick diagnosis.⁴⁰ Currently, *T. tonsurans* is

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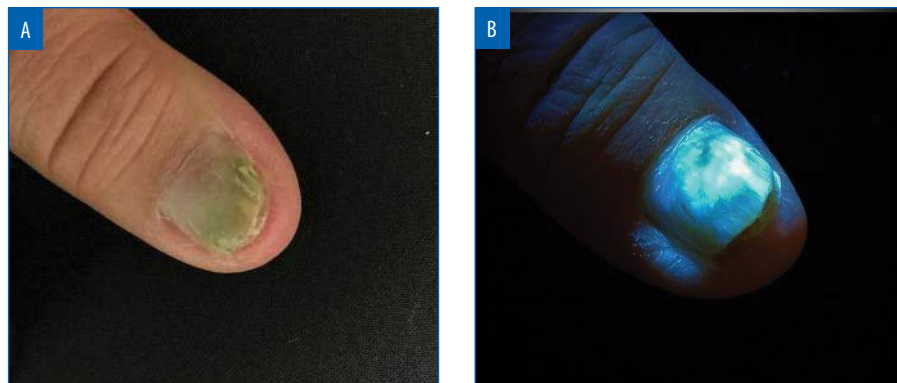


FIGURE 2. Pseudomonas green nail in normal light (A) and under Wood's lamp (B). Green fluorescence can be seen under Wood's lamp.



FIGURE 3. *Cutibacterium acnes* on the trunk under Wood's lamp. Orange-red fluorescence can be seen localized to pilosebaceous units. Photo courtesy of Daniel Chang, MD, FAAD.



FIGURE 4. Urine in porphyria cutanea tarda emits a pink to red fluorescence. This specimen was not acidified prior to Wood's lamp examination. Photo courtesy of Brittany Smirnov, DO, FAAD.

the leading cause of tinea capitis in the United States and does not fluoresce.⁴⁰ Therefore, when tinea capitis is suspected, a negative Wood's lamp test does not rule out this infection, and a fungal culture should be performed. *M. ferrugineum* is a prominent cause of juvenile tinea capitis in Russia, Asia, Africa, and Eastern Europe.⁴¹ This dermatophyte also creates a green-yellow fluorescence due to tryptophan metabolite accumulation.⁴¹ Another common superficial fungal skin infection is pityriasis versicolor, also known as tinea versicolor, caused primarily by *Malassezia globosa*. Wood's lamp displays a yellow-orange fluorescence with tinea versicolor infections due to the porphyrin pityrialactone.^{42,43} Wood's lamp has limited utility with diagnosing onychomycosis since dermatophytes, yeasts, and nondermatophyte molds are all causative agents, and the most common culprits do not fluoresce.⁴⁴ Pigmentary disorders are a standard purview for Wood's lamp diagnosis. Skin devoid of

melanin fluoresces brightly. In particular, the depigmentation of vitiligo appears strikingly white and sharply delineated under a Wood's lamp.² Nevus depigmentosus, a misleading appellation, is often hypopigmented, and thus shows only a dull, off-white glow with Wood's lamp.⁴⁵ Similarly, the hypopigmented macules of tuberous sclerosis complex (TSC) can also be accentuated by Wood's lamp. These elliptical or lancinate macules, termed ash-leaf spots, are more apparent under a Wood's lamp.⁴⁶ Whenever there is a history of TSC in a family, a newborn should receive a complete skin examination with a Wood's lamp to screen for ash-leaf macules.⁴⁶ Wood's lamp effectively magnifies hypopigmentation that the unaided eye can miss otherwise.

A Wood's lamp aids in the evaluation of linear scleroderma and morphea, considering active areas contain loss of pigment.^{47,48} Under Wood's lamp, a new plaque of morphea can be detected before induration is appreciable. Similarly, expanding scleroderma might be detected earlier with Wood's lamp.⁴⁹

Apart from diagnosing and delineating disorders of hypopigmentation, Wood's lamp has further particular use in vitiligo: to assess disease stability, to aid in skin graft harvesting, and to gauge success of surgical grafting itself. A stable disease state is a prerequisite for successful vitiligo surgery and is characterized by sharply demarcated borders.⁵⁰ Repigmentation after skin grafting procedures may be easily and inexpensively assessed using Wood's lamp.⁵⁰ One pilot study utilized Wood's lamp as an ultraviolet source to improve the speed and quality of suction blister harvesting for use in vitiligo; however, its authors did not enumerate technical parameters, including fluence, of the Wood's lamp device used. Further, they noted that induction of blisters might have been associated with heat, not UV light, produced by the Wood's lamp.⁵¹

Wood's lamp assists in diagnosing hyperpigmentation disorders, such as melasma. There is an increase in melanin in the epidermis and/or the dermis with melasma.⁵² When using Wood's lamp, epidermal melasma will appear as a sharply circumscribed brown or black patch, and dermal melasma will appear unaccentuated grey-blue.⁵³ Knowing the depth of melanin deposition may help tailor an appropriate treatment regimen.

Wood's lamp has distinctive findings in some cutaneous porphyrias, which arise from enzymatic defects in heme synthesis and subsequent accumulation of photoreactive precursors called porphyrins in tissue, blood, urine, and stool.² Diagnosis of a specific porphyria in modern medicine may utilize biochemical analysis to identify a specific porphyrin and its ratio in blood, urine, or feces, as well as genetic analysis to identify the specific mutation underlying an enzyme defect. Historically, however, Wood's lamp highlighted the presence of porphyrins as a classical screening test. Specifically, the porphyrins produced with porphyria cutanea tarda (PCT) fluoresce pink or orange-red in urine and feces under Wood's lamp (Figure 4). Urine specimens should be shielded from light, and acidification with undiluted acetic acid may enhance fluorescence.^{2,54-55} Hepatoerythropoietic porphyria, as a biallelic form of PCT, has a more severe phenotype and striking Wood's lamp

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findings, including fluorescent red blood cells and erythrodonia.⁵⁶ Congenital erythropoietic porphyria can present with red or violet wet diapers, intense photosensitivity, and similarly fluorescent erythrodonia; urine, blood, and teeth fluoresce bright coral, due to massive amounts of uroporphyrin I and coproporphyrin I.^{2,57-58} Skin, teeth, nails, and urine in patients with erythropoietic protoporphyria fail to fluoresce, though affected erythrocytes will.⁵⁹

Lastly, Wood's lamp is utilized in many miscellaneous cutaneous conditions. In particular, the diagnosis of solar urticaria includes exposure to UVA light to produce a reaction, so a Wood's lamp is commonly used.⁶⁰ A common condition seen in dermatology is milia; which are small cysts caused by retention of keratin in the dermis.⁶¹ The keratin produces a bright yellow fluorescence under Wood's lamp; thus, milia can be differentiated easily from other minute facial papules.⁶¹ Finally, one study asserts that a Wood's lamp can delineate among porokeratosis, granuloma annulare, and lichen planus annularis. Granuloma annulare fluoresces blue-black at the center and red on the edges; lichen planus annularis fluoresces blue-black without a ring structure; porokeratosis fluoresces blue-brown at the center and white on the edge, resembling a diamond.¹⁸

SURGICAL APPLICATIONS

Determination of appropriate surgical margins can be aided by Wood's lamp.⁶² To answer this question when removing lentigo maligna melanomas, Wood's lamp is used to outline the borders and excise the full lesion.⁶² This method will accentuate the hyperpigmentation in the epidermis of the lesion. When trying to take the narrowest margin, the Wood's lamp is an excellent additional step. In a study, Wood's lamp was used to delineate the margins before surgical resection of lentigo maligna. In this particular study, only one of the 16 patients had a recurrence of melanoma eight years after surgery and most lesions were resected with a margin of 0.6 to 1.0 cm.⁶³ Along with using Wood's lamp to delineate neoplastic lesional margins, there is a new pre-operative technique that allows surgeons to only take damaged tissue and keep as much healthy skin as possible. Photodiagnosis uses methyl aminolevulinate (MAL) cream as a phosphor when applied to patients with basal cell carcinoma (BCC) and then this is fluoresced with Wood's lamp.⁶⁴ The bright red fluorescence is the main area of cancerous tissue, but there is also

a fainter fluorescence termed the "gray zone."⁶⁴ Photodiagnosis has allowed surgeons to achieve radical excision in 90 percent of patients by taking the gray zone, without taking too much tissue.⁶⁴ Wood's lamp is valuable in surgical procedures when visualizing cancerous margins.

MEDICAL APPLICATIONS

Superficial chemical peels are used frequently in dermatology to address lentigines, rhytides, keratoses, comedonal acne, and dyschromia.⁶⁵ Wood's lamp can be used after applying a chemical peel to avoid missing or over-treating areas on the skin.⁶⁵ Salicylic acid and fluorescein sodium both can be added to chemical peels to create fluorescence. These two peels produce two different fluorescence; salicylic acid creates a green fluorescence, and the fluorescein sodium peel is a yellow-orange color.⁶⁵ Wood's lamp can also be used before and after applying the peel to measure its effectiveness based on the depth of pigment.⁶⁵ Similarly, Wood's lamp is also able to assess the proper application of sunscreen, especially in relatively inaccessible areas such as the back.^{66,67} Wood's lamp is advantageous when evaluating patient adherence to tetracycline by examining the toenails for yellow fluorescence.⁶⁸ Dihydroxyacetone (DHA) is a chemical in sunless tanning cosmetics and is often used to cover vitiligo lesions.⁶⁹ Wood's lamp can determine the actual size of vitiligo lesions, as DHA fluoresces a salmon color and vitiligo lesions are bright blue-white.⁶⁹

CONCLUSION

Wood's lamp is an inexpensive yet invaluable asset in a dermatologist's arsenal. It is easy to use, safe, cost effective, and yields rapid results. Its utility in dermatology encompasses superficial infections, pigmentary disorders, and metabolic diseases. It also has many practical applications in cutaneous surgery and cosmetics. Although it has been over a century since its invention, the Wood's lamp is a valuable tool in dermatology, helping to reveal the unseen.

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