ATTACHMENT 2

In vitro Critical Wavelength (λ_c) determination

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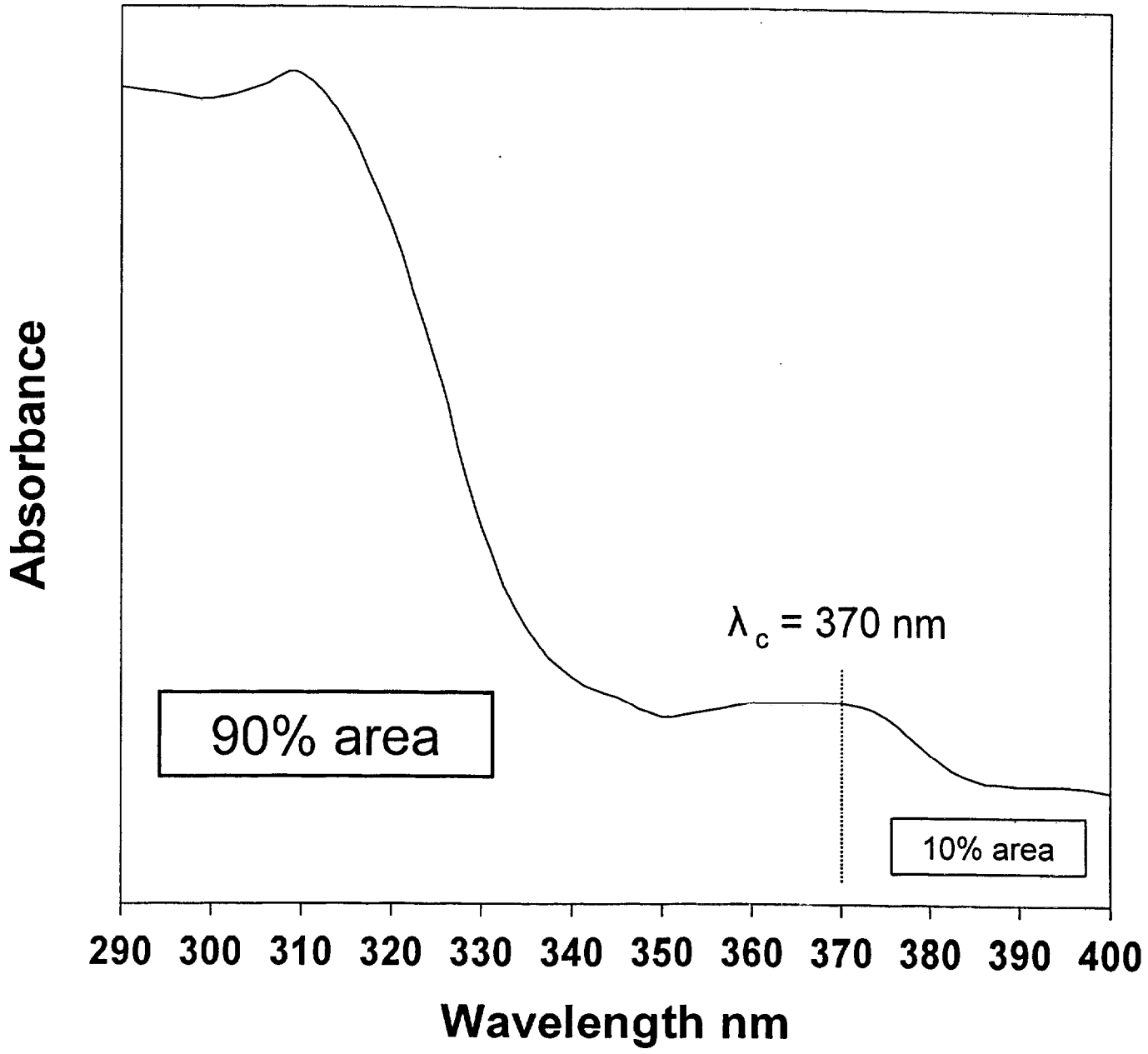
Development of Critical Wavelength Method

- **Developed in 1994***
- **Rationale for method:**
  - absorption spectrum of sunscreen is most relevant attribute
  - 2 key features of absorbance curve: amplitude and width
    - *in-vivo* SPF determination essentially measures amplitude
    - proposed simple single index to characterize width
- **Method Description**
  - determine that wavelength (λ_c) below which 90% of sunscreen's UV absorbance occurs

*Diffey, BL. (1994) A method for Broad Spectrum Classification of Sunscreens. *Int. J Cosmet Sci.* **6:** 47-52.

The Critical Wavelength



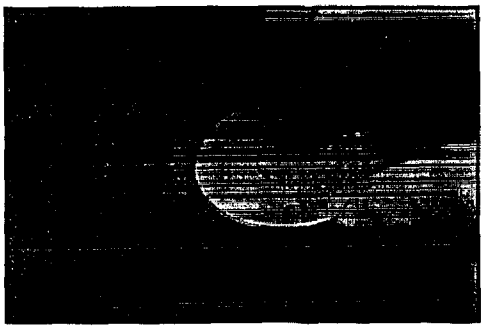
Critical Wavelength and Protection Factors

- Critical wavelength depends **only** on extinction coefficients of sunscreen active ingredients - breadth of protection

- Protection factors (SPF, mPF, UVA PF) depend on both extinction coefficients **and** application thickness - amplitude of protection

Ex vivo determination of sunscreen absorbance

Obtain waste skin from surgery

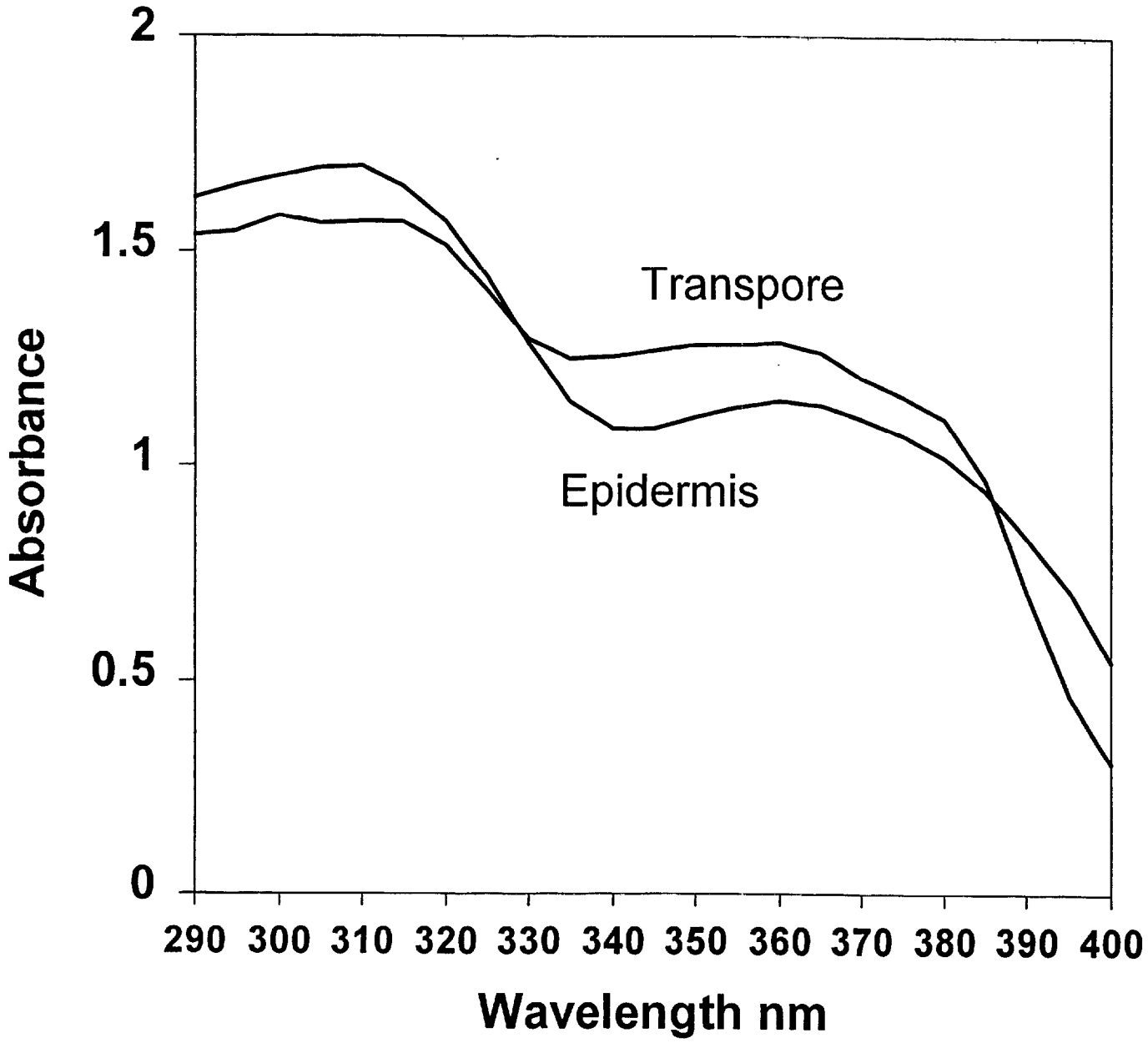


Apply sunscreen

Measure SPF *in vitro*

SPF30 sunscreen

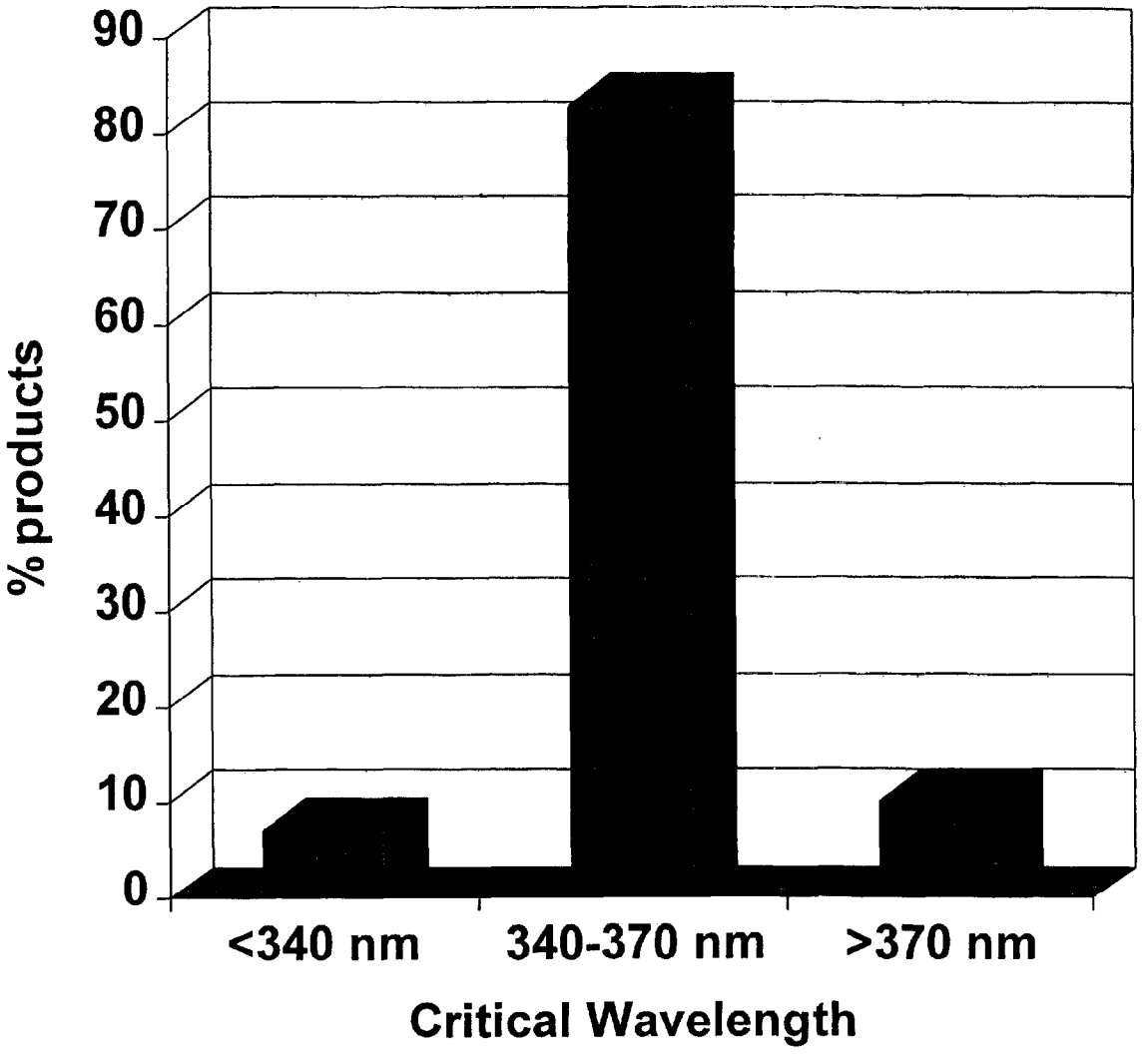
λ_c 381nm on epidermis
λ_c 380nm on transpore



Market Classification Study

- Design
  - determined λ_c for 59 commercial sunscreen products marketed in US
  - SPF ranged from 4 to 45
  - daily use and recreational products
  - creams, lotions, oils

Market Classification of 59 sunscreens

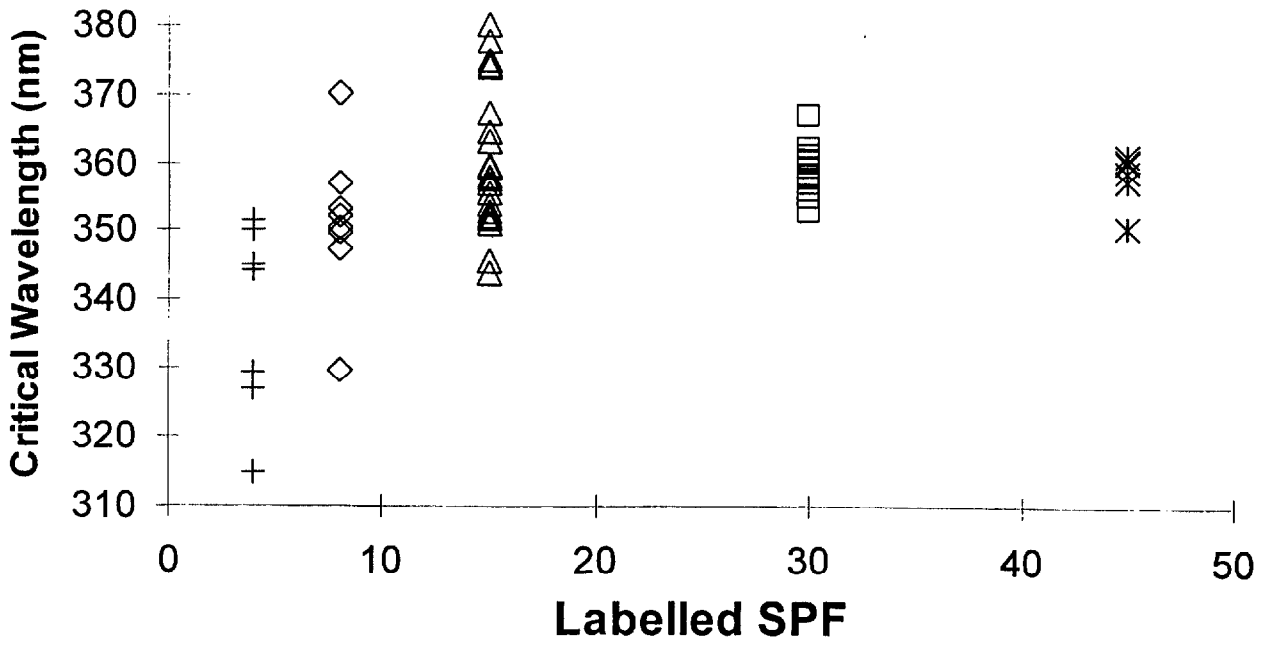


Market Classification Study

- **Results**
  - **93% of products achieved λ_c > 340 nm**
    - 98% of SPF 8 to SPF 45 products achieved λ_c > 340nm
    - only 10% of products achieved λ_c > 370nm
  - **a UVA-I active is necessary, but not sufficient to achieve λ_c > 370nm**
    - all products with λ_c > 370nm contained a UVA-I active
  - **27% contained a UVA-I active but only 10% achieved λ_c > 370nm**

Market Classification Study

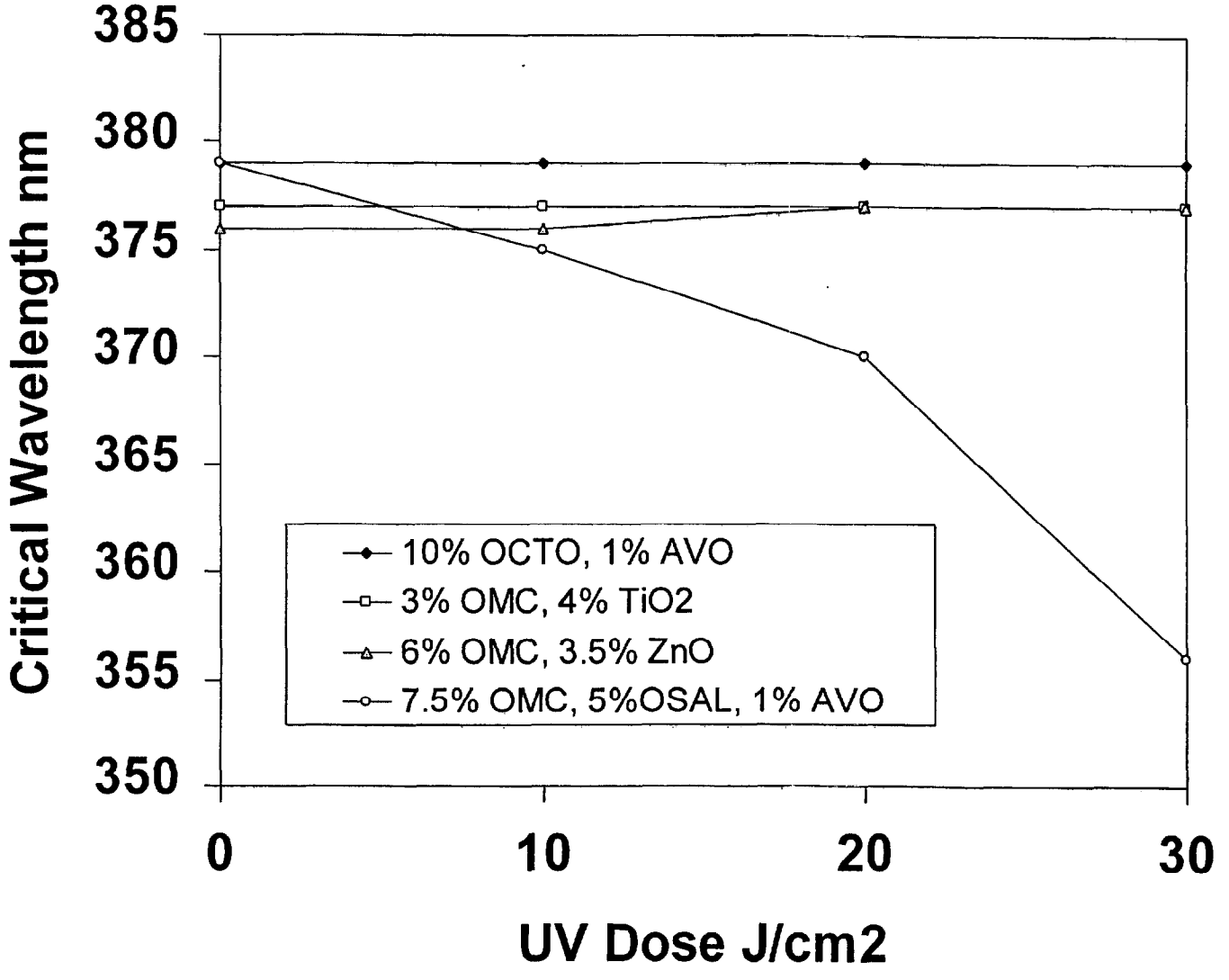
- Analysis of variance (for SPF>4) showed no association between λ_c and labelled product SPF



Can critical wavelength account for product photostability?

- Study Design
  - 4 model SPF 15 sunscreens with different sunscreen combinations
  - assess λ_c initially and after various doses of broad spectrum UV
  - for photostable systems, UV irradiation does not change λ_c
  - UV irradiation changes λ_c for systems that are not photostable

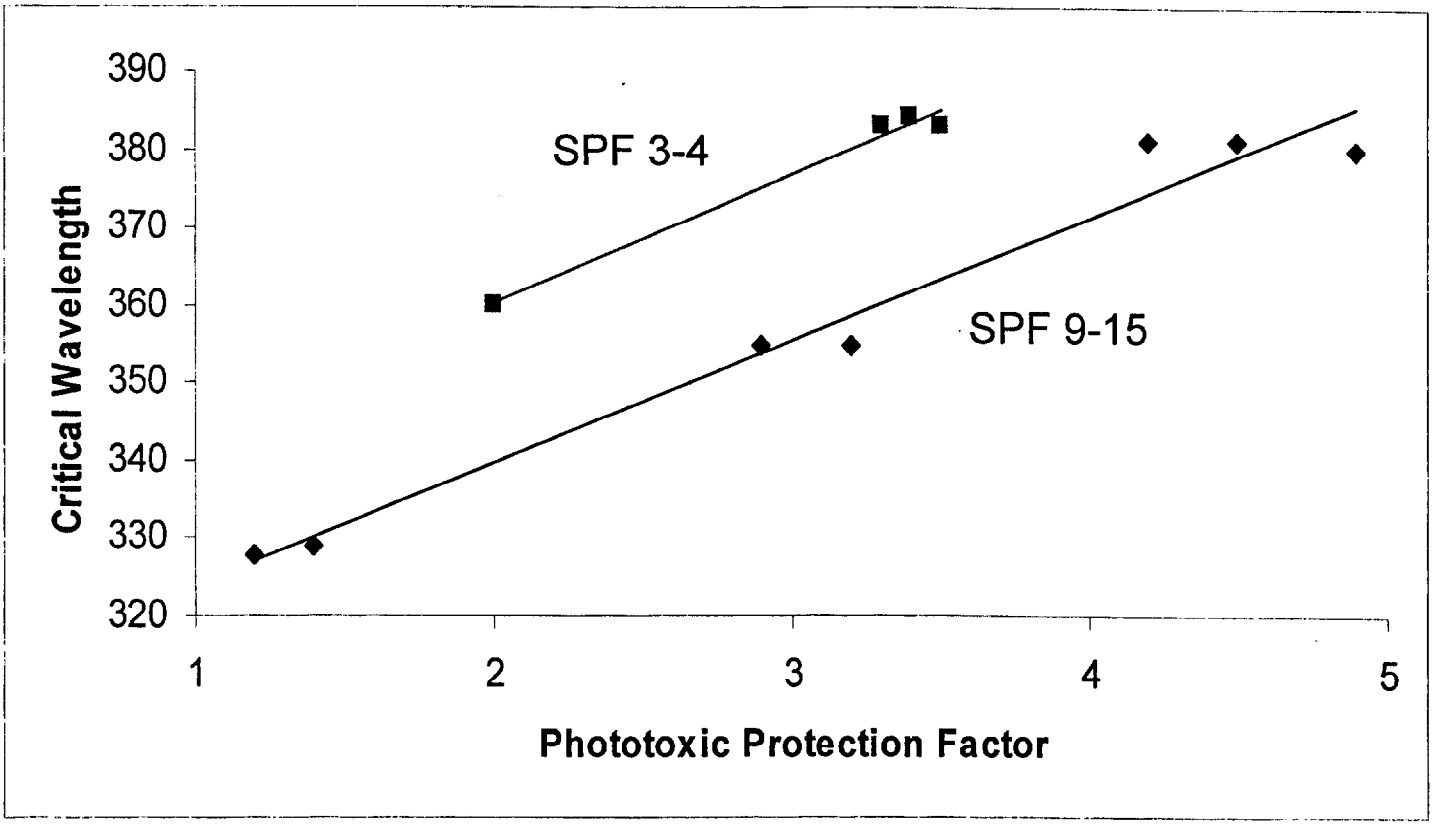
Can critical wavelength account for product photostability?



Does critical wavelength agree with *in-vivo* UVA efficacy?

- **Study Design**
  - ***in vivo* UVA data from published literature**
    - phototoxic protection factor (PPF) data
  - **3 different data sets**
    - made model sunscreen creams with same sunscreen actives
  - **determined λ_c and compared to *in vivo* PPF data**

λ_c and PPF are correlated when SPF accounted for



In vivo UVA assay: is it relevant?

- biological end-points of dubious relevance to chronic effects
- UV source spectrum of no natural significance

In vivo UVA assay: is it ethical?

- modern sunscreens require skin exposures of several 100 J/cm^2 to induce pigmentation/erythema
- non-uniformity of sunscreen over test area means some melanocytes exposed to very high doses (>>100 J/cm^2) UVA i.e. high-dose, intermittent exposure
- is this ethical?

Summary

Critical Wavelength method

- provides a measure of the breadth of UV photoprotection (i.e. UVA efficacy)
- is a reproducible, straight-forward measure that is inexpensive and eliminates the need for human testing
- when combined with *in vivo* SPF, provides the necessary depth and breadth description of sunscreen products
- avoids the need for high-dose UVA exposure *in vivo*

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74 Commerce Drive

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