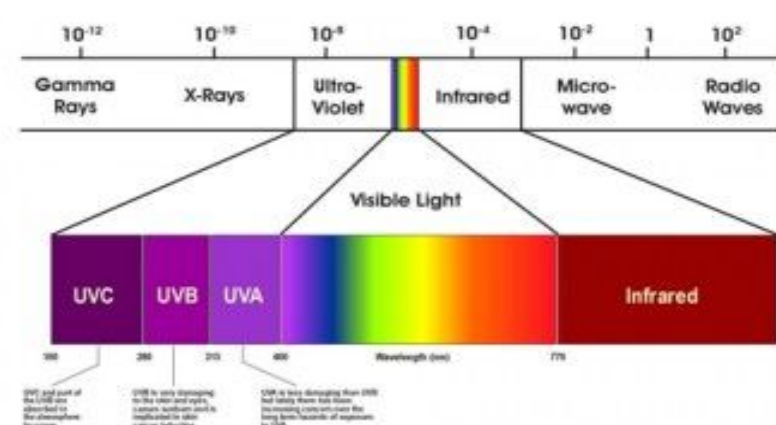


# Designing an Effective Novel Sunscreen Molecule: Proposed Synthesis of (2E,4E)-1-(4-Amino-2,6-Dimethoxyphenyl)-3,5-Dicyclohexylpenta-2,4-Dien-1-one

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## Background

- Need
  - Prevents skin damage and lowers skin cancer risk by absorbing sun's harmful UV radiation
  - Ozone layer is currently depleting and body needs additional protection
  - Prevents premature aging of skin and maintains even skin tone
- Overexposure
  - Induces DNA damage
  - Premature skin aging
  - Skin cancer
- 15 FDA Approved Sunscreen Ingredients
- Improvements
  - Large data gaps (toxicology)
  - Mechanism of action are not yet fully understood
    - Conduct more research
- Inorganic: physically deflect light away from the skin; Organic: absorbs harmful UV rays using a 3 step mechanism
- UV-Vis Spectrometers
  - Establishes transmittance ratio ( $I/I_0$ ) or %T
  - Translated into absorbance values
  - What wavelengths are absorbed ( $\lambda$  max)
  - Extent of conjugation



## Structural Features

- UV-Vis spectra of sunscreen molecules homosalate, oxybenzone, octyl 4-methoxy cinnamate, PABA, and avobenzone
  - Belong to different classes, protect from varying wavelengths of light, absorb rays at different ranges and vary in  $\lambda$  max values
- Functionality
  - Carboxylic acid : hydrogen bond acceptors (carbonyl group) and donors (hydroxyl group)
  - Nitrogen atoms (amine groups): H bond donors (lone pairs) and acceptors (H)
  - Aromatic ring: hydrophobic and electron rich
  - N atoms in ring: hydrogen bond acceptors (lone pairs)
- Conjugation
  - $\uparrow$  conjugation =  $\downarrow$  energy gap
  - HOMO-LUMO = Longer absorbed wavelength
  - OCH<sub>3</sub> similar to CH<sub>3</sub> group attached to ring (HOMO-LUMO gap)
- Benefits of Theoretical Assessment
  - Powerful prediction ability, no associated health risk or synthesis, time-saving, inexpensive

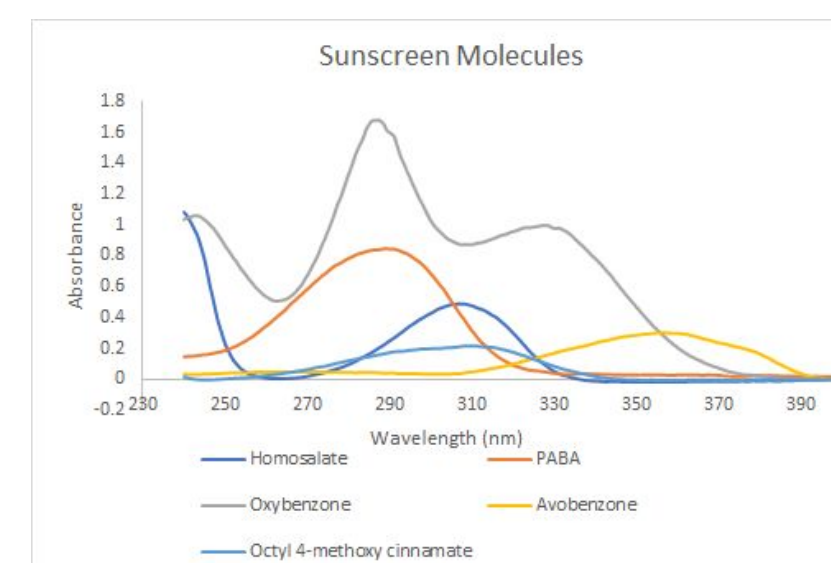
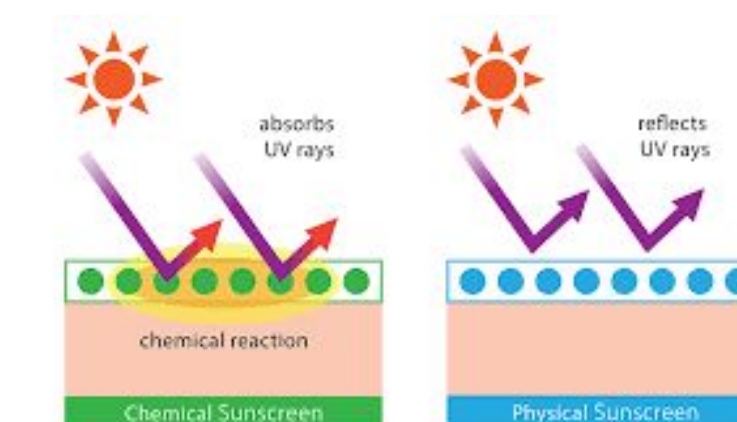


Figure1: This graph illustrates the relationship between the observed absorbance and wavelength ( $\lambda$  max values) of 5 common organic sunscreen molecules

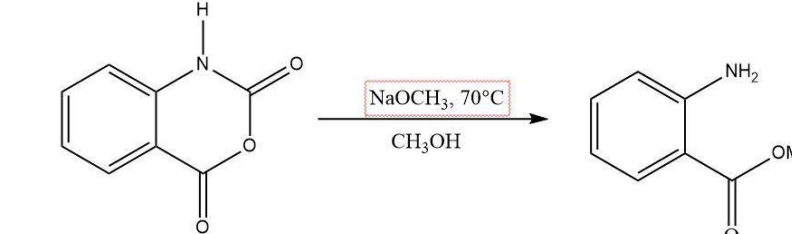
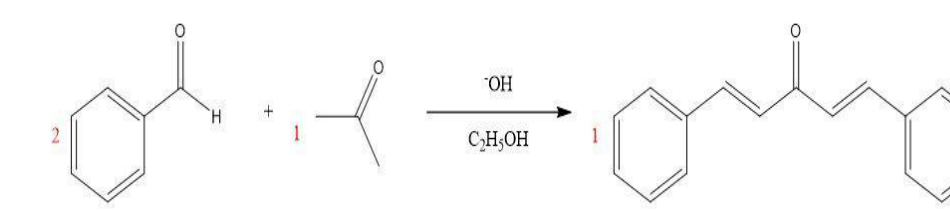
## Critical factors in designing Sunscreens

- Hydrophobicity
- Structure's extent of conjugation and  $\lambda$  max value
- Toxicity
- Heat Resistance
- Stability to sun
- Safety
- Relative permeability
- Smell



## Comparison of DBA and MA

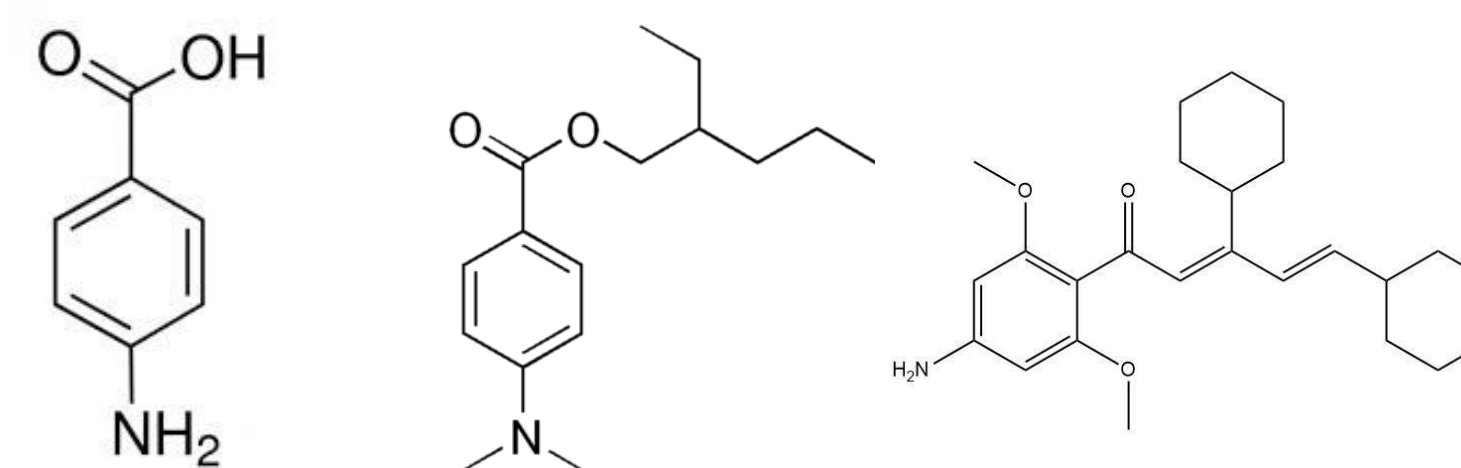
- Dibenzylidene Acetone (DBA)**
  - Percent Yield: 144.7%
  - Actual (2.069g)/Theoretical (1.429 g)
  - Properties
    - Pros
      - Easy to synthesize
      - Absorbs at good wavelength
      - Strong absorption properties
    - Cons
      - Irritant
      - Environmental Hazard
      - Toxic to Aquatic Life
- Menthyl Anthranilate (MA)**
  - Properties
    - Pros
      - Simple synthesis
      - Water and oil soluble
      - pleasant grape odor
      - Many lone pairs and absorbs at higher wavelengths
    - Cons
      - Irritant
      - Low extinction coefficient



## (2E,4E)-1-(4-Amino-2,6-Dimethoxyphenyl)-3,5-Dicyclohexylpenta-2,4-Dien-1-one

Mainly water insoluble in nature

- Absorbs at 320 nm (a good wavelength) using Woodward-Fieser's rule
  - Amine and Ether functional groups (LG reaction and DNA)
  - UVA (320-400 nm) and UVB (280-320)
- Has strong absorption properties
- Started with aromatic template and added further conjugation
- Easy to synthesize



Sunscreen	$\lambda$ max non-polar solvent	$\lambda$ max polar solvent	Extinction Coefficient $\epsilon$
PABA	293	266	13600
Octyl dimethyl PABA	300	316	28400

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