# Biomechanical Impact of Vitamin Species on Human Stratum Corneum


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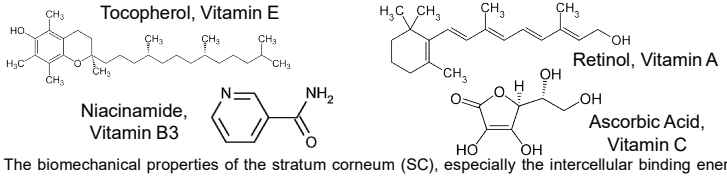
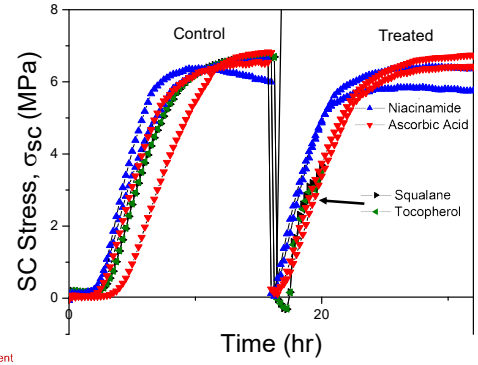
## Motivation

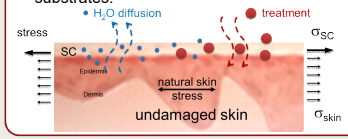



The biomechanical properties of the stratum corneum (SC), especially the intercellular binding energy of corneocytes and drying stress response, have only recently begun to be understood. These properties are critical in determining the tactile impression and efficacy of topical treatments. As such, quantifying the impact of common ingredients such as vitamin species is beneficial for developing improved formulations. Here, we examine the role of vitamins A, B3, C, and E in the biomechanical response of the SC.

## 5% (w/w) Solutions – Drying Stress

- Rate and magnitude of drying stress are dominated by water and squalane carriers.
- Rate of stress development indicates rate of water volume loss from the SC. This data suggests that topical vitamin treatments have little impact on water loss through the SC.
- Plateau stress is governed by the load bearing properties of the intercellular keratin fibrils. Topical vitamin treatments do not appear to alter the tensile capacity of the keratin.
- Squalane carrier disrupts the adhesion of the tissue to the glass substrates.



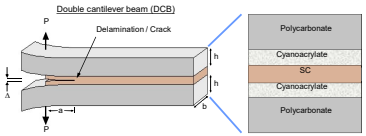




Peak stress and stress rate unaffected after treatment.

## Techniques

- A double cantilever beam (DCB) method is used to quantify decoesion energy, $G_c$
- Corneocyte decohesion is achieved through repeated load/unload cycles.

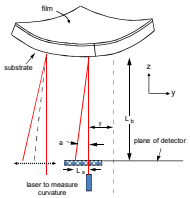
Repeatable, quantifiable insight into corneodesmosome and lipid binding




Corneocyte decohesion if: $G \geq G_c = \frac{12 P_c^2 a^2}{b^2 h^3 E'}$

- A thin-film substrate curvature technique is used to measure development of drying stress.
- Parallel incident lasers measure changes in the curvature of a glass substrate.
- Biaxial stress state is then calculated via Stoney's equation.

Requires only elastic properties of substrate, thickness of tissue




$$\Delta\sigma_{film} = \left(\frac{E_{sub}}{1-\nu_{sub}}\right)\frac{t_{sub}^2}{6\,t_{film}}\Delta\kappa$$

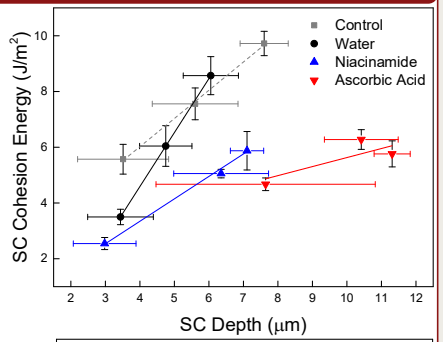
### Treatments:

- For isolated vitamin tests, 20 minute soak in water (for niacinamide and ascorbic acid) or squalene (for tocopherol) with 5% (w/w) vitamin species
- For tests with o/w emulsions, 2 hour topical exposure followed by removal of excess surface cream

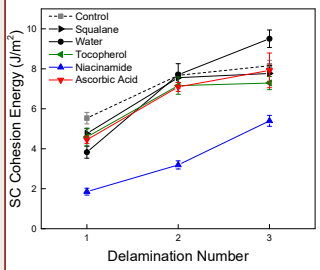
## 5% (w/w) Solutions – Cohesion Energy

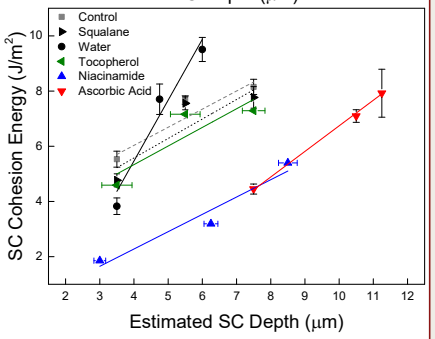
- Water reduces Gc in upper layers of tissue where corneodesmosomes (CDs) are partially degraded.
- Niacinamide reduces Gc at all depths.
- Vitamin C (pH 2.4) strips the top layers of tissue and substantially reduces Gc at all depths.
- Removal of NMF or degradation of CDs can both contribute to large reductions in intercellular cohesion.

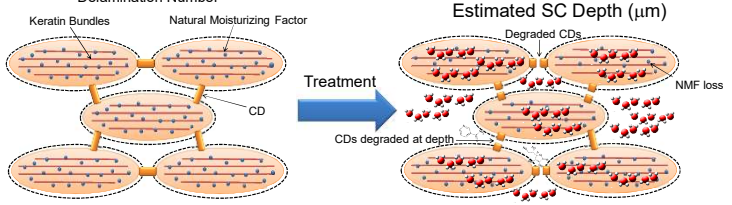
Niacinamide and ascorbic acid substantially reduce corneodesmosome binding at all depths




- New depth measurements allow additional insight from prior data



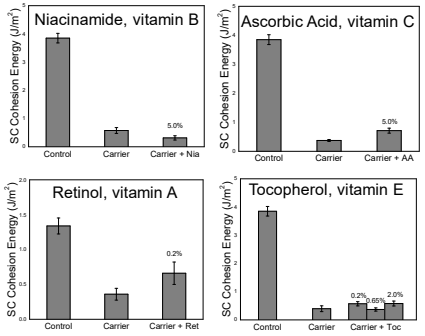




## Creams – Cohesion Energy

- Vitamins were also tested in complex moisturizing carriers
- In each case, cohesion effects were dominated by the formulations
- Vitamins did produce small variations when added to the carrier creams
- Tocopherol was tested for dose dependence, but no systematic trend was observed.
- Future work will include depth studies to further elucidate impacts with formulated vitamins.

Upper tissue layer cohesion dominated the cream, low impact of vitamins in formulation




## Acknowledgements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