PHOTOPOLLUTION: SYNERGY BETWEEN UVA AND POLLUTANTS

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UVA ARE PRESENT EVERYWHERE, ALL SEASONS

UVA (75% LONG UVA) ARE MOSTLY PRESENT IN UV RADIATION AND PENETRATES DEEPER IN DERMIS.

UVA MOSTLY CONTRIBUTE TO DAILY UV SKIN BIOLOGICAL DAMAGES (80% IN EPIDERMIS/ 97% IN DERMIS)

- Human skin pigmentation as an adaptation to UV radiation. Jablonski N, PNAS 2010
- Diversity of biological effects induced by longwave UVA rays (UVA1) in reconstructed skin. Marionnet C. et al., PLOS one 2014
80% OF VISIBLE CLINICAL SIGNS OF SKIN AGING ARE DRIVEN BY SOLAR EXPOSURE

INDUCING OXYDATIVE STRESS & DNA DAMAGES, INFLAMATION

AFFECTING DERMAL BREAKDOWN (MMP1, Elastase)

- Effect of the sun on visible clinical signs of aging in caucasian skin. Flament F. et al., Clinical, Cosmetic and investigational Dermatol, 2013
- Solar exposure (s) and facial clinical signs of aging in Chinese women: impacts upon age perception. Flament F. et al., Clinical, Cosmetic and investigational Dermatol. 2015
- Dermal damage promoted by repeated low-level UV-A1 exposure despite tanning response in human skin. Wang et al., JAMA Dermatol 2013
- Diversity of biological effects induced by longwave UVA rays (UVA1) in reconstructed skin. Marionnet C. et al., PLOS one 2014
- Different oxidative stress response in keratinocytes and fibroblasts of reconstructed skin exposed to non extreme daily-ultraviolet radiation. Marionnet C. et al., PLOS one 2010

Skin & Environmental Exposure
....2nd Territory: Air Pollution....

What are we talking about?

Particulate matter

Skin & Environmental Exposure

OMI/MLS Tropospheric Column Ozone ( Dobson Units) - July 2013

PM$_{2.5}$, PM$_{10}$, NO$_2$, NO$_x$, O$_3$, SO$_2$
Air pollution’s composition is different regarding the Area

- Seasonality impact: PM 10 > in winter / O3 > in summer

Geographical variability, daily fluctuations, weekly, seasonal, and annual cycles
Historical clinical data

More than 15 years of research at L’Oréal

Consequences on skin homeostasis?
Cutaneous modifications?
On a long term basis, on skin aging?
In 2000 first Multicenter Study
96 subjects

Evaluation of the impact of urban pollution on the quality of skin. A multicenter study in Mexico. Lefebvre M.A et al., IJCS, 2015, 1-10
In 2008 second Multicenter Study
80 subjects
Samples of stratum corneum, Skin secretion
Consumer evaluation (5-points scale related to skin quality)

Consequence of urban pollution upon skin status.
A controlled study in Shanghai area. Lefebvre M.A et al., IJCS, 2016 Jun;38(3):217-23
## MAIN RESULTS

### MEXICO MULTICENTER STUDY
- Reduced Skin hydration
- Barrier function alteration
- Higher frequency of atopy
- Increase of oily skin
- No gender difference
- Increase of Squalen oxydation
- Decrease of vitamin C & E
- Reduced pH

### SHANGHAI MULTICENTER STUDY
- **Oxydation process:**
  - Increase of lactic acid
  - Decrease of Squalen content
- Reduced **desquamation**
- **Consumer evaluation:**
  - Skin look worse – dryer – more sensitive
Mechanism of pollution stress

Evaluation models

EX VIVO MODEL USING CIGARETTE SMOKE

IN VITRO NHK/HRS MODELS USING SOLAR SIMULATOR/PME/PAH/O₃

NHK: Normal Human keratinocytes
HRS: Human Reconstructed Skin

Skin & Environmental Exposure
Mechanism of pollution stress
Evaluation models

1\textsuperscript{RST}: EFFECT AT THE SURFACE LEVEL

Stratum corneum
Living epidemis
Blood circulation

Sebum

PM / PAH
O\textsubscript{3}, NO\textsubscript{2}, SO\textsubscript{2}, PM...

75\text{-}80\% Long UVA
Mechanism of pollution stress

First evidence for a deleterious effect of pollutants on oxidative stress

Sebum → squalene

**NEW EX VIVO EVALUATION MODEL USING CIGARETTE SMOKE**

- **Decrease of squalene content**
- **Increase of squalene peroxidation**

UVA rays → Particulate Matter → Peroxidized Squalene?

Skin & Environmental Exposure
Mechanism of pollution stress

Catalytic-like effect of pollutants (cigarette smoke model) on UV

FIRST DEMONSTRATION OF A SYNERGISTIC DELETERIOUS EFFECT OF POLLUTANTS AND UV RADIATION ON SKIN

“PHOTOPOLLUTION”

Increase of squalene peroxidation

Mechanism of pollution stress
Evaluation models

2ND: EFFECT AT THE CELLULAR LEVEL

IN VITRO NHK/HRS MODELS USING SOLAR SIMULATOR/PME/PAH

NHK: Normal Human keratinocytes
HRS: Human Reconstructed Skin

Skin & Environmental Exposure

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Mechanism of pollution stress

Particulate matter
a major contributing factor

Particulate Matter (PM): Decorated with polyaromatic hydrocarbon (PAH), heavy metal, ionic compounds...

In vitro Evaluation

Solar simulator

NHK

PME or PAHs

Polycyclic Aromatic Hydrocarbons (PAHs)

Indeno c,d pyrene (IcdP)

Benzy (a) pyrene (BaP)

Most common PAHs among 16 PAHs classified by the U.S. EPA agency

Particulate Matter and Particulate Matter Extract

<table>
<thead>
<tr>
<th>Index</th>
<th>Compound</th>
<th>Mass Fractions (mg/kg) (a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenanthrene</td>
<td>$^{b,c}$</td>
<td>8.00 ± 0.20</td>
</tr>
<tr>
<td>Fluoranthene</td>
<td>$^{b,c}$</td>
<td>13.5 ± 0.6</td>
</tr>
<tr>
<td>Benzo[e]anthracene</td>
<td>$^{b,d,e}$</td>
<td>0.092 ± 0.015</td>
</tr>
<tr>
<td>Chrysene</td>
<td>$^{c,d,e}$</td>
<td>1.95 ± 0.07</td>
</tr>
<tr>
<td>Triphenylene</td>
<td>$^{c,d,e}$</td>
<td>2.38 ± 0.10</td>
</tr>
<tr>
<td>Benzo[b]fluoranthene</td>
<td>$^{c,d,e}$</td>
<td></td>
</tr>
<tr>
<td>Benzo[k]fluoranthene</td>
<td>$^{c,d}$</td>
<td></td>
</tr>
<tr>
<td>Benzo[e]pyrene</td>
<td>$^{b,d}$</td>
<td>0.268 ± 0.023</td>
</tr>
</tbody>
</table>

Particulate Matter Extract (PME): Ref: SRM 1975; NIST

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While PME absorb mostly in UVB domain, PME phototoxicity under daily-UV = PME phototoxicity under long UVA

Absorption spectrum of Particulate Matter extract

Phototoxicity of KHN exposed to PM+ UVA1 or daily-UV (d-UV) at 7.5 J/cm²
Keratinocytes were exposed with PAH+ Long UVA (7.5 J/cm²).
Oxidative stress was measured with DHR 123 immediately after exposure.

### Non photo-toxic concentrations BaP and IcdP exacerbate Long UVA-induced oxidative stress

Keratinocytes exposed with PAH before UVA1 (7.5 J/cm²). GSH content measured 5h after PAH+UV exposure.

Combination of PAH (IcdP) and long UVA decrease GSH intracellular concentration.

Reconstructed skin was exposed 16h each day (x3) before UVA1 exposure. Measure of viability 24h after last UV exposure.

Confirmation of the synergistic deleterious effect of Long UVA & Particulate matter

Photopollution

Beneficial effect of long UVA filter

Long UVA filter improves the photo-protection of classical sunscreen

J. Sœur et al., Unpublished data.
Anti-Oxidant protect from O₃-induced cytotoxicity, ROS levels, lipid peroxidation and inflammation

Mix 1: 15% vitamin C + 1% vit. E + 0.5% Ferulic acid
Mix 2: 10% Vit. C + 2% Phloretin + 0.5% Ferulic Acid
Mix 3: 1% resveratrol + 1% vit. E + 0.5% Baicalin

Ozone-induced damage in 3D-Skin Model is prevented by topical vitamin C and vitamin E compound mixture application. G. Valacchi et al., J. Derm Science, letter to editor, 82:204-214, 2016.
Effect of particulate matter:
Synergy with long UVA on
- Squalene peroxidation
- Keratinocyte toxicity
- Cellular oxidative stress
- Epidermal morphological alterations
- Intracellular GSH decrease

Effect of ozone:
Secondary pollutant produced under UV/heat
- Oxidative stress: ROS production, peroxidation
- Inflammation

Beneficial effect
- Long UVA filtration

Beneficial effect
- Antioxidant mix
  Vitamin C, E, Phloretin, Baicalin, Resveratrol, Ferulic acid.
SPECIFIC 3 STEPS COSMETIC ROUTINE

PURIFY
• CLEANER TO CLEAN OFF POLLUTANT FROM SKIN

REPAIR
• EMOLLIENT TO PRESERVE & RESTORE SKIN BARRIER

PROTECT
• UV FILTER TO BLOCK LONG UVA RADIATION
• ANTI-OXIDANT TO PREVENT OXIDATIVE STRESS
• ANTIADHESION FORMULATION AGAINST POLLUTANTS

Pollution and skin: From epidemiologic and mechanistic studies to clinical implication. J. Krutmann et al., Arch Derm Research, 2014
.... And the future will be ....get connected – get protected

MEASURE ENVIRONMENTAL STRESSES

Wearable and flexible electronics

CHANGE BEHAVIOURS

- ADAPT ROUTINE REGIMEN TO YOUR SKIN
- KEEP YOUR SKIN HEALTHIER LONGER

Stretchable Sensor
Anywhere on the skin

App- Education
Recommendations

Skin & Environmental Exposure
WEARABLE CONNECTED

Clairity Tzoa

Plume Air Cube

MINIATURIZED WEARABLE CONNECTED MULTIPARAMETRIC

Particulate matter: PM 10, PM 2.5,

Gaz: VOC, NO₂, O₃, CO₂,

Weather conditions: temperature, humidity,

Sun exposure: UV, ambient light,

Air pollution devices to measure & monitor exposure

…. Exposure measurements …. Already a reality ….