AIR POLLUTION AND ITS IMPACT ON SKIN

EXPOSURE to the elements is of paramount interest to the cosmetics and cosmeceutical industry. Sun and air pollution, both indoor and outdoor, deserves closer inspection. The subject of air pollution and its effect on the skin in particular warrants a closer in-depth review of actual pollutants, their sources, their quantification, regulations, and the immediate and long-term effects of pollutants on the skin. This topic will require two columns; the first column will define the problem of overexposure to air pollution and the elements, and the second column will address the methods and procedures to protect the skin and reduce the impact on public health in general from the damaging effects of air pollutants.

Air pollution is the introduction of harmful materials into the Earth's atmosphere resulting in potential pathologies and death in human populations, as well as potential damage to other life, such as food crops, herds, and ecosystems and/or "built" environments. Indoor and urban air pollution are two of the world's worst toxic pollution problems according to the Blacksmith Institute's "World's Worst Polluted Places"[1]

Severe air pollution Feb. 28, 2013 in Beijing, China. Air quality index levels were classed as "Beyond Index" (PM 2.5 over 700 micrograms per cubic meter).

Air Pollutant Classification

Air pollutants may be classified as chemicals, particulates or biological materials, which have adverse effects on organisms and ecosystem, and can be solid particles, liquid droplets or gases.[2] Air pollutants have natural or man-made (anthropogenic) origins and may be classified as:

1) *Primary air pollutants*—directly introduced into the atmosphere from sources such volcanic eruptions, motor vehicle exhaust, or manufacturing smokestacks. Major anthropogenic primary pollutants include:

a) Sulfur oxides (SOx), often produced by fossil fuel combustion and volcanoes. SO2, in the presence of vaporized moisture catalysts, such as nitrogen dioxide (NO2), often forms atmospheric sulfuric acid (H2SO4), thus contributing to acid rain.

b) Nitrogen oxides (NOx), produced by high temperature combustion and electric discharges during thunderstorms. NO2, may also further react in the presence of vaporized moisture to form atmospheric nitric acid (HNO3), thereby contributing to acid rain, such as H2SO4.

c) Carbon monoxide (CO), a colorless, odorless, non-irritating, yet highly toxic, gas produced by incomplete combustion of organic fuels, such as petroleum, coal and wood; e.g., forest and grassland fires.

d) Volatile Organic Compounds (VOCs), ubiquitous outdoor air pollutants, produced by anaerobic decay of organic matter; e.g., swamp gas, and ruminant digestive processes are classified as either: i) methane (CH4); or ii) non-methane volatile organic compounds (NMVOCs), including the potentially carcinogenic 1,3-butadiene and the aromatic NMVOCs benzene, toluene and xylene.

e) Particulates or particulate matter

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(PM), microscopic atmospheric suspensions of solid or liquid particles, produced by fossil fuel combustion, by volcanoes, dust storms, living vegetation and sea spray.

f) Aerosols, combined PMs and gas, produced by fossil fuel combustion. Global averages of anthropogenic aerosols indicate that they account for 10% of total atmospheric aerosols.

g) Persistent free radicals associated with PMs.

h) Toxic metals, such as lead and mercury, and their derivatives, produced by coal combustion.

i) Chlorofluorocarbons (CFCs), from currently banned products, which destroy tropospheric and stratospheric ozone; i.e., the Earth's atmospheric UV filter.

j) Ammonia (NH3), produced by agricultural processes.

k) Radioactive PMs, produced by nuclear events.

2) *Secondary air pollutants*—formed by the interactions of primary pollutants or secondary pollutant precursors, which are not pollutants in and of themselves. Ground level ozone is an ubiquitous secondary pollutant.

a) Photochemical smog, produced by UV activation of primary PM and gaseous pollutants and their consequent products. Photochemical smog is derived from photoactivated vehicular and industrial emissions and primary smog.

b) Ground level ozone (O3), produced by oxygen and VOC interactions—abnormally high anthropogenically-derived concentrations contribute to the formation of photochemical smog.

c) Peroxyacetyl nitrate (PAN), produced by NOx and VOC interactions. PAN is a thermally unstable secondary photochemical smog constituent, which decomposes into peroxyethanoyl radicals and NO2. A major anthropogenic source of PAN is ethanol added to automotive fuels.

d) Persistent organic pollutants (POPs), organic compounds resistant to chemical, biological, and photolytic environmental degradation, which often attach to PMs; e.g., dioxins and furans. POPs may significantly impact human health and the environment because their persistence; i.e., metastability, enables their: i) long-range transport, ii) bioaccumulation in biological tissue, and, consequent, iii) biomagnification in ecological biocycles. POPs are usually endocrine disruptors and/or mutagens/teratogens.

Although official Environmental Protection Agency (EPA) recognition of air pollution as a health issue was delayed by special interest interference, a 1994 court order obtained by the American Lung Association (ALA) forced an official EPA recognition of air pollution as an pandemic public health threat in 1997.[3]

Fig. 1: Environment Canada Air Quality Health Index (AQHI) Scale[5]

Table 1 : Environment Canada Air Quality Health Index (AQHI) Categories and Health Messages[6]

HEALTH RISK CATEGORIES

		Health Messages	
Health Risk	**Air Quality Health Index**	**At Risk Population***	**General Population**
Low	1 - 3	Enjoy your usual outdoor activities.	Ideal air quality for outdoor activities.
Moderate	4 - 6	Consider reducing or rescheduling strenuous activities outdoors if you are experiencing symptoms.	No need to modify your usual outdoor activities unless you experience symptoms such as coughing and throat irritation.
High	7 - 10	Reduce or reschedule strenuous activities outdoors. Children and the elderly should also take it easy.	Consider reducing or rescheduling strenuous activities outdoors if you experience symptoms such as coughing and throat irritation.
Very High	Above 10	Avoid strenuous activities outdoors. Children and the elderly should also avoid outdoor physical exertion.	Reduce or reschedule strenuous activities outdoors, especially if you experience symptoms such as coughing and throat irritation.
*People with heart or breathing problems are at greater risk. Follow your doctor's usual advice about exercising and managing your condition.			

Quantification

Air pollutant emission factors are usually quantified as pollutant concentration (pollutant mass/air mass or volume, e.g., kgp/kga, ppm, or kg/m3), pollutant dispersal (pollutant mass/[distance from source or area surrounding origin]; e.g., kg/km or kg/km2), pollutant emission rate (pollutant mass/duration of originating activity; e.g., kg/[sec, min, or hr]), or pollutant dispersal rate (pollutant mass/[distance from source or area surrounding origin]/duration of dispersal; e.g., kg/[km or km2]/[sec, min, or hr]).

The United States Environmental Protection Agency (EPA), United Kingdom (UK), Australia, Canada, several other countries, and European Environmental Agency

(EEA) have published air pollutant emission factor data compilations for several industrial processes.[4] Below are the health risk categories as assessed by Canada's Air Quality Health Index (AQHI).

Indoor air quality (IAQ) is an area often overlooked with regard to air pollution, as most individuals think of air pollution as an outdoor phenomenon. However, IAQ is now being examined as a significant, and insidious, source of air pollution due to pollutant concentration from a lack of ventilation in locations where many people spend the majority of their time and feel "safe." Indeed, the EPA estimates that "human exposure to [indoor] air pollutants… may be 2 to 5 times–and occasionally more than 100 times–higher than outdoor pollutant levels":[7]

1) Incidental indoor air pollutants, including a) Radon (Rn) gas, a natural exudate from the Earth; b) formaldehyde (H2CO) a gas from deteriorating building materials, such as carpeting and plywood; c) VOCs from paint and solvents; d) lead dust (older lead-based paints can degenerate into dust and be inhaled); e) tetrachloroethylene (C2Cl4), and other chemicals, from dry cleaned items; f) PMs from wood stoves and fireplaces; g) second-hand smoke; and h) asbestos, which is currently banned in many countries, but still may be found in older buildings/fire-retardant items.

2) Poisonous vapors from accidental appliance malfunctions/mishandling source materials include: a) Carbon Monoxide (CO) (obstructed chimneys, improperly adjusted pilot lights); b) hydrogen sulfide (H2S) (sewer gas); and c) pesticides and other chemical sprays (improper application without adequate ventilation).

3) Intentional air pollutants (although not often thought of as such), usually including scented items such as air fresheners and incense.

4) Biological air pollutants, including a) pet dander; b) human "dander" (dust from exfoliated skin and decomposing hair micro-flakes; c) dust mite feces and residual enzymes; d) methane from digestive processes; e) mold mycotoxins and spores; and f) pollen.

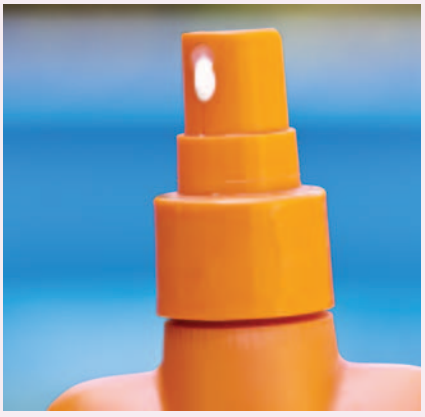
Air Pollution Regulation

In addition to promulgation and enforcement of quality standards, current efforts to control, and, hopefully, reduce/eradicate air pollution utilize technologies which destroy or sequester contaminants from emissions before atmospheric release, including:

1) Controlling: a) PMs (collection and scrubbing); b) NOx (burning, scrubbing, reduction and conversion); c) acid gas/SO2 (scrubbing and desulfurization); d) mercury (adsorption and oxidation); and

PASS APPLAUDS SUNSCREEN INNOVATION ACT

• **As this column was being written and ready to go to press,** Senators Jack Reed (D-RI) and Johnny Isakson (R-GA) introduced Senate Bill No 2141 and Congressman Ed Whitfield (R-KY) and John Dingell (D-MI) introduced House bill No HR 4250 both entitled "Sunscreen Innovation Act."



This legislation, that has been supported by the Public Access to SunScreen (PASS) Coalition, is the responsible way to alleviate the current 12-year backlog on sunscreen ingredients, and streamline the review process so the public can gain access to the most effective and innovative sunscreen products.

The last Over-The-Counter (OTC) sunscreen ingredient to be approved was in the 1990s. Since that time, eight new sunscreen applications have been filed and are still awaiting review. New sunscreen technologies currently awaiting approval in the US have been widely available in Europe, Asia, and Central and South America, in some cases for more than 15 years.

PASS notes skin cancer is the most common form of cancer in the US. Fortunately, it can be prevented through regular and appropriate use of sunscreens. This much needed and long overdue legislation is a key step for the approval of critical and innovative ingredients to be used in future sunscreens. The FDA has approved several new drugs for the treatment of melanoma in the recent years, and these drugs have made a profound impact on the lives of many patients with advanced disease. Now, it is time for the FDA to focus on prevention of skin cancers and approve the sunscreen ingredients that can better protect the public from harmful ultraviolet rays.

The creation of a predictable, transparent and timely review process for sunscreen ingredients addresses a growing public concern, and opens the door for further innovation. The PASS Coalition strongly encourages swift legislative action in both the House and the Senate to see the Sunscreen Innovation Act become law. —*N.S.*

e) dioxins and furans; and

2) VOC abatement (adsorption, scrubbing, oxidation, condensation, conversion, and biofiltration).[7]

Effects of Air Pollutants

It is fairly well-established in the "cosmeceutical" industry that intact skin, although a barrier, is also a prominent route of introduction of beneficial substances at the molecular via topical applications, including antioxidants, essential oils, and "baths."[8] A corollary of this phenomenon is whether transdermal absorption may also be a prominent route of introduction of undesirable substances at the molecular via incidental topical contact, viz., air pollution.

Unfortunately, in this modern era of medically significant air pollution, human populations are also absorbing a wide spectrum of pollutants transdermally, with the consequence that these noxious agents and/or their products enter the bloodstream and are globally circulated to all the body's other cells. At least 20-30% of the total toxins in a human body's cells are potentially derived from incidental environmental transdermal absorption, with the overall toxic impact not limited solely to the skin.

In the May edition of Happi, my column will address the factors affecting dermal skin absorption of environmental pollutants and the effect of air pollution on the skin. A special focus on the role of vitamins E and C depletion in the skin as a direct consequence of air pollution will be detailed. ●

Acknowledgment:

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