Quadrant II – Transcript and Related Materials

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Module Name: Photochemical products: Benzopyrene, Peroxybenzoyl Nitrate (PB_2N) and Peroxyacetyl Nitrate (PAN).

Module No: 10

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Notes

Introduction:

Photochemical products are compounds that are formed due to the absorption of radiant energy. They are acquired due to photochemical reactions that occur between highly reactive organic and inorganic species in the atmosphere. Examples of photochemical products include benzopyrene, Peroxybenzoyl nitrate and Peroxyacetyl Nitrate.

1. **Benzopyrene**

Introduction:

Benzopyrene is a carcinogenic pollutant that is classified under Polycyclic Aromatic Hydrocarbons (PAH). Its principal sources include,

- Heating of wood, coal, and other biological matter.
- Cooking
- Tobacco smoke
- Vehicular exhaust
- Forest fires
- Industrial emissions

Benzopyrene has no domestic and commercial use as it is a by-product of combustion. However, it is carcinogenic in nature and therefore, its primary use is in cancer studies.

Environmental Fate and Behaviour of Benzopyrene:

a) *Atmosphere*: When benzopyrene is present in the atmosphere in its particulate phase, it is readily removed by the processes of wet and dry deposition. In addition, benzopyrene is also susceptible to photolysis.

b) *Soil:* Benzopyrene' mobility in soil is slow. This mobility chiefly depends upon the compounds that accompany benzopyrene in the soil.

Toxicity of Benzopyrene

a) *Animals:* As a carcinogen, benzopyrene is known to cause tumours in the lungs, liver, and ovaries. It also increases the occurrence of abnormalities and mortality in foetuses. It also affects the development of T-lymphocytes and decreases the antibody response of the organism.
b) *Humans:* In humans, benzopyrene supresses the immune system and causes anaemia. It also affects the process of chromosomal replication and alters the DNA in gametes. Furthermore, in terms of male gametes, benzopyrene alters the morphology of the sperm and decreases sperm count.
c) *Ecotoxicity:* Based on research, it has become evident that benzopyrene has severe effects on aquatic organisms. E.g., benzopyrene is known to affect the immune system of seabass. It also persists for a long time (~15 days) in contaminated fish species. In addition to this, benzopyrene is also known to cause liver injury in killifish.

2. Peroxybenzoyl Nitrate (PB_2N)

Introduction:

Peroxybenzoyl Nitrate is a component of photochemical smog. It is formed when sunlight acts on polluted air containing trace concentrations of partially oxidized hydrocarbons and nitrogen oxides. Peroxybenzoyl Nitrate is a secondary pollutant that is formed in the presence of NO_2 and olefins. It is a very unstable compound that either undergoes decomposition or is readily absorbed onto surfaces. The principal sources of Peroxybenzoyl Nitrates are:

- Industrial Areas
- Urban Complexes

Effect of Peroxybenzoyl Nitrate (PB_2N) on Organisms:

Peroxybenzoyl nitrate is an eye irritant and lachrymator. It is approximately 100 times more irritating to the eyes that Peroxyacetyl Nitrate (PAN). Peroxybenzoyl nitrate also has severe effects on micro-floral assemblages in terrestrial and aquatic ecosystems i.e., it is phytotoxic in nature.

3. Peroxyacetyl Nitrate (PAN)

Introduction:

Peroxyacetyl Nitrates (PAN) is a compound that results from photochemical reactions between contaminants released into the atmosphere by combustion of organic fuels. PAN is formed due to the oxidation of non-methane volatile organic compounds. Therefore, Peroxyacetyl Nitrate is classified as secondary pollutant. The principal sources of Peroxyacetyl Nitrate are,

- Burning of fossil fuels
- Tobacco smoke
- Vehicular emissions

Environmental Occurrence of Peroxyacetyl Nitrates (PAN):

The occurrence and persistence of Peroxyacetyl Nitrate in the environment chiefly depends on the climatic condition of the region it is emitted from.

a) *Cold climates:* In cold climates, Peroxyacetyl Nitrate remains in the atmosphere for a long time (i.e., approximately 03 months) after formation. Due to this, it readily moves with the wind current and gets transported over long distances. This results in air pollution of relatively larger areas.
b) *Warm climates:* In warm climates, Peroxyacetyl Nitrate persists only for a few hours and is readily decomposed to form NOx.

Effects of Peroxyacetyl Nitrates (PAN):

a) Effects on plants: Peroxyacetyl Nitrate has severe effects on plants.
- Peroxyacetyl Nitrate causes mortality of microflora occurring in soil and water.
- It is known to cause smog. This smog blankets the sun reducing the sunlight that enters the lower atmosphere. This affects the photosynthetic rate of plants. In addition, Peroxyacetyl Nitrate also inhibits the hill reaction of photosynthesis.
- It causes the silvering of leaves.
- Peroxyacetyl Nitrate increases the maturity rate of trees. It also increases the mortality rate of trees.
- It is known to cause injuries in plants such as beets, spinach, lettuce, alfalfa, and coniferous trees.

b) Effects on humans: Although long term studies have not been carried out in humans, it is well known that Peroxyacetyl Nitrate can cause eye irritation and subsequent lacrimation. It is also known to damage the respiratory tract of humans.

c) Effects on test animals: In test animals, Peroxyacetyl Nitrate can cause severe lung lesions and damage to the epithelium and upper parts of the respiratory tract.

Photochemical smog:

Also called as Los Angeles Smog, it is formed when NOx reacts with volatile organic compounds in the presence of UV radiation. Photochemical smog contains several chemical species viz. CO, NOx, H_2O_2, O_3, PAN, PB_2N, Peroxy-Propionyl Nitrate (PPN) and acetyl peroxide.

Photochemical smog can have severe impact on the environment and human life:

- It is known to destroy tomato and spinach crops because they are overly sensitive to low-level ozone.
- Ozone in the lower atmosphere causes necrosis on the surfaces of leaves.
- Photochemical smog is known to reduce the capacity and elasticity of lungs.
- As it is a type of smog, it reduces visibility and leads to road accidents.

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