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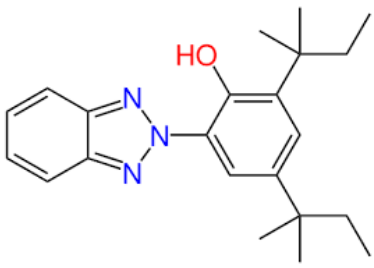
UV-328

[2-(2H-Benzotriazol-2-yl)-4,6-bis(2-methylbutan-2-yl)phenol]:

A Potential Persistent Organic Pollutant

KEY FACTS

- UV-328 is a ultraviolet (UV) light absorber that protects surfaces from discoloration and degradation under UV/sunlight
- It is mainly used in surface coatings, plastic additives, in some personal care products (sunscreen lotions), and as a printing ink additive
- UV-328 is found in the environment and biota, including in remote areas such as the Arctic and the Pacific Ocean, far from its production and use
- UV-328 poses potential risks to wildlife, human health, and the environment. It acts as an endocrine-disrupting chemical and can cause adverse effects on several organs including the liver and kidneys
- In the European Union, UV-328 was identified as a Substance of Very High Concern in 2014, and has been classified as persistent, bioaccumulative and toxic (PBT) as well as very persistent and very bioaccumulative (vPvB)
- It is also the first non-halogenated chemical to be considered as a potential POP



Chemical structure of UV-328

A preview to UV-328

Benzotriazoles (BZTs) are a class of compounds that absorb the full spectrum of UV light.[1] Therefore, BZTs that are widely used to protect materials against harmful UV radiation are also known as Benzotriazole UV stabilizers (BUVs). UV-234, UV-326, UV-327, UV-328, UV-329, UV-350, UV-P, etc. are commonly known BUVs.

> **Commercial manufacture and use of benzotriazoles began in the United States in 1950 to prevent oxidation and corrosion in commercial boilers, radiators for cooling systems.**

UV-328 [IUPAC name: 2-(2H-Benzotriazol-2-yl)-4,6-bis(2-methylbutan-2-yl)phenol] is a predominantly used UV absorber and belongs to the class of **substituted phenolic BZT compounds**.

- UV-328 is added to plastics and other polymers due to its photostability to prevent discoloration and prolong product stability
- UV-328 is structurally similar to UV-326 and UV-327 but shows better compatibility with resin
- It exhibits low thermal evaporation and high washing resistance[2]
- Because it is not bound to the polymer, UV-328 can migrate from within the polymer matrix and eventually diffuse out of the matrix and enter the environment

*Certain UV benzotriazoles such as UV-328, UV-234, and UV-329 are currently listed as **High Production Volume Chemicals** by the Organisation for Economic Cooperation and Development (OECD). **Annual global production volume of UV-328 exceeds 1000 tons**.*[3]

In May 2020, a proposal submitted by Switzerland to list UV-328 in Annex A to the Stockholm Convention

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Reviewed by POPRC at its 16th meeting (January 2021) and concluded that UV-328 satisfies all criteria (persistence, bioaccumulation, potential for long-range transport, and adverse effects on humans and the environment) set out in Annex D of the Stockholm Convention

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At its 17th meeting (January 2022), the POPRC adopted a risk profile for UV-328 and decided that global action on this chemical is warranted

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An intersessional working group of POPRC was established to prepare a risk management evaluation for UV-328 that includes an analysis of possible control measures in accordance with Annex F to the Convention for consideration by the POPRC at its 18th meeting (September 2022)

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Draft risk management evaluation has recommended that the COP to the Stockholm Convention consider listing and specifying the related control measures of UV-328 in Annex A with specific exemptions for the use in legacy spare parts in the automotive industry. The draft will be reviewed by POPRC in its 18th meeting (September 2022)

POPRC: Persistent Organic Pollutants Review Committee
COP: Conference of Parties

Applications of UV-328

- Used as a **UV protection agent in plastics, rubber, resins and cosmetics as well as in coatings** e.g., cars, wood and textiles
- Used in **construction materials, fillers, surface treatment, adhesives, paint/lacquers/varnishes, printing inks, consumer fragrances, fabric/textile/leather products and inert pesticides**
- Added to **cooling liquids in refrigerators, oil-based electric heaters, hydraulic liquids in automotive suspensions or lubricants in motor oil and break fluids**
- Recommended for **stabilization of styrene homo- and copolymers, acrylic polymers, unsaturated polyesters, polyvinylchloride, polyolefins, polyurethanes, polyacetals, polyvinyl butyral, elastomers, and adhesives**
- Used as a **printing ink additive in food contact materials**

Production

The global BZT market in 2020 is estimated to be 355.5 million USD according to a study conducted by Research and Markets. **It is expected to reach 531.8 million USD by 2027 at 5.9% compound annual growth rate (CAGR) from 2020 to 2027**.

The US BZT market is estimated to be 96.2 million USD in 2020, while Chinese market is expected to reach a size of 113.6 million USD by 2027 at 9.1% CAGR.

Other countries, such as Japan and Canada, are expected to grow at 3.2% and 5.3% CAGR from 2020 to 2027, respectively. Within EU, Germany is expected to grow at 3.8% in the global BZT market.

Maximum production and usage of BUVs takes place in Asian countries, especially China.

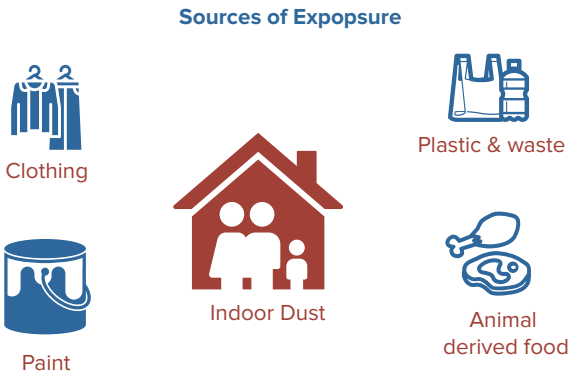
Release to the environment and Sources of exposure

UV-328 is expected to be released into the environment in the following ways:[4-8]

- During industrial production of UV-328
- During its use (e.g. as sunscreen lotions)
- Post-use disposal of products containing UV-328 into waste streams and the environment (e.g. plastics and food packaging)

UV-328 has been detected in air, dust, wastewater, wastewater sludge, surface water and biota in several regions across the world, including in remote regions. A large number of studies have detected UV-328 in several fish species belonging to different trophic levels.[10–12] This compound was also detected in bird tissues and eggs, indicating its tendency for maternal transfer to eggs.[13,14]

It is one of the numerous chemicals added in the plastic manufacturing process which some scientists are now concerned could spread far and wide via microplastics, posing potential risks to wildlife, human health or the environment.



UV-328 has a major use as an additive in plastics. Plastics mismanagement at the end-of-life stage allows them to end up in the oceans in the form of plastic debris. Therefore, plastic litter containing UV-328 is a major source of UV-328 in the environment and in biota that ingest plastics[9].

A 2021 global analysis by International Pollutants Elimination Network (IPEN) found UV-328 in **92% of beached plastic pellets from 22 countries** and in nearly **75% of recycled plastic pellets from 23 countries, including from India**. Plastic pellets are the base material used to manufacture new plastic items. Moreover, **this chemical was detected in toys and hair accessories from Russia, Indonesia and China.**

Humans may be exposed to UV-328 through ingestion of contaminated dust as well as consumption of contaminated foodstuffs. The presence of UV-328 in textiles, indoor dust, and particulate matter of outdoor air may also lead to dermal or inhalative contact to the chemical.

Since UV-328 is known to leach out of plastic products, its presence in children's toys is deeply concerning.

Toxicity of UV-328

- Liver is expected to be the main metabolism site based on the hydrophobic properties of UV-328 and metabolites would mostly be excreted via the kidneys. Therefore, **repeated exposure can cause adverse effects in specific target organs, mainly the liver and kidneys**[15]
- Repeated exposure to UV-328 in rats has found to result in severe liver toxicity as well as harm to other organs. Chronic exposure of fish to UV-328 led to elevated oxidative stress in the liver as well as significant effects on the activity of antioxidant enzymes and gene expression
- It is an endocrine-disrupting chemical and its metabolic activity can promote alternation in reproductive organs and antiandrogenic effects leading to potential adverse effects on sex differentiation in animal systems[16,17]
- UV-328 can also bind to blood proteins, indicating a potential for bioaccumulation in humans and potential disturbance of its normal biological functions[18]

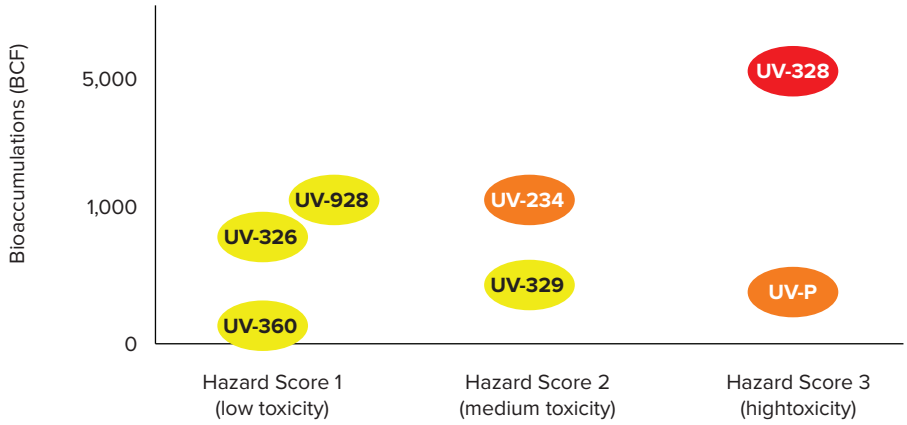
Predicted No-Effect Concentration (PNEC) values of UV-328 for aquatic organisms in different matrices

Matrix	PNEC
Freshwater	10 µg/L
Freshwater (intermittent releases)	100 µg/L
Marine water	1 µg/L
Sewage treatment plant	1 mg/L
Sediment (freshwater)	451 mg/kg sediment dw
Sediment (marine water)	45.1 mg/kg sediment dw

Derived No-Effect Levels (DNEL) for systemic effects due to long-term exposure to UV-328 in workers and general population

Exposed group	Exposure route	DNEL
Workers	Inhalation	0.7 mg/m^3
	Dermal	0.3 mg/kg bw/d
General population	Inhalation	0.17 mg/m^3
	Dermal	0.14 mg/kg bw/d
	Oral	0.14 mg/kg bw/d

Comparison of Bioaccumulation & Toxicity Hazards



Regulations in different countries

Country/Agency	Regulations
United Kingdom	Included in the high priority chemical list due to its persistent, bioaccumulative, toxic (PBT) characteristics
Norway	UV-328 was added to the national list of priority substances in 2017
European Union	• Since 2014, identified as a Substance of Very High Concern (SVHC) and has been classified as persistent, bioaccumulative and toxic (PBT) as well as very persistent and very bioaccumulative (vPvB) • Since 2020, UV-328 is regulated under Annex XIV (Authorisation) of the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) regulation
Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention)	Listed as a substance of possible concern in 2006
Singapore	National Environment Agency of Singapore (NEA) has proposed to regulate UV-328 as hazardous substance under the Environmental Protection Management Act and the Environmental Protection Management (Hazardous Substances) Regulations tentatively by March 1, 2023

Currently, apart from Japan, none of the Asian countries has classified neither regulated the production and usage of BUVs. UV-320 is classified as Class I specified chemical substances under chemical control substance law in Japan in 2007 which depicts similar characteristics as that of POPs. However, till now, Japan has not come up with any regulation on UV-328.

Data from India

There is no information available on the indigenous manufacturing of UV-328 in India. **In 2018–20, India mostly imported (about 70%) such chemicals (heterocyclic compounds with nitrogen atoms, HS code: 29339900) from China, as per the Department of Commerce, Ministry of Commerce and Industry, Government of India.**

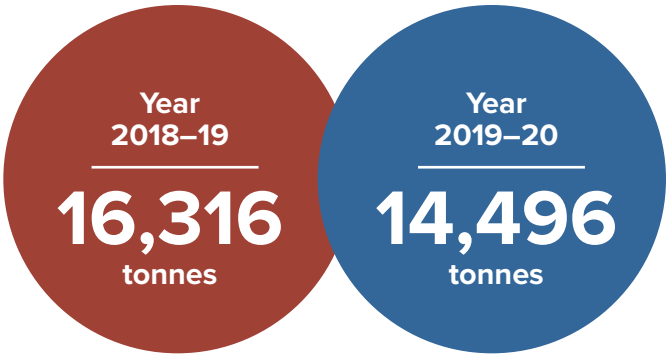
For example, Riasorb UV-328 light stabilizer manufactured by Rianlon Corporation, China is available for sale in India and marketed as a plastic additive.

In India, there is no regulation or restriction on the use of UV-328 at present.

Potential Alternatives

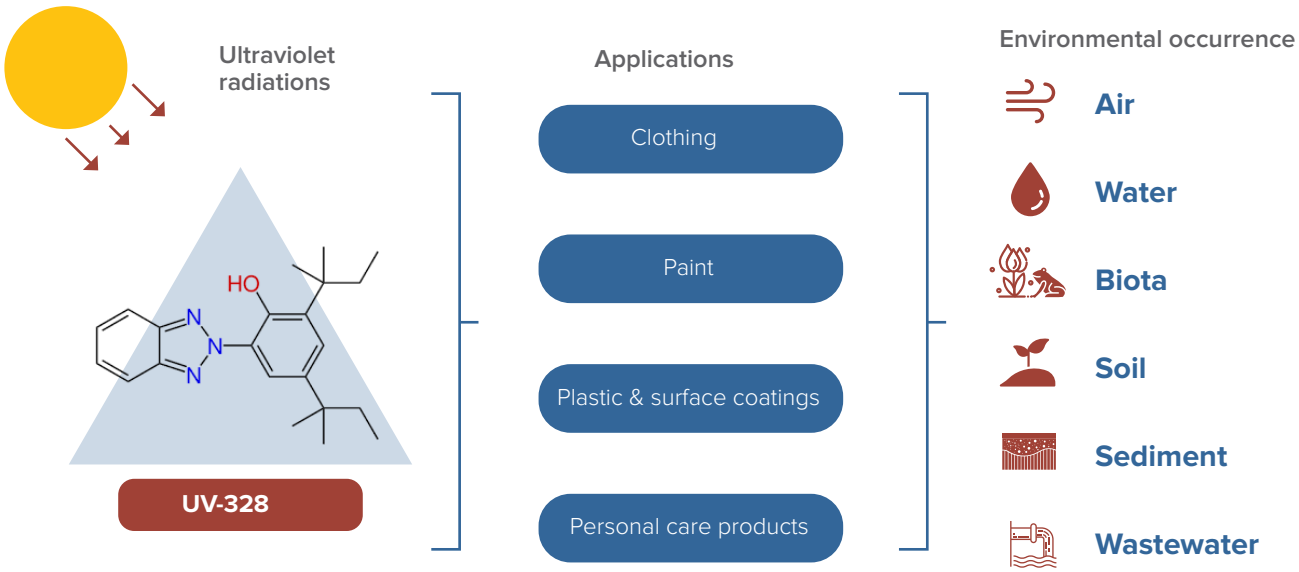
- **Other phenolic benzotriazoles** (may also have PBT/vPvB properties)
- **Benzophenones**: technically important UV absorbers for transparent plastic materials but may be potential endocrine disruptors
- **Hindered amine light stabilisers (HALS)**: Protect plastics from UV radiation (not UV absorbers but function as degradation inhibitors)

Import of heterocyclic compounds with nitrogen atoms such as UV-328 from China to India



Small quantities were imported from other countries such as Japan, Belgium, France and Germany.

There is a lack of literature on the presence of UV-328 in the Indian environment. Vimalkumar et al.[19] conducted a study to analyse UV BZTs in water, sediment and fish from Kaveri, Vellar, and Tamiraparani rivers in Tamil Nadu, India. The maximum concentrations detected in water, sediment and fish were 5.2, 4.3 and 6.1 ng/L respectively. In human adipose tissue, few to several ng/g lw concentrations of UV-328 were also found in India.



2022	2021	2020	2017	2014
Risk profile adopted by POPRC	Listed in Annex-D of Stockholm Convention	UV-328 regulated under EU-REACH	Listed as HPV plastic additive by EU	Listed as SVHC by EU

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