The Ubiquitous Triclosan

A common antibacterial agent exposed

By Aviva Glaser

Chemical Name: *2,4,4′-Trichloro-2′-hydroxydiphenyl ether. CAS# 3380-34-5. Other names: Microban, Irgasan DP-300, Lexol 300, Ster-Zac, Cloxifenolum, Biofresh etc.*[1]

There is a disinfectant showing up in hundreds of common consumer products that is raising serious cause for concern. The chemical, triclosan, is a synthetic, broad-spectrum antimicrobial agent that in recent years has exploded onto the consumer market in a wide variety of antibacterial soaps, deodorants, toothpastes, cosmetics, fabrics, plastics, and other products. Studies have increasingly linked triclosan to a range of health and environmental effects, from skin irritation, allergy susceptibility, bacterial and compounded antibiotic resistant, and dioxin contamination to destruction of fragile aquatic ecosystems. Concerns about triclosan have even led some manufacturers, such as Tom's of Maine, to specifically state that their toothpaste products do not contain triclosan. According to the American Medical Association, "Despite their recent proliferation in consumer products, the use of antimicrobial agents such as triclosan in consumer products has not been studied extensively. No data exist to support their efficacy when used in such products or any need for them…it may be prudent to avoid the use of antimicrobial agents in consumer products…"[2]

Triclosan possesses mostly antibacterial properties, but also some antifungal and antiviral properties. It is marketed under the trade name Microban® when used in plastics and clothing, and Biofresh® when used in acrylic fibers. Triclosan is most often used to kill bacteria on the skin and other surfaces, although it sometimes is used to preserve the product against deterioration due to microbes.[3] Antibacterials are similar to antibiotics in that they both inhibit bacterial growth. But while the purpose of antibiotics is to cure disease, the purpose of antibacterials are to prevent transmission of disease-causing micro-organisms.[4]

Triclosan has been used for over 30 years. Its uses were originally confined mostly to health care settings, first introduced in the health care industry in a surgical scrub in 1972. Over the last decade, there has been a rapid increase in the use of triclosan-containing products.[5] A marketplace study in 2000 by Eli Perencevich, M.D. and colleagues found that over 75% of liquid soaps and nearly 30% of bar soaps (45% of all the soaps on the market) contained some type of antibacterial agent. Triclosan was the most common agent found – nearly half of all commercial soaps contained triclosan.[6] While EPA does not publish total sales volume numbers, it is clear that the prevalence of triclosan in multitudes of personal care products amounts to massive quantities of active

Get updated information at www.beyondpesticides.org/antibacterial/triclosan.htm.

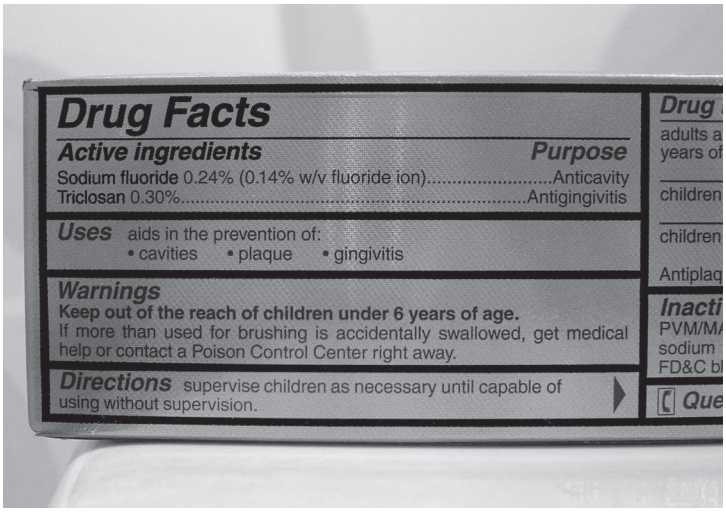
What is an Antimicrobial?

Antimicrobial pesticides are substances or mixtures of substances used to destroy or suppress the growth of harmful microorganisms whether bacteria, viruses, or fungi on inanimate objects and surfaces, and like all pesticides, are registered by the Environmental Protection Agency (EPA). However, many of these same chemicals are also used in personal care products, such as soap, toothpaste and lotion, but are not considered pesticides, because of a loophole in federal law. Antimicrobial products used on the human body or in processed food or food wrappers, even with identical active ingredients, are technically not considered pesticides and are regulated by the U.S. Food and Drug Administration (FDA).[8] Since the toxicology is the same, this factsheet will consider all uses.

Antimicrobial products contain about 275 different active ingredients and are marketed in several formulations: sprays, liquids, concentrated powders, and gases. Approximately one billion dollars are spent per year on antimicrobial products. More than 5,000 products are currently registered as antimicrobial pesticides with EPA under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). Unlike other pesticides, antimicrobials registered for public health uses require efficacy reviews so that EPA can make sure the manufacturers' claims hold up. However, EPA's Office of Pesticide Programs (OPP) Antimicrobial Division director Jack Housenger revealed in 2004 that approximately half of all hospital disinfectants and sterilants, which are also regulated as antimicrobial pesticides, fail the agency's efficacy tests.[9]

ingredient produced every year. For example, in Sweden in 1998 alone, 25% of the total amount of toothpaste sold contained triclosan, corresponding to around 2 tons of active ingredient.[7]

How it works. Triclosan works by blocking the active site of the enoyl-acyl carrier protein reductase enzyme (ENR), which is an essential enzyme in fatty acid synthesis in bacteria.[10] By blocking the active site, triclosan inhibits the enzyme, and therefore prevents the bacteria from synthesizing fatty acid, which is necessary for building cell membranes and for reproducing.[11] Since humans do not have this ENR enzyme, triclosan has long been thought to be fairly harmless to them. Triclosan is a very potent inhibitor, and only a small amount is needed for powerful antibiotic action.[12]



Close-up of a popular toothpaste label, which lists triclosan as an active ingredient.

Effectiveness. Under the appropriate settings and conditions, such as in hospitals to prevent hospital-acquired infections, triclosan has been proven to be effective.[13] But no current data demonstrate any extra health benefits from having antibacterial-containing cleansers in a healthy household.[14] For example, a study of over 200 healthy households found that those households that used antibacterial products did not have any reduced risk for symptoms of viral infectious diseases.[15] The Centers for Disease Control and Prevention says that antibacterial soaps are not necessary in everyday use, and washing hands with ordinary soap and warm water is an effective way to ward off infections.[16]

Toxic Characteristics

Acute Toxicity. In classical toxicological terms, triclosan is relatively non-toxic to humans and other mammals.[17] However, there have been reports of contact dermatitis, or skin irritation, from exposure to triclosan.[18] There is also evidence that triclosan may cause photoallergic contact dermatitis (PACD), which occurs when the part of the skin exposed to triclosan is also exposed to sunlight.[19] PACD can cause an eczematous rash, usually on the face, neck, the back of the hands, and on the sun-exposed areas of the arms.[20] There is also a reported case of an immunotoxic and neurotoxic reaction to triclosan.[21] Manufacturers of a number of triclosan-containing toothpaste and soap products claim that the active ingredient continues to work for as long as 12 hours after use. Thus, consumers are exposed to triclosan for much longer than the 20 seconds it takes to wash their hands or brush their teeth. The dermal LD_{50} (the lethal dose that kills 50 percent of a population of test animals) for rats is 5000 mg/kg. The oral LD_{50} for rats is 4500-5000 mg/kg, for mice it is 4000 mg/kg, and for dogs it is over 5000 mg/kg.[22]

Chronic Health Effects. Triclosan has not been found to have any carcinogenic, mutagenic, or teratogenic effects.[23] A Swedish study found high levels triclosan in three out of five human milk samples, indicating that triclosan does in fact get absorbed into the body, often in high quantities.[24] Additionally, triclosan is lipophilic, so it can bioaccumulate in fatty tissues. Concerns over triclosan interfering with the body's thyroid hormone metabolism led to a study that found that triclosan had a marked hypothermic effect, lowering the body temperature, and overall causing a "nonspecific depressant effect on the central nervous system" of mice.[25] Although the chemical structure of triclosan closely resembles certain estrogens, a study on a Japanese species of fish did not demonstrate estrogenic effects.[26] However, it did find that triclosan is weakly androgenic, causing changes in fin length and sex ratios.[27]

Allergy Link. Another potential problem with overuse of triclosan (and other antibacterials) is their link to allergies. The "hygiene hypothesis," theorizes that there is a correlation between too much hygiene and increased allergies and asthma.[28] This hypothesis is based on studies that have found an increase in the frequency of allergies, asthma, and eczema in persons who have been raised in more sterile and hygienic environments. Through over-cleaning ourselves, the theory states, the body's immune system is not challenged, and thus prevent it is prevented from developing and maturing.[29] In one study, children who grew up on farms had fewer allergies than did their counterparts who did not live on farms.[30] In another study, researchers found that respiratory allergies were less frequent in people who were heavily exposed to microbes, leading the researchers to conclude that, "Hygiene and a westernised, semisterile diet may facilitate atopy by influencing the overall pattern of commensals and pathogens…thus contributing to the epidemic of allergic asthma and rhinitis in developed countries."[31]

Dioxin Link. Recently, there have been a number of concerns about triclosan and its link to dioxin. Dioxin can be highly carcinogenic and can cause health problems as severe as weakening of the immune system, decreased fer-

tility, altered sex hormones, miscarriage, birth defects, and cancer.[32] Triclosan is listed as "could be" and "suspected to be" contaminated with dioxins in EPA's draft Dioxin Reassessment.[33] Because of the chemical structure as a polychloro phenoxy phenol, it is possible that dioxin can be found in triclosan as synthesis impurities.[34] In addition to being formed during the manufacturing process, dioxin may also be formed upon incineration of triclosan.[35]

Researchers who added triclosan to river water and shined ultraviolet light on the water found that between one and twelve percent of the triclosan was converted to dioxin in the water, leading to fears that sunlight could transform triclosan to dioxin naturally.[36] An even more serious health threat may stem from treatment of triclosan-tainted water at water treatment plants—sunlight could convert chlorinated triclosan into highly toxic forms of dioxin.[37] Exposure to sunlight in the solid state of triclosan, such as on commercial textile products, also causes formation of dioxin, albeit in smaller amounts than aqueous solutions.[38]

Resistance Concerns. A number of recent studies have raised serious concerns that triclosan and other similar products may promote the emergence of bacteria resistant to antibiotics.[39] One concern is that bacteria will become resistant to antibacterial products like triclosan, rendering the products useless to those who actually need them, such as people with compromised immune systems. Scientists also worry that because triclosan's mode of action and target site in the bacteria is similar to antibiotics, bacteria that become resistant to triclosan will also become resistant to antibiotics. There are also at least two other proven resistance mechanisms that are similar for both triclosan and antibiotics.[40] Triclosan does not actually cause a mutation in the bacteria, but by killing the normal bacteria, it creates an environment where mutated bacteria that are resistant to triclosan are more likely to survive and reproduce.[41] With so many products on the market containing triclosan, the speed with which resistance develops is likely to be increased.[42]

Laboratory studies with triclosan have found a number of different strains of mutated bacteria that are resistant to triclosan.[43] These studies found that these mutant strains of bacteria also showed resistance to certain antibiotics, including a drug widely used for treatment of tuberculosis, an experimental antibiotic currently under development, and a number of other "clinically relevant" antibiotics.[44] While most resistant bacteria grow more slowly than sensitive bacteria, *E. coli* strains that are resistant to triclosan actually have increased growth rates. Constant exposure to triclosan will cause these resistant strains to tolerate it better, become increasingly hardy, and ever more resistant.[45] Because antibiotic resistance has become an increasingly serious problem worldwide, the link to antibacterials may prove to be very important.[46] In a recent review of the subject, one researcher concluded, "It is therefore quite possible that widespread use of triclosan may indeed compound antibiotic resistance."[47]

Environmental Effects

Over 95% of the uses of triclosan are in consumer products that are disposed of in residential drains.[48] Since wastewater treatment plants fail to remove triclosan from the water and the compound is highly stable for long periods of time,[49] a huge amount of triclosan is expected to be emitted into waterways. In a U.S. Geological Survey study of 95 different organic wastewater contaminants in U.S. streams, triclosan was one of the most frequently detected compounds, and in

How Does FDA Regulate Antimicrobials?

As mentioned above, if an antimicrobial product is intended for use on the human body, it falls under the jurisdiction of FDA, rather than EPA. FDA categorizes triclosan and other antimicrobial products based on use and product claims. If a product makes a health-related claim, such as "kills germs" (soap, first aid creams, etc.), FDA registers it as a drug. If it makes no claim at all or if its claims are cosmetic, such as "fights odors" or "improves skin" (deodorant, make-up, shaving cream), it is registered as a cosmetic. All uses not applied to the human body (bathroom and kitchen cleaners, hospital disinfectants), that make pesticidal claims, such as "kills bacteria and mildew" are regulated by EPA as pesticides.

FDA regulates drugs similar to the way that EPA regulates pesticides, using a risk-benefit analysis based on data gathered from animal studies and human clinical trials. The manufacturer must prove that: the drug is safe and effective in its proposed use(s), and that the benefits of the drug outweigh the risks; the drug's proposed labeling is appropriate; and the manufacturing methods used are able to maintain the drug's quality, identity, strength, quality, and purity.

On the other hand, FDA is only able to regulate cosmetics after products are released on the marketplace. Neither cosmetic products nor cosmetic ingredients are reviewed or approved by FDA before they are sold to the public. FDA cannot require companies to do safety testing of their cosmetic products before marketing. However, if the safety of a cosmetic product has not been substantiated, the product's label must read: "WARNING: The safety of this product has not been determined." FDA does not require, but maintains a voluntary data collection program. If cosmetic products are found to present a hazard, recalls are also voluntary.

some of the highest concentrations.[50] A study of triclosan in bodies of water in Switzerland also found high concentrations of the chemical in several lakes and rivers, as well as lower levels of methyl triclosan, its breakdown by-product.[51] Methyl triclosan, which is formed by a process called biological methylation, is actually more lipophilic than its parent compound, and thus more bioaccumulative.[52]

Triclosan can have detrimental effects on aquatic ecosystems. It has been found to be highly toxic to different types of algae.[53] Triclosan effluents affect both the structure and the function of algal communities in stream ecosystems.[54] Because algae are the first-step producers in aquatic ecosystems, high levels of triclosan discharged into the environment may cause possible destruction of the balance of aquatic ecosystems.[55] The risks are especially high immediately downstream from wastewater treatment plants.[56]

Because of its lipophilic nature and resistance to degradation, triclosan in waterways is readily available for absorption and bioaccumulation by aquatic organisms in the environment.[57] Researchers in Sweden found high levels of triclosan present in the bile of fish that were placed in cages downstream of sewage treatment works in Sweden.[58] Methyl triclosan has also been found in fish.[59] Although little is known about the effects on fish, triclosan has been found to be highly toxic to Japanese medaka fish in their early life stages, and may be a weak endocrine disruptor.[60]

Regulatory Information and History

EPA and FDA share responsibility for regulating antimicrobial products. In general, EPA regulates all of the pesticidal uses of triclosan- when it is used as a preservative, a fungicide, or a biocide, such as with Microban® in plastics. The FDA regulates all food and drug uses of triclosan, including its use in soaps, deodorants, creams, and acne medications. The first patent for triclosan was issued in 1966.[61] A year later, the first patent was issued for a product containing triclosan, issued to the Colgate-Palmolive Company for antibacterial soap bars. Over the next decade, other soaps, disinfectants, deodorants, shampoos, and medical supplies, all containing triclosan and designed to be antibacterial, were invented and put on the market.[62] Triclosan has not undergone a reregistration by the EPA.

In 1997, the EPA acted to prevent the manufacturer of Playskool toys, Hasbro, Inc. (which sells toys made with Microban® plastic containing triclosan), from making false claims about protecting children from microbial infections. Hasbro could no longer claim that toys treated with triclosan

List of Products Containing Triclosan

SOAP: Dial® Liquid Soap; Softsoap® Antibacterial Liquid Hand Soap; Tea Tree Therapy™ Liquid Soap; Provon® Soap; Clearasil® Daily Face Wash; Dermatologica® Skin Purifying Wipes; Clean & Clear Oil Free Foaming Facial Cleanser; DermaKleen™ Antibacterial Lotion Soap; Naturade Aloe Vera 80® Antibacterial Soap; CVS Antibacterial Soap, pHisoderm Antibacterial Skin Cleanser, Dawn® Complete Antibacterial Dish Liquid, Ajax® Antibacterial Dish Liquid.
DENTAL CARE: Colgate Total®; Breeze™ Triclosan Mouthwash; Reach® Antibacterial Toothbrush; Janina Diamond Whitening Toothpaste
COSMETICS: Supre® Café Bronzer™; TotalSkinCare Makeup Kit; Garden Botanika® Powder Foundation; Mavala Lip Base; Jason Natural Cosmetics; Blemish Cover Stick; Movate® Skin Litening Cream HQ; Paul Mitchell Detangler Comb, Revlon ColorStay LipSHINE Lipcolor Plus Gloss, Dazzle
DEODORANT: Old Spice High Endurance Stick Deodorant, Right Guard Sport Deodorant
Queen Helene® Tea Trea Oil Deodorant and Aloe Deodorant; Nature De France Le Stick Natural Stick Deodorant; DeCleor Deodorant Stick; Epoch® Deodorant with Citrisomes; X Air Maximum Strength Deodorant
OTHER PERSONAL CARE PRODUCTS: Gillette® Complete Skin Care MultiGel Aerosol Shave Gel; Murad Acne Complex® Kit, ®; Diabet-x™ Cream; T.Taio™ sponges and wipes, Aveeno Therapeutic Shave Gel.
FIRST AID: SyDERMA® Skin Protectant plus First Aid Antiseptic; Solarcaine® First Aid Medicated Spray; Nexcare™ First Aid, Skin Crack Care; First Aid/Burn Cream; HealWell® Night Splint**;** 11-1X1: Universal Cervical Collar with Microban
KITCHENWARE: Farberware® Microban Steakknife Set and Cutting Boards; Franklin Machine Products FMP Ice Cream Scoop SZ 20 Microban; Hobart Semi-Automatic Slicer; Chix® Food Service Wipes with Microban; Compact Web Foot® Wet Mop Heads
COMPUTER EQUIPMENT: Fellowes Cordless Microban Keyboard and Microban Mouse Pad
CLOTHES: Teva® Sandals; Merrell Shoes; Sabatier Chef's Apron; Dickies Socks; Biofresh® socks
CHILDRENS TOYS: Playskool®: Stack 'n Scoop Whale, Rockin' Radio, Hourglass, Sounds Around Driver, Roll 'n Rattle Ball, Animal Sounds Phone, Busy Beads Pal, Pop 'n Spin Top, Lights 'n Surprise Laptop
OTHER: Bionare® Cool Mist Humidifier; Microban® All Weather Reinforced Hose; Thomasville® Furniture; Deciguard AB Ear Plugs; Bauer® 5000 Helmet; Aquatic Whirlpools; Miller Paint Interior Paint; QVC® Collapsible 40-Can Cooler; Holmes Foot Buddy™ Foot Warmer, Blue Mountain Wall Coverings, California Paints®, EHC AM-Rail Escalator Handrails, Dupont™ Air Filters, Durelle™ Carpet Cushions, Advanta One Laminate Floors, San Luis Blankets, J Cloth® towels, JERMEX mops

protect children from infectious diseases caused by bacteria because it did not prove efficacy to EPA. Labels and advertisements for the toys suggested that the treatment protects children from health risks, when in fact it protects only the plastic in the toy. The company is prevented from making such claims due to a lack of reliable data to support them. Under the agreement, Hasbro had to publish large advertisements in certain newspapers and magazines about misrepresentation of the public health claim.[63]

Overall, the FDA and the EPA have done little to warn consumers of the possible health and environmental effects of triclosan. European countries, by contrast, have taken a much different approach to this chemical. In 2000, the Danish EPA, National Board of Health, National Central Laboratory and the Danish Consumer Information Center issued a joint statement advising consumers against the routine use of antibacterial household and personal hygiene products, stating that their use is unnecessary for domestic use and potentially harmful to the environment as they "are extremely persistent and highly toxic in the marine environment."[64] Six Finnish public authorities also issued a statement urging consumers to not use certain anti-bacterial chemicals, stating they are unnecessary and that their growing use increases the risk of spreading antibiotic resistance in microbial populations. The joint statement, also issued in 2000, stated, "Even Finnish hospitals don't use such chemicals for routine cleaning operations. In households we see more disadvantages than advantages."[65] That same year, soap and detergent manufacturers in Europe agreed to a ban on any increase in its use over 1998 levels.[66] The following year, German environment minister Jurgen Trittin called on consumers to not use cleaning agents containing anti-bacterial agents and on industry to stop marketing and advertising the antibacterial qualities of their products, calling their use in households, "superfluous and risky." He also demanded that industry stop suggesting to consumers that they are "surrounded by enemy germs which they had to fight aggressively."[67]

Alternatives to Triclosan

When used in hospitals and other health care settings, or for persons with weakened immune systems, triclosan represents an important health care and sanitary tool. But outside of these settings, it is unnecessary, and the constant exposure to triclosan becomes a health and environmental hazard. The best solution to preventing infections is good old soap and water. Here are some guidelines on keeping clean without antimicrobials:

- Wash hands frequently and thoroughly. Regular soaps lower the surface tension of water, and thus wash away unwanted bacteria. Lather hands for at least 10 to 15 seconds and then rinse of in warm water. It is important to wash hands often, especially when handling food, before eating, after going to the bathroom, and when someone in your house is sick.

- Dry hands with a clean towel to help brush off any germs that did not get washed down the drain

- Wash surfaces that come in contact with food with a detergent and water

- Wash children's hands and toys regularly to prevent infection

Because triclosan has become so ubiquitous in soaps and toiletries, make sure to read all ingredients when buying these products (also refer to the following list of products containing triclosan). There are also some essential oils that have antimicrobial properties, such as Australian tea tree oil, grapefruit seed extract, and pine oil.

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