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PVC: Pandora's poison

From food packaging to floor tiles, it's hard to imagine modern society without plastics — and in particular, the range of products derived from polyvinyl chloride or PVC. Since commercial production of PVC began, this plastic has permeated every facet of daily life. But at what cost? Few would believe that one of the most versatile plastics in use today might also be one of the most hazardous. Slowly, evidence is emerging that a product and a process once thought inert has the potential to cause harm at every stage in its lifecycle.

What is PVC?

PVC is a synthetic polymer comprised of repeating units of the monomer vinyl chloride. Like other plastics, PVC contains hydrogen and carbon — but with one important difference — chlorine. In fact, it is the chlorine molecule that distinguishes PVC from other plastics, allowing the addition of stabilizers and plasticizers, and manipulation of PVC into a wide range of products.

After polyethylene, PVC is the second most common plastic produced. It comes in two forms: rigid and flexible. In 2002, over 25 tonnes of PVC were manufactured worldwide. More than three quarters of all PVC produced today is used in building materials. Commercial piping including tubing, conduits and fittings, account for almost half of all PVC sales. PVC is also widely employed in the automotive industry for under floor protection and instrumentation panels and in the health care field for medical supplies and equipment.

Why is PVC hazardous?

The presence of chlorine and the addition of stabilizers and plasticizers make PVC unique among plastics but also render the production, fabrication and disposal of this material hazardous to human and environmental health.

PVC production: The hazards of PVC start at production. Workers employed in facilities that make or use vinyl chloride (VC) and those who live or work near these plants are most likely to be exposed. Exposure to VC occurs through inhalation of workplace or ambient air or consumption of contaminated water. Those exposed to high concentrations over a short time or lower levels over an extended period are at greatest risk of adverse health effects.

VC is a known human carcinogen associated with development of angiosarcoma (a rare liver cancer) as well as tumors of the brain, lung and hemolymphatic systems. Documentation regarding the carcinogenicity of VC dates back to the 1960s. But it was not until the early 1970s when several workers died of angiosarcoma, that the relationship was confirmed.

PVC fabrication: The final step in PVC production is manipulation of the polymer into a final product. It is during this stage that stabilizers and plasticizers are added to enhance durability and flexibility of both the processed and finished product.

Stabilizers are added to the PVC polymer to prevent deterioration of the final product by heat and light. The main stabilizers in use today include salts of the metals lead, cadmium, barium, calcium and tin. Lead, and to a lesser extent, organic tin compounds, are the most common. Of the lead stabilizers, lead sulphate and lead phosphite find the widest application, particularly in coloured PVC piping, profiles and cables. Tin is used predominately in clear PVC products such as blood bags and intravenous tubing.

Workers involved in the mixing of lead salt stabilizers during PVC formulation are at risk for exposure to lead. Typically, these stabilizers are in the powder form and become airborne during pouring and mixing. Inhalation of lead in workplace air is the commonest route of occupational exposure. Lead adversely affects many of the body's systems – the most sensitive being the nervous and reproductive systems. Studies of worker exposure to even low lead levels in workplace air have found evidence of personality and behavioural changes. Children are particularly vulnerable to lead with impaired intelligence the most common manifestation of lead absorption. Much of the evidence regarding the reproductive effects of lead comes from studies completed in the past half century on women in the lead trades who reported decreased fertility and increased frequency of miscarriage. Studies of male lead workers with moderate to heavy lead exposure show a decline in sperm counts and greater than expected sperm abnormalities.

Plasticizers are the second most important additive to PVC and impart flexibility to the final product. The most common plasticizers used in PVC today are phthalates. In fact, vinyl is the only major building product that uses phthalates exclusively, accounting for 90 per cent of total phthalate consumption. In the U.S. alone, over 5 million tons of phthalates are used in PVC production every year. Common phthalates are bis-2-ethlhexyl phthalate (DEHP), diisodecyl phthalate (DIDP) and diisonoyl phthalate (DINP).

Like stabilizers, many plasticizers, manufactured as powders, are mixed with the polymer during formulation. Workers may be exposed to phthalates as dust generated during mixing. Release of phthalates during product fabrication is the primary route of occupational exposure. Phthalates act as endocrine disruptors with the human reproductive system particularly sensitive to exposure. Exposure to DEHP, at levels far below those of previous toxicological concern, has resulted in demasculinization of the male fetus. A draft report published by the National Toxicology Program in 2000 related DEHP exposure to reduced sperm counts.

Recently, there has been growing recognition of the potential for non-occupational exposure to stabilizers and plasticizers. Neither is chemically bound to the PVC polymer and therefore can migrate, under certain conditions, from the final product into air, water or soil. Several studies have demonstrated the leaching or release of stabilizers and plasticizers during both normal use and under specific conditions. Recently published literature shows the accumulation and leaching of lead from new PVC piping exposed to heat and light. Greenpeace has also reported the presence of lead and cadmium, in levels high enough to exceed federal U.S. guidelines, in 20 per cent of children's toys tested. Still other investigations have suggested an association between exposure to DEHP in consumer products and premature breast development in girls. The U.S. Centre for Disease Control recently released the first substantive assessment of phthalate exposure in the American public. This study analyzed metabolite residues of seven phthalates in urine and found the metabolite of DEHP — DBP — highest in women of childbearing age.

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PVC disposal: Worldwide, the majority of PVC waste, both from manufacturing and consumer streams, is landfilled. A small percentage is burned in medical and municipal incinerators. Both present long-term impacts for public and environmental health.

Leaching of plasticizers, especially phthalates, from flexible PVC products in landfill is well documented. Several different phthalates have been found in municipal landfill leachates. There is also evidence phthalates may be released in the gaseous emissions from landfill sites. Less information is available on the leaching of stabilizers.

Incineration of PVC waste, the second most common method of disposal, generates both hydrochloride acid and dioxin. Burning PVC generates dioxin in significant amounts. Dioxin is one of the most toxic chemical compounds known to man. It accumulates in fatty tissue of humans and has been linked to cancer, impaired child development, infertility and immune system damage. Once dioxin is released to the atmosphere, it can travel long distances and deposit on land and water far from the original source. Persistent in soil for more than a decade, dioxin can contaminate both food and water.

What can be done?

To date, two approaches have been employed in an effort to minimize and/or eliminate potentially hazardous occupational and environmental exposure to PVC — legislation governing exposure, specific to a chemical and a jurisdiction, and broad based policy focusing on eliminating use.

In Ontario, vinyl chloride has been a designated substance since 1982. Those industries either producing or using vinyl chloride are required to assess the potential for worker exposure and implement appropriate control measures. The same holds true for lead, also a designated substance in Ontario.

General policy to eliminate PVC hazards is more recent. In 2000, the Commission of the European Communities signed a voluntary commitment on the sustainable development of PVC, agreeing to reduce use of certain metal stabilizers, the mechanical recycling of certain post-consumer wastes and development of PVC recycling technologies. Other jurisdictions have gone further, including Germany, Seattle, Washington and San Francisco, California, either reducing or phasing-out PVC use.

Other initiatives have focused on specific additives. Three member states of the European Union have implemented risk management strategies designed to reduce phthalate use with Sweden phasing-out DEHP use in specific applications by 2001. The Danish government committed to reducing phthalates by 50 per cent over the next decade. In Canada, the approach has been similar. In 1997, Health Canada released its Strategy for Reducing Lead as a preventive measure to reduce children's exposure to lead in consumer products. A year later, the Consumer Product Safety Commission asked manufacturers to eliminate lead from all consumer products. The Toy Manufacturers Association complied.

Eliminating PVC use is not without challenges though, especially for those workers whose livelihood may be threatened as a result. Involvement of those potentially impacted and reestablishment of those displaced in alternative industries — or just transition — is a critical component of the current strategy to phase-out PVC.

Are there alternatives?

Given the wide range of applications, replacing PVC with a single material is not possible. Investigations into suitable alternatives are ongoing. Studies completed in Canada in the 1990s identified viable (and more durable) alternatives for PVC flooring and roofing. Single-ply or flexible membrane roofing, made from non-chlorinated plastics — either TPO (thermoplastic elastromer polyolefin) or EPDM (ethyl propylene diene monomer) — currently offers the best roofing option, being used most recently in public schools and sports stadiums in the U.S.

Replacements for siding have proven more difficult. Several recently developed products, including fiber-cement siding, engineered wood siding and TPO siding show promise. The fiber cement option has proved particularly popular as it contains no chlorine and is as durable and attractive as vinyl. Appropriate alternatives to PVC piping in buildings also exist. Both polyethylene and metal pipes have been used instead of PVC, with these substitutes most common in new hotel and hospital construction. Both the EPA, at its headquarters in Washington, D.C. and the Sydney Olympics chose green products instead of PVC for most of their construction. Meantime, New York State is providing tax credits for those using green building materials. Great Lakes United, a bi-national environmental group, would go further yet, calling for the stipulation of green materials in building codes.

Many alternatives to consumer products containing PVC also exist — canvas instead of PVC shower curtains, Gortex instead of PVC rainwear and heavy glass (or at least plastics other than number three, the recycling code for PVC) rather than PVC containers are just three examples.

Hoping to avoid litigation, many corporations are voluntarily eliminating PVC in their products. Still others have ceased PVC operations altogether. General Motors was the first automaker to ban PVC plastic from new car interiors effective 2004. Other automakers, including Ford and DaimlerChrysler, have since eliminated PVC from instrumentation panels in select car models. The actions of other companies compare. Baxter Healthcare recently committed to exploring PVC alternatives, as has Kaiser Permanente. Nike has also agreed to phase-out use of PVC in the soles of its footwear. Visa International is now using non-PVC based plastics in credit cards. Firestone, one of the largest manufacturers of roofing products, has recently implemented PVC alternatives, as have the communications firms German Telecom and Nippon Telegraph and Telephone. Exxon is one of the few petrochemical organizations moving away from PVC, investing instead in metallone polyolefins — a substitute polymer.

Without a doubt, PVC production and disposal poses significant hazards, to workers, communities and society at large. Viable alternatives exist. The question now is: do we have the will to change? Given the threat to human health, both today and tomorrow, we may have no choice.

A better understanding of how PVC is produced can be found at **www.hydropolymers.co.uk/en/products/pvc/pvc-today.html**. The website **www.healthybuilding.net** provides details on viable alternatives to PVC building materials. Also be sure to check out **www.bluevinyl.org**.

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