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Environmental and health hazards of chemicals in plastic polymers and products

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Abstract

Plastics are extremely diverse in terms of chemical composition, properties and possible applications, and are widely distributed in the society and the environment. In the last 15 years the global annual production has doubled, reaching 245 million tons in 2008. Several of the chemicals used to produce plastics are hazardous for human health and the environment. These, and their degradation products, may be released during the life cycle of a plastic product. The plastic polymers are not considered as toxic, but in plastic products there may be non-bound residual monomers, polymerisation chemicals, degradation products, and additives which have toxic properties.

The overall aim of this thesis, which is based on five papers [I-V], was to study the environmental and health hazards of chemicals in plastic polymers and products. Leaching tests, toxicity tests and Toxicity Identification Evaluations (TIEs) were made on plastic products [I, II], synthetic textiles [III], and discarded electronic products [IV]. A hazard ranking model was developed and used to rank plastic polymers based on monomer composition and environmental and health hazard classifications [V]. Also other hazardous substances needed to produce each polymer were identified [V].

Substances causing acute toxicity to *Daphnia magna* (water flea) leached from one third of all 83 plastic products/textiles even during short term (1-3 d) leaching in deionised water [I-III]. The toxic leachates came mainly from products that were soft to semi-soft, i.e. plasticised PVC (11/13) and polyurethane (3/4), and from epoxy products (5/5), and from synthetic textiles made of various plastic fibres [I-III]. The electronic product leachates that were acutely toxic came from mixed material and metal components, and not from plastics components. TIEs, performed on some leachates, indicated that the major toxicants were hydrophobic organics for the plastic product and synthetic textile leachates [I-III], and metals for the electronic product leachates [IV].

The polymers ranked as most hazardous are made of monomers classified as mutagenic and/or carcinogenic (category 1A or 1B). These belong to the polymer families of polyurethanes, polyacrylonitriles, PVC, epoxy resins, and styrenic copolymers (ABS, SAN and HIPS), and have a large global production (1-37 million tons/year). A considerable number of polymers, 31 out of 55, are made of monomers that belong to the two highest of the ranking model's five hazard levels [V]. Examples of such polymers, with a large global production (1-5 million tons/year), are phenol formaldehyde resins, unsaturated polyesters, polycarbonate, polymethyl methacrylate, and urea-formaldehyde resins [V].

The ranking model was useful for identifying and comparing hazardous substances, and the results from the hazard identification can be used for further hazard and risk assessment for decisions on the need for risk reduction measures, substitution or phase out.

In conclusion, considering the extensive dispersion in the society and the environment, the growing production, and the release and use of many hazardous chemicals, it is important to further assess the risks of chemicals associated with plastic polymers and products.

Key words: plastics, plastic products, plastic polymers, consumer products, environmental hazards, environment, health hazards, human health, hazard ranking, hazard assessment, chemical ranking, hazard identification, hazardous chemicals, emissions, toxic substances, toxicity, acute toxicity, aquatic toxicity, *Daphnia magna*, Toxicity Identification Evaluation, TIE, leaching, leachates, product leachates