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Organic Solvent Levels in Model and Hobby Glues

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Many organic solvents have been shown to be harmful to human health and the environment (Gregersen and Hansen 1986; CEC 1986; RSC 1989; Howard 1990). Besides occupational exposure to organic solvents, chronic non-occupational exposure to low levels of organic solvents may also be of concern to human health (Mølhave et al. 1986; Otto et al. 1992; Hundell et al. 1992). The health and safety aspects related with the industrial use of organic solvents or products containing organic solvents are regulated and controlled by national authorities. However, the conditions under which products containing organic solvents are used in private homes can not be controlled. It may, therefore, be presumed that the consumers may be at risk with the uncontrolled use of solvent-containing products, the risk which has not yet been evaluated or recognized.

Commonly used model and hobby glues are known to contain organic solvents. These glues are used for assembling various consumer goods and toys. The materials that need to be glued may be paper and paperboard, wood, leather, metal, plastic, textiles, china, etc. Thus, for various types of application, a wide range of model and hobby glues are available to the consumers. An analysis of 12 differnt toxic organic solvents in model and hobby glues was undertaken to obtain information regarding the solvents to which consumers may be exposed and the possibility of substitution of toxic solvents in these products with safer solvents. The results of the study are described in the present communication.

MATERIALS AND METHODS

26 samples of glues from 12 different manufacturers in Europe and the U.S.A. were obtained from the Danish Market, especially from toy dealers. The glues were marketed as universal glue, contact glue, plastic

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Table 1. Model and hobby glues analyzed.

Number of samples	Area of Application
5	Glue for polystyrene plastic model toy
3	Glue for plastic toys
5	Liquid cement for plastic
2	Cyanoacrylate glue for china, rubber, metal, wood, leather, plastic, etc.
6	Contact/universal glue for glass, wood, leather, china, earthenware, marble, paper and paperboard, textiles, metals, ceramics, etc.
1	Two component epoxy glue for metal, glass, wood, paper, photographs, textiles, leather, rubber, plastic, and synthetic materials
1	Two component methylmethacrylate glue for synthetic materials, wood, and metal. Not for polyethylene, PTFE, soft PVC, or polyamide
1	Glue for balsa wood, cork, china (glue for balsa wood model aircraft kit)
1	Glue for model building and repair
1	Glue for synthetic materials

glue, plastic cement, polystyrene cement, instant glue etc. The application areas of the glues analysed in the present study are described in Table 1.

Organic solvents in model and hobby glues were analysed by headspace gas chromatography (GC) and GC-mass spectrometry as described before (Rastogi 1991, 1992a, 1992b). The contents of the solvents in concentation >0.1% in the glues were determined by standard additions method employing headspace GC, and the solvents in concentration <0.1% were determined by headspace GC employing an external standard method.

RESULTS AND DISCUSSION

The 12 organic solvents, all of which are known to be harmful to human health, benzene, toluene, xylenes (a

mixture of o-, m- and p-xylene and ethyl benzene), styrene, methanol, cyclohexanone, dichloromethane, trichloromethane, tetrachloromethane, 1,1,1-trichloroethane, trichloroethylene, and tetrachloroethylene were selected for analysis in the present study. Besides their toxicity, another criterion for targetting these solvents was the fact that the glues for professional use were shown to contain these solvents in a previous study (Rastogi 1987). The solvents present in the model and hobby glues were identified on the basis of their retention times by GC as well as by their mass spectra.

Table 2. The content of toxic solvents in the investigated model and hobby glues.

Solvent	Detection limit (ppm)	No. of samples	Solvent content % (w/w)
Cyclohexanone	50	none	
Benzene	2	11	0.003 - 0.075
Toluene	10	9	0.001 - 0.042
		6	0.050 - 0.043
		7	1.0 - 28.5
Xylenes	10	11	0.001 - 0.045
		4	0.050 - 0.150
		1	21.4
Styrene	20	4	0.020 - 0.110
Methanol	20	2	0.005, 0.007
		4	0.060 - 0.340
		3	1.0 - 6.8
Dichloromethane	20	2	0.004, 0.004
		4	0.050 - 0.120
		2	1.0, 9.2
Trichloromethane	50	1	0.066
Tetrachloromethane	50	1	0.005
1,1,1-trichloroethane	20	2	0.002, 0.014
		1	5.1
		3	74.5 - 97.5
Trichloroethylene	50	2	0.007, 0.017
		1	0.160
Tetrachloroethylene	20	1	0.009

The detection limits and the contents of the 12 selected solvents in the model and hobby glues analysed are described in Table 2. The relative standard deviation (RSD) of the determination by standard additions and external standard methods were 3.9% and, 7.9% respectively.

None of the glues analysed in the present study were found to contain cyclohexanone. Benzene in the range of 0.003-0.075% (w/w) was present in 11 of the investigated samples, and 22 samples contained toluene in the concentration range of 0.001-28.5%. Xylenes were present in 16 samples; one sample contained 21.4% xylenes and the other 15 samples contained <0.15% xylenes. Four of the glues were found to contain 0.02-0.11% styrene. Methanol was found to be present in 9 samples; 3 of these contained 1-6% methanol, and the methanol content in the other 6 samples was <0.34%. Trichloromethane (0.066%), tetrachloromethane (0.005%), and tetrachloroethylene (0.009%) were present in one sample each, and trichloroethylene (0.007-0.150%) was found in 3 of the glues analysed. Six glues contained 1,1,1-trichloroethane; its content in 3 of the samples was >74%, and was 5.1, 0.014, and 0.002% in the other three samples. Dichloromethane was identified in 8 of the samples analysed. The content of dichloromethane in 6 of these samples was <0.2% and the other 2 samples contained 1 and 9.2%.

The results thus revealed that >1% of toluene, xylenes, methanol, dichloromethane, and 1,1,1-trichloromethane were present respectively in 27, 4, 12, 8 and 16% of the 26 model and hobby glues investigated. Small amounts (0.001 - 0.5%) of other toxic solvents selected, except cyclohexanone, were also found in several of the glues analysed. Residues of benzene, which is known to be a carcinogen (IARC 1982), were present in 42% of the glues. The model and hobby glues are used under uncontrolled conditions both by children and adults. Some persons, for example, model makers, may therefore be (sub)chronically exposed to toxic organic solvents by the use of model and hobby glues. The extent of the exposure will depend upon the amount of the solvent in the vapour phase, which depends upon the solvent content and the matrix of a glue, during the use of a glue, frequency of the use of the glue, contact of the glue with the skin, etc. The uptake of solvents by skin and its contribution to toxicity has been described by Daniell et al. (1992). The behavioral or developmental effects as a result of non-professional use of glues containing toxic solvents are not known, and no threshold value is available.

GC-MS analysis of the glues in the present study also

revealed other organic solvents present in these products. The main solvents of concentration >1% present in the glues are described in Table 3. From the knowledge of the main solvents identified in the glues (Table 3), a few possibilities of substitution of toxic solvents in the formulation of model and hobby glues may emerge. For example, 2 of the 5 polystyrene model glues in the present study did not contain xylene or

Table 3. Main solvent components in some of the glues.

Glue type	Sample no.	Main solvents % (w/w)
Liquid cement for plastic	674	1,1,1-trichloroethane (74.5%), toluene (24.4%), acetone, ethyl acetate
	902	1,1,1-trichlorethane (97.5%), isopropanol
	1506	Butanol, methyl acetate, butyl acetate, aromatic hydrocarbons C_9-C_{12}
	1509	Benzine, ethanol, n-butanol, ethyl acetate, butyl acetate, 1-methoxy-2- propanol, aroma- hydrocarbons C_9-C_{12}
	1511	Ethanol, n-butanol, methyl acetate, butyl acetate, aromatic hydrocarbons C_9-C_{12}
Polystyrene model glue	612	Ethanol, ethyl acetate, propyl acetate, isopropyl acetate
	672	Benzine, isopropanol, ethyl acetate, isobutanol, 1,1,1-trichloroethane (79.2%)
	903	Benzine, ethanol, acetone, methyl ethyl ketone, ethyl acetate, n-butanol, butyl acetate, xylene (21.4%)
	1507	Benzine, ethanol, ethyl acetate, propyl acetate, butyl acetate
	1510	Ethyl acetate, butyl acetate, n-butanol, aromatic hydrocarbons C_9-C_{12}

Table 3. Continued.

Glue type	Sample no.	Main solvents % (w/w)
Universal/ contact glue	614	Benzine, ethanol, methyl ethyl ketone, toluene (3.8%), dichloromethane (9.2%)
	743	Ethanol, isopropanol, methyl ethyl ketone, ethyl acetate, butyl acetate, methanol (1.0%), toluene (10.2%)
	889	Acetone, isopropanol, methyl acetate, ethyl acetate, propyl acetate, butyl acetate, 1,2-dimethoxyethane
	896	Benzine, ethyl acetate, toluene (8.4%)
	904	Ethanol, isopropanol, ethyl acetate, butyl acetate
	1527	Benzine, ethanol, methyl ethyl ketone, methyl acetate, ethyl acetate, toluene (1.5%)

Benzine: a mixture of C_5-C_7 alkanes, cyclohexane, methylcyclohexane and isooctane, as major components. n-hexane content <5%.

1,1,1-trichloroethane. Thus, presuming that these two polystyrene model glues (sample no. 612 and 1507) served their purpose of gluing polystyrene pieces properly, xylene or 1,1,1-trichloroethane may not be required for the formulation of this type of glue. From Table 3, it can also be seen that dichloromethane was found in only 1 of the 6 universal/contact glues analysed. Thus, it may be argued that dichloromethane may not be necessary in the formulation of universal/contact glue.

REFERENCES

CEC (1986) Organo-chlorine Solvents: Health risk to workers, Publication No. EUR 10531 EN, Commission of the European Communities, Directorate-General Information Market and Innovation, Luxembourg.

Daniell W, Stebbins A, Kalman D, O'Donelll JF, Horstman SW (1992) The contributions to solvent uptake by skin and inhalation exposure. Am Ind Hyg Assoc J 53 : 124-129.

Gregersen P, Hansen TB (1986) Organic Solvents. Miljøprojekt 72, National Agency of Environmental Protection, Copenhagen, Denmark.
Howard PH (1990) Fate and Exposure Data for Organic Chemicals, Vol. II : Solvents, Michigan, Lewis Publ.
Hundell HK, Otto DA, House DE, Mølhave L (1992) Exposure of humans to a volatile organic mixture, II. Sensory. Arch Environ Health 47 : 31-38.
IARC (1982) Discussion on benzene. IARC Eval Carcinogen Risk hum, IARC Monograph no. 29, Lyon, France, pp 95-144.
Mølhave L, Bach B, Pedersen OF (1986) Human reactions to low concentrations of volatile organic compounds. Environ Int 12 : 167-176.
Otto DA, Hundell HK, Mølhave L, Counts W (1992) Exposure of humans to a volatile organic mixture, I. Behavioral assessment. Arch Environ Hlth 47 : 23-30.
Rastogi SC 1987. Organiske opløsningsmidler i klæbestoffer, spartel- og fugemasser (Organic solvents in glues, jointing- and filling products), Report no. 7-1600L, Chemical Supervision Service, National Agency of Environmental Protection, Copenhagen, Denmark.
Rastogi SC (1991) Levels of organic solvents in printing inks. Arch Environ Contam Toxicol 20 : 543-547.
Rastogi SC (1992a) Headspace analysis of chlorinated organic solvents in aerosol cans by gas chromato graphy. Chromatographia 33 : 117-121.
Rastogi SC (1992b) Organic solvents in shoe- and leather glues. Toxicol Environ Chem 35: 213-217.
RSC (1989) Chemical Safety Data Sheets. Vol. I : Solvents, ed., D. Walsh, Royal Society of Chemistry, Cambridge, England.

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