



Phthalate and Organophosphate Plasticizers in Nail Polish

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Introduction

- ❖ In the early 2000s in the U.S., many nail polish products were found to list dibutyl phthalate (DnBP) as an ingredient.
- ❖ DnBP is a plasticizer that improves the flexibility of the nail polish film.
- ❖ Concerns grew because animal studies had identified DnBP as a reproductive and developmental toxicant .



the European Union banned DnBP in cosmetics in 2004.¹⁰ By 2006, companies in the U.S. started voluntarily labeling nail polish as “3-Free,” meaning the nail polish does not contain three widely publicized, so-called “toxic trio” chemicals: DnBP, toluene (a developmental and neurological toxicant), and formaldehyde (a human carcinogen).

The reported removal of DnBP has been promising given growing evidence of adverse effects on reproductive health, fetal development, thyroid function, and obesity.





Method

nail salons recruited for convenience by our parent exposure assessment study. For each of these brands, we examined the online descriptions of nail polish ingredients and chemical-related labels (e.g., 3-Free). In this manuscript, the term “label” refers to claims listed on the product itself or advertised by the company (e.g., in online product descriptions).

When brands had more than one nail polish product line (i.e., a nail polish product category that typically shares one label and ingredient list but consists of several different color options grouped together), we evaluated the product lines individually.

Then, we expanded our investigation with a multistep online search of labels.





Method

We started with the Google search keywords "nail polish," "3-Free," and "nontoxic," and iteratively expanded our search terms to include each other label type discovered.

In the searches, we again identified nail polish product lines with relevant labels .





Result

Nail Polish Labels. Identified 11 different n-Free labels ranging from 3-Free to 13-Free that reported the exclusion of n ingredients.

The 5-Free label was the most commonly used (17 brands[followed by 10-Free 0 brands])

Identified six different 10-Free label definitions, as well as three different definitions of 5-Free and 7-Free

Result

- Although all 10-Free product lines removed seven of the same chemicals (DnBP, toluene, formaldehyde, camphor, tosylamide/formaldehyde resin, parabens, and xylene), the remaining three chemical exclusions varied.
- For example, TPHP was only excluded in four 10-Free definitions and phthalates were only excluded in one definition .
- Other exclusions by only some of the 10-Free product lines were ethyl tosylamide, gluten, animal-derived ingredients, fragrance, lead, tert-butyl hydroperoxide, and soy
- Plasticizer-related ingredient exclusions included: DnBP, phthalates, camphor, TPHP, and ethyl tosylamide.^{50–55} All investigated product lines excluded DnBP, four of which excluded all phthalates

Result

plasticizer	<i>n</i> (%) detected	median [range]
OPs^b		
EHDPP	9 (22.5)	<0.01 [<0.01, 49.4]
PBDPP	30 (75)	0.387 [<0.005, 115]
TMPP	12 (30)	<0.0002 [<0.0002, 0.379]
TPHP	24 (60)	2.73 [<0.002, 7940]
phthalates^c		
BBP	40 (100)	1.00 [0.415, 2.13]
DEHA	35 (87.5)	0.107 [<0.002, 0.467]
DEHP	39 (97.5)	1.65 [<0.001, 331]
DEP	25 (62.5)	0.0140 [<0.001, 1.56]
DiBP	40 (100)	0.114 [0.00300, 0.778]
DMP	2 (5)	<0.0005 [<0.0005, 1.57]
DnBP	36 (90)	0.021 [<0.0005, 0.138]
DnHP	3 (7.5)	<0.0005 [<0.0005, 0.918]
DnOP	8 (20)	<0.0005 [<0.0005, 11.5]

Result

plasticizer	type	median [range]			
		old generation label ($n = 12$)	new generation label ($n = 28$)	detected TPHP ($n = 24$)	no detected TPHP ($n = 16$)
DEHP	phthalate	1.61 [0.703, 2.23]	1.67 [<0.001 , 331]	1.51 [<0.001 , 2.50]	68.5 [0.684, 331] ^b
PBDPP	OP	0.287 [<0.005 , 0.62]	0.522 [<0.005 , 115]	0.531 [<0.005 , 2.27]	0.151 [<0.005 , 115]
TPHP	OP	3730 [<0.002 , 7940]	<0.002 [<0.002 , 5330] ^c		

^aNote: Old generation, unlabeled or 3-Free; New generation, 5- to 13-Free; $<$, calculated value fell below the limit of detection. ^bSamples with detected TPHP significantly different from samples without detected TPHP at $p < 0.05$ (Wilcoxon rank sum test). ^cNew generation samples significantly different from old generation samples at $p < 0.001$ (Wilcoxon rank sum test).

Result

country	sample selection	n	OPs		phthalates								reference
			TPHP	BBP	DCHP	DEHA	DEHP	DEP	DiBP	DMP	DnBP	DnOP	
U.S.A.													
	popularity & labels	40	7900	2.1	ND	0.47	330	1.6	0.78	1.6	0.14	12	this study
	convenience & TPHP	10	17 000										Mendelsohn et al (2016)
	convenience & popularity	8		2.2	ND		140	9.2	59	0.22	27000	ND	Guo & Kannan (2013)
	convenience	4		ND	ND	ND	1–100	ND	1–100		ND	ND	Dodson et al (2012)
	convenience & 3-Free	25	25 000								88 000		CalEPA (2012)
	convenience	24		ND			ND	ND		ND	63 000		Hubinger (2010)
	convenience	6		110			ND	1100		15 000	60 000		Hubinger & Havery (2006)
other ^b													
Canada	convenience	20		ND	ND		1000	ND	0.4	ND	24 000	ND	Koniecki et al (2011)
China	convenience	10		ND	140		80	2	79	ND	5.7	5	Bao et al (2015)
Korea	convenience	21		ND			25	31			3900		Koo & Lee (2004)



Discussion

Can be defined differently by brands, the ingredient exclusions are usually not validated by a third party or justified for their relevance to health, and new label types are often not consistent with preceding labels in regard to the ingredients excluded. results showed that the number of ingredient exclusions in n-Free labels does not always translate to the degree of reduced toxicity. For example, the exclusions of animal-derived ingredients, gluten, fat, or soy may not impact nail polish toxicity. Thus, the expanded labels can cause confusion about the meaning of the labels, which originally intended to denote the number of toxic nail polish ingredients removed.





Discussion

Plasticizer Ingredient Levels. analysis showed that DnBP was not added as an ingredient in the 40 nail polish samples. The detected levels, all below 1 $\mu\text{g/g}$, were much lower than had been previously detected by most studies, although our sample selection was weighted toward popularity and label variety. The finding that samples do not contain added DnBP and that TPHP use has decreased demonstrates a public health success in which scientific research about harmful ingredients has successfully reached industry and impacted manufacturing practices.

Unmeasured plasticizers disclosed in the ingredient lists of our samples included alternatives that have been less studied for toxicity.





STRENGTHS AND LIMITATIONS

The results do not provide a comprehensive assessment of plasticizers in nail polishes across the whole nail polish market. For one, it is possible that DnBP is still present in some other products we did not analyze.

Second, during online research, investigated nearly 100 different U.S. nail polish brands, so our sampling of a dozen brands may not be generalizable to the large nail polish market.




Summary

In the 2000s, nail polish manufacturers started promoting “3-Free” products, phasing out three widely publicized toxic chemicals: toluene, formaldehyde, and dibutyl phthalate (DnBP).





Reference



Young, A., Allen, J., Kim, U., Seller, S., Webster, T., Kannan, K. and Ceballos, D., 2018. Phthalate and Organophosphate Plasticizers in Nail Polish: Evaluation of Labels and Ingredients. *Environmental Science & Technology*, 52(21), pp.12841-12850.



Thank you

