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Beyond HEMA: Shifts in the (Meth)acrylate Composition of Matched Nail Cosmetics Between 2023 and 2026

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ABSTRACT

Background: Allergic contact dermatitis from nail cosmetics is common. Most patients are allergic to HEMA. Increasingly, products are labelled 'HEMA-free'.

Objectives: To use ingredient lists to assess changes in the use of HEMA, Di-HEMA trimethylhexyl dicarbamate (Di-HEMA TMHDC), and other (meth)acrylates in nail cosmetics, and to investigate whether HEMA and Di-HEMA TMHDC occur in products not marketed for professional use.

Materials and Methods: We searched online for 394 products from 2023 and compared the 2023 and 2026 ingredient lists of products with the same brand and commercial name.

Results: Among 127 matched products, HEMA decreased from 65.4% to 16.5% (−75%) and Di-HEMA TMHDC from 27.6% to 7.1% (−74%). Trimethylolpropane triacrylate and urethane acrylate decreased by 63% and 54%, respectively. Benzyl methacrylate, urethane methacrylate, and trimethylolpropane trimethacrylate increased by 100%–225%. Four of 24 products containing HEMA and/or Di-HEMA TMHDC (16.7%; 3.1% overall) were apparently marketed directly to consumers without an identifiable online professional-use restriction.

Conclusions: Among matched nail cosmetics, ingredient lists indicated that the use of HEMA and Di-HEMA TMHDC decreased by approximately 75% over 3 years, while the use of several other (meth)acrylates changed substantially. Few products containing HEMA and/or Di-HEMA TMHDC appeared to be marketed directly to consumers.

1 | Introduction

In June and July 2023, we examined the ingredient lists of 394 nail cosmetics (gel nail polish, gel nails, acrylic nails and polygel nails) for the presence of 2-hydroxyethyl methacrylate (HEMA), Di-HEMA trimethylhexyl dicarbamate (Di-HEMA TMHDC), and other (meth)acrylates. HEMA was listed as an ingredient in 58% of these products, Di-HEMA TMHDC in 34%, and at least one of the two substances in 67% [1]. We found evidence suggesting that HEMA and Di-HEMA TMHDC were also present in products not specifically labelled for professional use, despite both substances having been restricted to professional-use nail products in the European Union since September 2021 [2]. The observation that many nail cosmetics are now labelled 'HEMA-free' prompted us to re-examine the ingredient lists of products included in our previous study [1]. The objectives of the present study were (1) to assess whether the proportions of products listing HEMA and Di-HEMA TMHDC decreased between 2023 and 2026; (2) to determine whether the listing of other (meth)acrylates and acrylate-related substances changed

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during this period; and (3) to investigate whether HEMA and Di-HEMA TMHDC continued to be used in products not specifically labelled for professional use.

2 | Materials and Methods

An artificial intelligence (AI)-assisted web search was conducted using OpenAI Codex (OpenAI, San Francisco, CA, USA; GPT-5.5 and GPT-5.6 Sol). The Excel database from our previous investigation, containing details of 394 nail cosmetic products examined in 2023, was used as input for the searches. For each product, Codex was instructed to identify a currently available product with the same brand and commercial product name and a current, publicly accessible ingredient list. Searches were first conducted on www.bol.com, the primary source used in the previous investigation, and then on manufacturers' websites and, when necessary, other publicly accessible retailer websites. The first sufficiently product-specific ingredient list identified through this sequence was used.

For the 127 products ultimately included, the corresponding publicly available webpages were also reviewed for explicit statements that a product was 'for professional use only' or that it 'can cause an allergic reaction' including equivalent wording in other languages. Products for which either statement was confirmed were categorised as warning-positive. General descriptions such as 'professional product' or 'professional quality' were not accepted as evidence of restricted use. Failure to identify a warning online was not considered evidence that it was absent from the product label or packaging.

All candidate product matches, and ingredient lists identified by Codex were manually reviewed by one author (N.A.I.). A product was included only when N.A.I. confirmed that its brand and commercial product name matched those recorded in 2023 and that a current ingredient list was available. Following this verification, Codex was used to assist with entering the 2026 ingredient lists into the Excel database containing the 2023 data, harmonising ingredient nomenclature, comparing the acrylate-related ingredient profiles in 2023 and 2026, and generating detailed tables. Product matches, extracted ingredient and warning data, comparisons, and tables were subsequently checked and corrected where necessary by the authors.

Throughout the manuscript, references to the presence or use of an ingredient, and to increases or decreases therein, refer to information derived from the available ingredient lists rather than chemical analysis; these terms are used for readability, although ingredient lists may not always be complete, accurate, or up to date.

2.1 | Statistical Analysis

The distribution of the four main product categories among products included and not included in the paired analysis (gel nail polish, gel nails, acrylic nails, polygel) was compared using the Fisher–Freeman–Halton exact test. Differences in the 2023 prevalence of HEMA, Di-HEMA TMHDC, and either substance were assessed using Cochran–Mantel–Haenszel analyses stratified by product category and are presented as common odds ratios (ORs) with 95% confidence intervals (CIs).

Within-product changes were classified as listed in both years, listed in 2023 only, listed in 2026 only, or listed in neither year. Changes in HEMA, Di-HEMA TMHDC, and the three other acrylate-related ingredients showing the largest net decreases were analysed using two-sided exact McNemar tests based on the discordant pairs. The resulting p-values were adjusted for five comparisons using the Holm method. All tests were two-sided, with $p < 0.05$ considered statistically significant.

Analyses were performed using R version 4.6.1 (R Foundation for Statistical Computing, Vienna, Austria).

3 | Results

3.1 | Selection and Characteristics of the Paired Product Sample

Of the 394 products from our 2023 survey, 127 (32.2%) met the criteria for inclusion in this study of having the same brand and commercial product name as in 2023 and a current, publicly accessible ingredient list. All four main product categories were represented in the matched sample, although gel nail polish products were overrepresented (76.4% vs. 60.7%) and gel nail, acrylic nail and polygel products were correspondingly underrepresented (overall exact $p = 0.020$). After stratification by product category, no statistically significant differences were observed between matched and non-matched products in the proportions listing HEMA (common OR 1.50, 95% CI 0.96–2.35; $p = 0.075$), Di-HEMA TMHDC (common OR 0.66, 95% CI 0.41–1.06; $p = 0.081$), or either substance (common OR 1.15, 95% CI 0.72–1.83; $p = 0.560$). The subset comprised 38 of the 59 original brands and included products from every country-of-origin category represented in the original sample.

Seventy acrylates and acrylate-related chemicals (hereafter collectively termed acrylates) were identified in the products' ingredient lists; 50 were found in both 2023 and 2026, 10 only in 2023, and 10 only in 2026.

3.2 | Negative and Positive Changes Between 2023 and 2026

Selected negative and positive changes in acrylate use in the 127 nail cosmetics between 2023 and 2026 are shown in Table 1. The number of products containing HEMA decreased from 83/127 (65.4%) to 21/127 (16.5%), a decrease of 62 products (a relative decrease of 75% from 2023). Di-HEMA trimethylhexyl dicarbamate (Di-HEMA TMHDC) was present in 35 products (27.6%) in 2023 and in 9 (7.1%) in 2026, a decrease of 26 products (74%). The proportions of products containing trimethylolpropane triacrylate and urethane acrylate decreased by 63% (from 16 to 6) and 54% (from 26 to 12), respectively (Table 1).

Product-level transition analysis confirmed that the observed decreases predominantly reflected ingredients that were no longer listed in 2026. HEMA was listed in both years in 20

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TABLE 1 | Acrylate-related ingredients present in 127 nail cosmetic products: Changes from 2023 to 2026.

Acrylate-related ingredients	CAS number[b]	Number of products 2023, *n* (%)	Number of products 2026, *n* (%)	Change from 2023 to 2026, *n* (%)[e]
Negative change from 2023 to 2026				
HEMA	868-77-9	83 (65.4%)	21 (16.5%)	−62 (−75%)
Di-HEMA trimethylhexyl dicarbamate	72869-86-4	35 (27.6%)	9 (7.1%)	−26 (−74%)
Trimethylolpropane triacrylate	15625-89-5	16 (12.6%)	6 (4.7%)	−10 (−63%)
Urethane acrylate[a]		26 (20.5%)	12 (9.4%)	−14 (−54%)
Special tertiary amine acrylate[a]		8[c]	—	−8
Tetrahydrofurfuryl methacrylate	2455-24-5	5	1	−4
VP/dimethylaminoethylmethacrylate copolymer	30581-59-0	4	1	−3
Glycol HEMA-methacrylate (synonyms: Glycol dimethacrylate, Ethylene glycol dimethacrylate)	97-90-5	6	4	−2
Isopropylidenediphenyl bisoxyhydroxypropyl methacrylate	1565-94-2	3	1	−2
Positive change from 2023 to 2026				
Benzyl methacrylate	2495-37-6	4 (3.1%)	13 (10.2%)	+9 (+225%)
Urethane methacrylate[a]		4 (3.1%)	9 (7.1%)	+5 (+125%)
Trimethylolpropane trimethacrylate	3290-92-4	9 (7.1%)	18 (14.2%)	+9 (+100%)
Acrylates copolymer		39 (30.7%)	53 (41.7%)	+14 (+36%)
Hydroxypropyl methacrylate	27813-02-1	31 (24.4%)	42 (33.1%)	+11 (+35%)
Isobornyl methacrylate	7534-94-3	20 (15.7%)	26 (20.5%)	+6 (+30%)
Polyether modified polyurethane acrylate resin[a]		—	7[d]	+7
Acryloyl morpholine	5117-12-4	2	5	+3
Bis-HEA poly(1,4-butanediol)-9/IPDI copolymer		1	4	+3
Bis-HEA poly(1,4-butanediol)-22/IPDI copolymer		—	3	+3
Isobornyl acrylate	5888-33-5	6	9	+3
PPG-2 neopentyl glycol diacrylate	84170-74-1	—	3	+3

[a]Not present in the INCI nomenclature database. https://ec.europa.eu/growth/tools-databases/cosing/.
[b]CAS Registry Numbers were checked against publicly accessible chemical databases, including CAS Common Chemistry where available. They could not be independently validated against the full CAS Registry; therefore, occasional errors cannot be excluded.
[c]Multiple variants of top coats, base coats, primers, and base gels from the same brand.
[d]Seven products from one brand; in four of these seven products, 'special tertiary amine acrylate' was no longer listed in 2026.
[e]Percentages are shown only when the absolute change was at least five products and the ingredient was identified in both years.

products, in 2023 only in 63, in 2026 only in one, and in neither year in 43; the corresponding numbers for Di-HEMA TMHDC were 8, 27, 1 and 91, respectively. Both decreases were statistically significant (Holm-adjusted exact McNemar $p < 0.001$). Significant decreases were also observed for trimethylolpropane triacrylate, urethane acrylate and special tertiary amine acrylate (Holm-adjusted *p*-values: 0.041, 0.023, and 0.023, respectively; Table S1).

Acrylates that increased in frequency from 2023 to 2026 are shown in Table 1. Benzyl methacrylate showed the largest relative increase (from 4 to 13, 225%), followed by urethane methacrylate (from 4 to 9, 125%), trimethylolpropane trimethacrylate (from 9 to 18, 100%), acrylates copolymer (from 39 to 53, 36%), hydroxypropyl methacrylate (from 31 to 42, 35%), and isobornyl methacrylate (from 20 to 26, 30%). The absolute increase was largest for acrylates copolymer ($n = 14$), followed by

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hydroxypropyl methacrylate ($n = 11$), benzyl methacrylate, and trimethylolpropane trimethacrylate (both $n = 9$) (Table 1).

3.3 | HEMA and Di-HEMA Trimethylhexyl Dicarbamate in Relation to Professional-Use Warnings and Consumer-Directed Marketing

Of the 127 nail cosmetic products investigated, 37 (29.1%) were accompanied in 2026 by a confirmed, explicit professional-use restriction and/or allergic-reaction warning (hereafter termed warning-positive products). Among these products, the proportion listing HEMA and/or Di-HEMA TMHDC decreased from 33/37 (89.2%) in 2023 to 15/37 (40.5%) in 2026. Eighteen products (48.6%) changed from listing one or both substances to listing neither, whereas none changed in the opposite direction. The proportion listing HEMA decreased from 89.2% to 37.8%, and the proportion listing Di-HEMA TMHDC decreased from 32.4% to 10.8%.

Among the 90 products without a confirmed warning, the proportion listing HEMA and/or Di-HEMA TMHDC decreased from 55/90 (61.1%) in 2023 to 9/90 (10.0%) in 2026. Of the nine products without a confirmed warning that listed HEMA and/or Di-HEMA TMHDC, four were consumer-directed, two were considered likely to be intended for professional use, and three could not be assessed with confidence. Forty-seven products (52.2%) changed from listing at least one substance to listing neither, whereas one product changed from listing neither substance to listing HEMA.

Of the 21 products listing HEMA in 2026, 14 (66.7%) were warning-positive. One additional product was considered likely to be intended for professional use, two could not be assessed, and four (19.0%) were directly marketed to consumers without an identifiable professional-use restriction. Of the nine products listing Di-HEMA TMHDC, four (44.4%) were warning-positive, one was considered likely to be intended for professional use, one could not be assessed with confidence, and three (33.3%) were consumer-directed. HEMA and Di-HEMA TMHDC were co-listed in six products, three of which were warning-positive and three were consumer-directed.

3.4 | Detailed Supporting Information

Detailed data on acrylate-related ingredients in the 127 paired nail cosmetics are presented in Tables S1–S5: product-level transitions in five acrylate-related ingredients between 2023 and 2026 (Table S1), frequency and rank (Table S2), alphabetical listing (Table S3), changes from 2023 to 2026 (Table S4), and ingredients omitted or added (Table S5).

4 | Discussion

To the best of our knowledge, this is the first longitudinal study comparing the presence of (meth)acrylates and (meth)acrylate-related chemicals in the same group of nail cosmetics at two time points. This paired design allowed us to examine changes in the declared composition of established products during a period of increasing concern about nail cosmetic allergy and growing use of 'HEMA-free' marketing claims.

In recent years, an 'epidemic' of allergic contact dermatitis (ACD) has been observed among professional nail technicians applying gel polish, gel nails, and acrylic nails, as well as among consumers applying these products themselves [3, 4]. Many nail cosmetics have contained HEMA; in our previous market survey, HEMA was listed in 229 of 394 products (58%) [1]. Moreover, approximately 80%–90% of patients with ACD caused by nail cosmetics have positive patch test reactions to HEMA [5, 6]. In response to reports of sensitisation, Commission Regulation (EU) 2020/1682 amended Annex III to the EU Cosmetics Regulation. Since September 2021, nail products containing HEMA and/or Di-HEMA TMHDC have been restricted to professional use and must carry the warnings 'For professional use only' and 'Can cause an allergic reaction' [2].

The extensive attention paid to acrylate allergy in both the scientific literature and the public media, together with the prominent role attributed to HEMA, is likely to have influenced manufacturers. During the same period, increasing numbers of nail cosmetics were marketed as 'HEMA-free'. This suggested that HEMA might be removed from existing products and/or used less frequently in newly developed formulations and prompted us to re-examine products included in our 2023 survey.

Of the 394 products investigated in 2023, 127 could be matched to products that had the same brand and commercial product name and for which a current ingredient list was publicly accessible in 2026. All four product categories were represented, but gel nail polish products were overrepresented in the matched subset. After stratification by product category, however, no statistically significant differences were observed between matched and non-matched products in the proportions listing HEMA, Di-HEMA TMHDC, or either substance.

The paired comparison demonstrated a marked decrease in the listing of HEMA. The proportion of products listing HEMA decreased from 65.4% in 2023 to 16.5% in 2026, corresponding to a relative reduction of 75%. The proportion of products listing Di-HEMA TMHDC, the other substance restricted under the EU Cosmetics Regulation, decreased from 27.6% to 7.1%, a relative reduction of 74%. Substantial decreases were also observed for trimethylolpropane triacrylate (−63%) and urethane acrylate (−54%). Conversely, benzyl methacrylate, urethane methacrylate, and trimethylolpropane trimethacrylate showed relative increases of 100%–225%. More modest increases of 30%–36% were observed for acrylates copolymer, hydroxypropyl methacrylate, and isobornyl methacrylate.

Although the listing frequencies of several methacrylates increased while those of certain acrylates decreased, these opposing trends should not be interpreted as evidence of direct substitution. Our product-level comparison provided little evidence that individual acrylates had been replaced by their corresponding methacrylates within the same products. The observed changes may instead reflect broader reformulation strategies. Similarly, although the marked reductions occurred after the implementation of the EU restriction and during the increasing promotion of 'HEMA-free' products, this observational

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study cannot establish whether regulation, consumer demand, safety considerations, or other factors caused the changes.

Among the 37 products accompanied in 2026 by a confirmed professional-use restriction and/or allergic-reaction warning ('warning-positive products'), the proportion listing HEMA and/or Di-HEMA TMHDC decreased from 33/37 (89.2%) in 2023 to 15/37 (40.5%) in 2026. One or both substances were no longer listed in 18/37 products (48.6%), whereas neither substance was added to any product. However, we could not verify whether all 37 products had also been restricted to professional use in 2023; these findings therefore cannot be interpreted as a longitudinal comparison of products restricted to professional use.

The decrease was even more pronounced among the 90 products without a confirmed online warning in 2026: the proportion of products listing HEMA and/or Di-HEMA TMHDC decreased from 55/90 (61.1%) in 2023 to 9/90 (10.0%) in 2026. This category should not be equated with consumer products, because it was defined by the absence of a confirmed warning in the publicly available online information. Nevertheless, the decreases observed in both groups suggest that reformulation was not confined to a single market segment.

In our previous survey, complete label and packaging information was available for 25 products containing HEMA ($n = 20$) and/or Di-HEMA TMHDC ($n = 15$). All were legally required to carry both mandatory warnings. However, the statement 'For professional use only' was absent from nine products (36%), while 'Can cause an allergic reaction' was absent from 14 (56%). In the current investigation, four of the 24 products listing HEMA and/or Di-HEMA TMHDC (16.7%) appeared to be marketed directly to consumers without an identifiable online professional-use restriction, representing 3.1% of all 127 products investigated. These percentages cannot be compared directly; however, because the previous study assessed labels and packaging, whereas the current investigation was based primarily on publicly available online information.

Whether the marked reduction in HEMA will result in fewer consumers and nail technicians becoming sensitised or developing ACD remains unknown. Although 80%–90% of patients with ACD caused by nail cosmetics react to HEMA on patch testing, it is often impossible to determine whether HEMA was the primary sensitiser. Other (meth)acrylates present in the same products may have been the actual sensitisers, with the reaction to HEMA resulting from cross-reactivity, or several ingredients may have acted as co-sensitisers. Similar uncertainty applies to the clinical consequences of the decreased use of Di-HEMA TMHDC, trimethylolpropane triacrylate, and urethane acrylate, the last of which is a poorly defined chemical designation.

The implications of the increased use of benzyl methacrylate, urethane methacrylate, trimethylolpropane trimethacrylate, hydroxypropyl methacrylate, and isobornyl methacrylate are likewise difficult to predict. Importantly, 'HEMA-free' does not mean (meth)acrylate-free or necessarily imply a lower sensitisation risk. Fully polymerised copolymers would generally be expected to have less sensitising potential than reactive monomers because of the copolymers' higher molecular weight and limited skin penetration. However, 'Acrylates Copolymer' is an ill-defined INCI designation, and residual monomers may remain clinically relevant. Its increased use therefore cannot automatically be considered harmless.

In our clinic, we have not yet observed a clear decrease in the proportion of patch-tested patients diagnosed with ACD caused by acrylates in nail cosmetics: 2.7% in 2023, 2.4% in 2024, 4.0% in 2025, and 2.4% in 2026 up to June 30. The peak in 2025 may reflect increased referrals prompted by the exceptional media attention surrounding nail cosmetic allergy at that time rather than a genuine increase in incidence. These clinic-based frequencies are strongly influenced by referral patterns and should not be interpreted as population incidence. Moreover, any clinical effect of product reformulation may become apparent only after a delay.

Two previous studies investigated trends in HEMA contact allergy following the implementation of the 2021 European legislation restricting HEMA-containing nail cosmetics to professional use [7, 8]. The European Environmental Contact Dermatitis Research Group reported prevalences of 1.30% in 2021, 1.52% in 2022, and 1.98% in 2023 [7]. An Italian study likewise reported prevalences of 2.4%, 2.5%, and 2.7%, respectively [8]. Neither study therefore showed a decline after the implementation of the legislation. However, follow-up was limited to approximately 2 years after September 2021 and may have been too short to detect an effect on sensitisation frequencies.

4.1 | Conclusions

Among 127 matched nail cosmetics, ingredient lists indicated that the use of HEMA and Di-HEMA TMHDC decreased by approximately 75% between 2023 and 2026, while the use of trimethylolpropane triacrylate and urethane acrylate decreased by 63% and 54%, respectively. Benzyl methacrylate, urethane methacrylate, and trimethylolpropane trimethacrylate increased by 100%–225%. Few products containing HEMA and/or Di-HEMA TMHDC appeared to be marketed directly to consumers without an identifiable online professional-use restriction. HEMA-free labelling does not imply that a product is free of other potentially sensitising (meth)acrylates or necessarily has a lower sensitisation potential.

4.2 | Limitations

Only 127 of the 394 products investigated in 2023 could be included in the paired analysis, and gel nail polish products were overrepresented in this subset. Although product-category-stratified analyses showed no statistically significant differences between included and non-included products in the proportions listing HEMA, Di-HEMA TMHDC, or either substance, selection bias cannot be excluded and the subset may not fully represent the original sample or the wider nail cosmetics market. Ingredient lists were obtained from online sources, and their accuracy, completeness and current validity could not always be independently verified; they may therefore not reflect the formulation actually marketed at the time of the 2026 assessment. SKU numbers or product codes were not systematically available and therefore could not be used for product matching.

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Furthermore, the absence of a professional-use restriction or an allergy warning online does not establish that such information was absent from the product label or packaging. Professional-use status in 2023 could not be assessed reliably, precluding evaluation of changes in this status over time.

Author Contributions

Norbertus A. Ipenburg: conceptualization, investigation, formal analysis, writing – review and editing. **Anton C. de Groot:** investigation, writing – original draft, writing – review and editing. **Thomas Rustemeyer:** supervision, writing – review and editing.

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The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Research data are not shared.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Table S1:** Product-level transitions in five acrylate-related ingredients between 2023 and 2026. **Table S2:** Frequency and rank of acrylate-related ingredients in 127 paired nail cosmetic products in 2023 and 2026. **Table S3:** Alphabetical list of acrylate-related ingredients present in 127 nail cosmetic products in 2023 and 2026. **Table S4:** Acrylate-related ingredients present in 127 nail cosmetic products: Changes from 2023 to 2026. **Table S5:** Acrylate-related ingredients omitted and added between 2023 and 2026.

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