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An Initial Lexicon of Sensory Properties for Nail Polish

Chen Sun, Kadri Koppel*, and Edgar Chambers IV

The Sensory Analysis Center, Kansas State University, 1310 Research Park, Manhattan, KS, 66502, U.S.A. Tel.: 785-532-0163; fax: 785-532-3132; e-mail: csun@k-state.edu, kadri@ksu.edu, eciv@ksu.edu.

*Corresponding author: Kadri Koppel. The Sensory Analysis Center, Kansas State University, 1310 Research Park, Manhattan, KS, 66502, U.S.A. Tel.: 785-532-0163; fax: 785-532-3132; e-mail: kadri@ksu.edu.

Synopsis

OBJECTIVE: The objective of this study was to develop an initial lexicon for sensory properties of nail polish and to validate this lexicon using a descriptive analysis study of selected samples.

METHODS: Seventeen commercial products from four categories (regular, flake-containing, water-based and gel) were used in this study. Descriptive sensory analysis was conducted in this study to characterize and evaluate application and removal properties of these nail polishes. Data was then processed by Analysis of Variance (ANOVA), Principal Component Analysis (PCA) and Pearson's Correlation Coefficient analysis to explore the differences among samples and attributes.

RESULTS: A lexicon of twenty-one sensory attributes was developed to describe the application of nail polish. It included three initial texture attributes, thirteen initial appearance attributes and five aroma attributes. A lexicon of five attributes in five stages was developed to describe the removal of nail polish. The results from ANOVA and PCA showed that attributes in the lexicon separated the different product categories.

CONCLUSION: The results of this study indicated that descriptive sensory analysis can be used to evaluate nail polish. The results of this study present scientists who are working on nail polish an additional tool to describe application and removal properties of nail polish.

Keywords: nail polish, sensory, descriptive analysis, nail physiology, statistics, Colour cosmetics

Introduction

Cosmetics play an important role in our daily life. *Time.com* [1] reported that the nail care industry has been one of beauty's fastest-growing sectors in recent years and has encountered trends such as decorative treatments and textured polishes. *Women's Wear Daily* reports nail polish sales hit a record $768 million in the U.S. in 2012, a 32% gain over 2011[2]. This has probably happened because of uncertain economics, as consumers are looking for more affordable solutions for a manicure and opt for at-home treatments instead of salon services.

Several papers have been published on the physical aspects of nail polish. In 1981, Schlossman discussed techniques to evaluate the physical properties of nail polish. For example, a Taber Abraser or similar instrument is used to measure abrasion resistance through the action of two resilient abrading wheels which are made to rub the coated surface [3]. In 1993, Schlossman and Wimmer discussed new techniques such as employing acetone or halogenated hydrocarbons as the solvents to develop a quick drying nail polish, pouring nail enamel onto an adhesive-backed sheet of paper to make a non-brushing nail polish, and changing the ingredients to develop a water-dilutable nail polish [4]. A similar product, called "water-based nail polish" had been patented a year earlier by Koch and Rassek [5]. In 2000, Mui and *et al.* developed an internal flow time release formula by optimizing the film characteristics of conventional quick dry nail polish. This formula was able to provide consistent performance over a wide range of temperatures, oil content and surface abrasion of human nails [6].

As is common in the cosmetics and also other industries, most innovations in the nail polish sector are patented. Examples of innovations closely related to nail polishes are abundant; these include creation and implantation of an artificial nail [7], a foam applicator for nail polish [8], and a patent for a packaging and applicator device [9]. There are also several patented nail

polish inventions, such as a top coat system [10], UV-curable nail coating formulations [11], and nail strips [12], among others.

According to Parente *et al.*, understanding the sensory properties of emollients may help provide important information to the development of cosmetics [13]. However, scientific articles on the sensory properties of nail polish are scarce, which suggests the information is proprietary. One of the few such publications studied correlations between judgment and nervous system response using cosmetic products, including nail polishes [14]. Other cosmetics, such as spa spring waters [15], talc slips [16], personal care products [17], emollients [13], and lipstick [18] have been studied using sensory analysis methods. Thus, this study could provide important information on the sensory properties of nail polishes scientists who are interested in improving human perceived sensory aspects of the application, finish, and removal of nail polish.

The objective of this study was to develop a lexicon for application, appearance, and removal properties of nail polish and to validate the lexicon using descriptive sensory analysis.

Materials and Methods

Panelists

Six panelists from the Sensory Analysis Center at Kansas State University participated in this study. All panelists had received more than 120h of descriptive analysis training, and had more than 2000h of descriptive analysis experience, including evaluating nonfood products such as lipstick [18] and textiles [19, 20].

Samples and Carriers

Seventeen commercial nail polishes were used to develop and validate the lexicon (Table I). Only red nail polish products were evaluated to reduce the effect of different colors on nail

polish sensory attributes. The products were 9 regular nail polishes and three categories of specialty products, including gel nail polishes (n=4), water-based nail polishes (n=2), and flake-containing nail polishes (n=2).

All the seventeen products were used for application evaluation either with a basecoat (n=11, in cases where a same brand basecoat was available) or without a basecoat (n=17). Eleven of the products were used for removal evaluation either with a basecoat and a topcoat (n=7, in cases where a same brand basecoat and topcoat were available) or without any basecoat and topcoat (n=11). Only products that could be removed with acetone were included in the removal evaluation. The coated version and uncoated version from the same sample were treated as independent samples.

Application and removal were evaluated as two separate processes with their distinct sensory attributes. When applying a nail polish product, the aesthetic characteristics, mainly visual and textural, but also aromatic characteristics of a nail polish would be valued, whereas, when removing polish, the ease with which the nail polish can be removed would be valued.

All nail polishes were maintained in their original bottles wrapped with red masking tape to blind specific product information. A three-digit code was assigned to each product for tracking purposes. Products were stored at room temperature (25±1°C) and protected from sunlight.

A total of 12 identical artificial hands (Premier Soft Hands, China) were used as carriers for artificial nails (Brentwood Beauty laboratories International, Inc., Dallas, TX, USA). The nails were adhered to the hands using nail glue (Professional Nail Glue, American International Industries, Los Angeles, CA, USA). Nail polishes were evaluated on the artificial nails other

than on real nails to provide consistency among different panelists, and because of ease of cleaning and safety concerns for too frequent application and removal of polish for panelists actual nails.

Test Preparation

Application

The preparation work for application studies was done one day before the test day. Artificial nails were renewed daily. A label with a three digit code was placed on each finger of the artificial hand to indicate the product. If a basecoat was used, it was applied by a technician in three strokes – one in the middle, then one to the left, and finally one stroke to the right side of the artificial nail – before the panelists coated the nail with polish. Furthermore, if a curing process was required, the basecoat would be cured immediately under either a UV light or a LED light as required by the sample manufacturer (Table I). Prepared hands and nails were stored overnight at ambient temperature (25±1°C) at approximately 55% relative humidity.

Removal

Preparation work for removal studies also was done one day before the test day. In case a basecoat layer was needed, it was applied in three strokes (middle, left, right) and was allowed to dry for 5 min. If no basecoat was used, that step was skipped. The first coat of sample in three strokes was applied and was allowed to dry for 5 min. The second coat of sample was applied in three strokes and was allowed to dry for 5 min. Finally, a topcoat was applied if required by the sampling design.

Acetone (Brentwood Beauty laboratories International, Inc., U.S.) poured on a cotton pad (Esthetician Services, Inc., Los Angeles, CA, USA) was used as the removal liquid for the nail

polishes. The acetone used (0.41 ml) was measured into 5 ml brown glass bottles and supplied to each panelist for removal.

Lexicon development

A total of eight 1.5h sessions were used for lexicon development. Five of the sessions were used for lexicon development for the application process and appearance and the other three sessions were for lexicon development for the removal process. For guidance, the panel initially was given lexicons that had been used for lipstick [18] and in proprietary studies of automotive paint finishes, but were encouraged to modify terminology and add to or remove terms to create an appropriate lexicon for nail polishes. Panelists used the attributes that were appropriate for nail polish from previous studies, and generated new attributes according to the features of nail polish. Definitions for the new attributes were then created by the panel, and references were developed by researchers in Sensory Analysis Center according to the panel's request. All the sessions took place in a noise and climate controlled room (25±1°C and 55% relative humidity). This procedure is similar to that used for other recent studies [18, 21, 22] and has been shown to be reasonably consistent among different panels [23].

Lexicon validation

A total of two days of 1.5h orientation and fourteen days for 1.5h individual evaluation sessions were conducted. During orientation, several mock evaluations, followed by comparison of scores, were performed for calibration among panelists. Evaluation techniques (Table II) were developed so that panelists could use the same procedures evaluating products. An incomplete block design was used for evaluation of application and removal attributes of the samples. Six highly trained panelists participated in this study. Three replications were conducted for each sample. No discussion was allowed during evaluation. In the middle of each evaluation session,

there was a 10 min break. Panelists used a scale, from 0 (extremely low) to 15 (extremely high) with 0.5 increments to evaluate the intensity of attributes. These evaluation procedures are typical and have been used for other sensory studies. [18, 23]

Data analysis

The Sensory Analysis Center uses Compusense at-hand (Compusense Inc., Guelph, ON, Canada) for data collection. Analysis of Variance (ANOVA) was performed using the Glimmix procedure in SAS® statistical software (Version 9.3, SAS Institute Inc., Cary, NC) to identify significant differences ($p<0.05$) among nail polishes for each attribute. If significant differences were noted, the LSMeans procedure was used to determine specific differences among products. Pearson's correlation coefficients were calculated to explore the correlations between each pair of descriptive attributes using SAS®.

Principal Component Analysis (PCA) was conducted to detect the relationships among attributes and samples (The Unscrambler X version 10.2, Camo Software AS, Oslo, Norway). According to Abdi and Williams [24], PCA is a multivariate technique that analyzes a data table in which observations are described by several inter-correlated quantitative dependent variables. Its goal is to extract the important information from the table, to represent it as a set of new orthogonal variables called principal components, and to display the pattern of similarity of the observations and of the variables as points in maps.

Results and Discussion

Lexicon Development

Application and appearance of nail polish

Several attributes such as smoothness, spreadability, initial-drag, color intensity, shininess, wet-appearance, glittery, pearl-like, coverage, and opacity used in a lip product study conducted by Dooley *et al.* [18] were considered applicable for this nail polish study. Definitions and references for these attributes were modified for nail polish. For example, ChapStick® classic (Pfizer, Madison, NJ, USA) was not appropriate as a high intensity (12.0 on a scale from 0 to 15.0) reference for initial-drag. Thus, the panel assigned a lower score-6.0 to the Chapstick, and added two new references with higher intensities for initial-drag. These were sandpaper (fine) =10.0 and sandpaper (rough) =14.0 (Table III).

Some of the sensory properties developed by the panel and related to the liquid characteristics of the nail polish were runny, fatty-edge, blisters, pinholes and brushlines. A flake-protrusion attribute was developed to characterize the flake configuration in nail polishes F1 and F2. Five aromatics attributes developed for the application study were petroleum-like, acetone, nutty, woody, and fruity-floral. The standard references for aroma were either specific products or chemical solutions. For example, Vaseline® (Unilever, Trumbull, CT, USA) was used as the reference for attribute petroleum-like, and 2-acetyl-pyridine (100 ppm in water) solution was used as the reference for attribute nutty.

Appearance attribute references, except runny, wet-appearance and shininess, were all pictures or photographs. Some of them (color intensity, glittery, pearl-like, opacity) were adopted from a lip product study [18], while others (fatty-edge, blisters, pinholes, coverage,

brushlines, flake-protrusion) were developed or modified by the panel. For example, the attribute fatty-edge was defined, and references were developed by painting with a brush at different application pressures using different amounts of paint until the appropriate levels of edge were developed. Then photographs of those standards were used as references during evaluation.

Removal of nail polish

Five attributes were evaluated in the removal of nail polish to characterize ease of removal and potential residues on nail surface. The ease of removal attributes included drag and number of strokes; and the potential residues attributes included shine, coverage, and color intensity. Each attribute was evaluated at up to 5 different time points: before evaluation, after one stroke with acetone-soaked cotton pad, after five more strokes, after another five strokes, and number of strokes necessary to completely clean the nail. In case the number of strokes was higher than 20, the panel would stop and evaluate the attributes in the last stage. The standard references used for removal evaluation were the same as the ones used in the application evaluation.

Lexicon Validation

Application and appearance

Results (Table IV) suggested that the lexicon of 21 application attributes can separate the 28 nail polish samples (17 non-basecoat products + 11 basecoat products) effectively. Significant differences were detected in 20 out of 21 sensory attributes. Blisters was the only attribute where no significant differences among samples were found.

Flake-protrusion and pearl-like were attributes that were detected in only a limited number of samples. The flake-protrusion attribute separated flake-containing products and non-

flake products. Pearl-like was scored around 1.5 for two regular samples and one water-based sample, whereas it was scored a 0 or close to 0 in all the other samples. Pearlescent may not be a major characteristic of this set of sample, but it is still relevant to the sensory property of nail polish. In addition, although glittery separated samples into six groups, more than half of the samples scored zero for the attribute glittery because those samples did not have that characteristic. The use of attributes such as pearl-like and glittery would depend on the objectives and samples included in the study.

The texture and appearance attributes in the lexicon were able to discern differences among and within the four nail polish categories - regular, flake-containing, gel and water-based. Several attributes (smoothness, spreadability, initial-drag, wet-appearance and coverage) could separate flake-containing samples and water-based samples from regular and gel samples. For example, flake-containing samples BF2, F1 and F2 and water-based samples W1 and W2 were lowest in smoothness. Two attributes (color intensity and runny) were useful in separating water-based products from the other samples; water-based samples were low in intensity for both attributes. Shininess separated gel nail polish from the other samples, because all the gel nail polish samples (BG1, BG2, BG3, BG4, G1, G2, G3 and G4) exhibited shininess properties high in intensity. The brushlines and pinholes attributes separated samples within the gel category. Gel nail polish samples BG3 and G3 were scored highest in intensity of brushlines and pinholes. Among the aroma attributes, acetone separated regular samples from gel-type and water-based samples. The fruity-floral aroma addition to samples G2, W1 and W2 could cover up the acetone or other notes that could be present.

Principal Component Analysis (PCA) of the 21 application attributes helped visualize the differences among the four product categories (Fig. 1). PC1 accounted for 35% of the variation,

and it seemed to differentiate among samples according to most of the initial texture (such as smoothnesss and initial drag) and initial appearance (such as wet appearance and brushlines) attributes. PC2 accounted for 24% of the variation, and it seemed to differentiate samples according to all the aroma attributes, including acetone, nutty, petroleum-like, woody and fruity-floral.

A basecoat did not seem to affect application properties of a nail polish, because most samples with a basecoat positioned close to their non-basecoat version in the PCA map. A basecoat is a common nail care product, usually transparent, fills in irregularities of the nail plate and provides a uniform, neutral color as the starting point for the pigmented nail polish [25]. For example, BR2 was shown at almost the same place as R2. This was also true for flake-containing products and gel-type products. This suggested that a basecoat may not affect the sensory properties, although it may affect the physical properties, such as the staying power to resist chipping of nail polish. The gel nail polish products were more associated with most of the aroma attributes including woody, nutty, petroleum-like and fruity-floral, but they were low in acetone and runny.

The two water-based nail polish samples (W1 and W2) were grouped together, but both were located far from the other samples. This suggested that W1 and W2 were similar in initial texture, initial appearance and aroma (PC1 and PC2) characteristics, but quite different from the others. The binder/cross-linker of water-based nail polishes can be dispersed in water and this may keep the volatile organic content low [26]. These two samples had pronounced fruity-floral, petroleum-like, and nutty aromatics.

All three flake-containing samples (F1, F2 and BF2) were grouped together, but separated from all the other samples. These samples had pronounced flake-protrusion, glittery

and initial-drag attributes, but exhibited low smoothness, spreadability, wet-appearance, coverage, shininess, and opacity intensities.

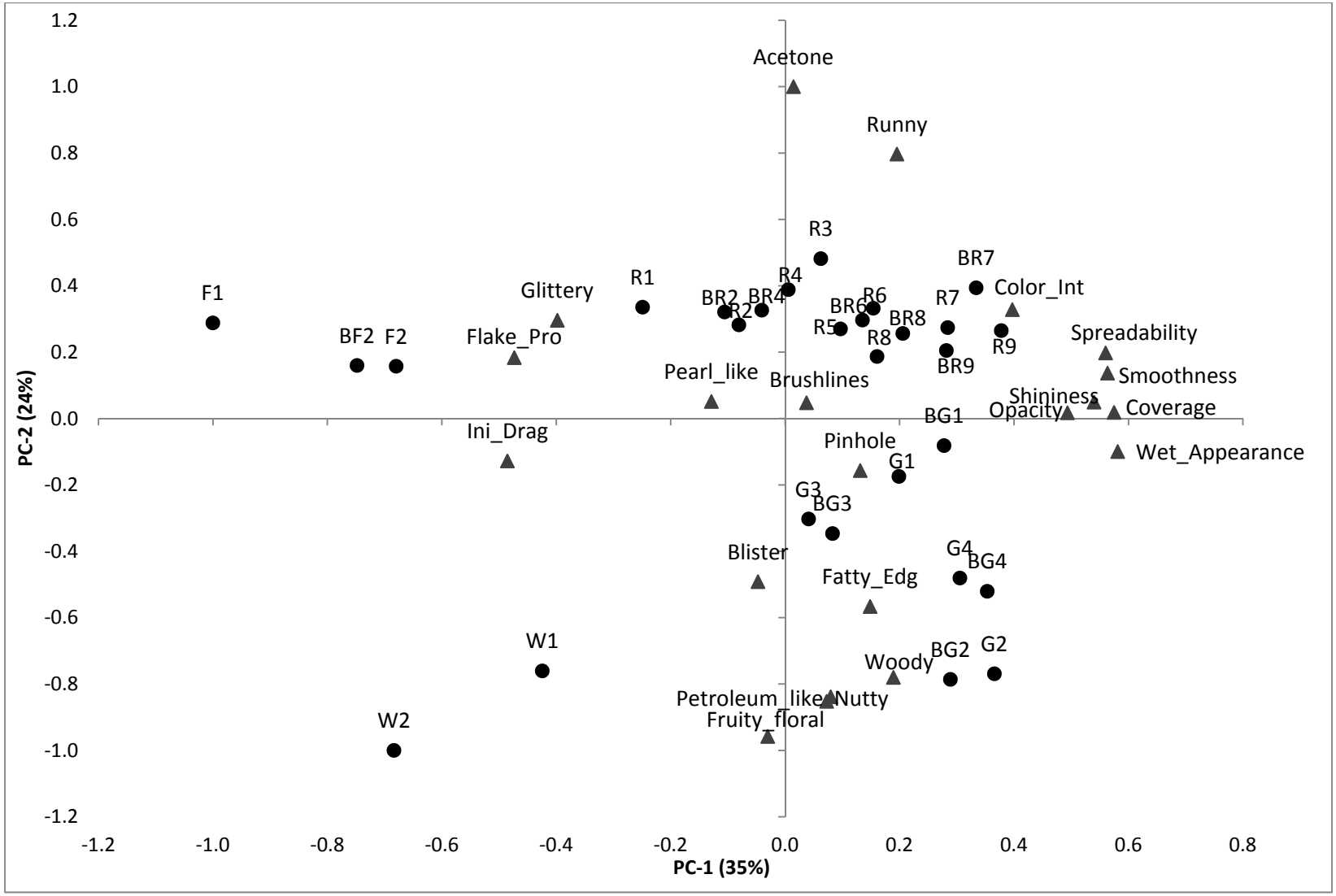

Figure 1 Principal Component Analysis of nail polish samples based on 21 application attributes.

(▲, attributes; ●, products)

The results from Pearson's Correlation Coefficient analysis showed that spreadability, smoothness, shininess, opacity, coverage, and wet-appearance were positively correlated with each other, which suggests that although they measure different characteristics, they are all related similarly to underlying formulation differences in products. These attributes were negatively correlated with both initial-drag and flake-protrusion. It was found that opacity was positively related to color intensity (r=0.74). Runny was negatively related to initial-drag (r=-0.51). The initial drag could be caused by the viscosity of the nail polish sample, and viscosity could negatively associate with the runny property. Both initial-drag and glittery were positively correlated with flake-protrusion (r=0.77, r=0.56). Flakes may increase the resistance to application, resulting in the amount of pressure required to apply the sample (initial-drag) to increase.

Removal

According to the average intensity values (Table V), before any treatment (stage 0), the intensities of shine and color intensity were consistent with the application attributes shininess and color intensity. Coverage was evaluated as 15.0 in intensity in all samples other than F1. Similar findings were detected during application as sample F1 was evaluated low in coverage attribute intensity (Table IV). According to these results sample F1 exhibited characteristics in application that were likely to result from product formulation rather than application procedures.

In stage 1 of removal, the intensities of shine, coverage, color intensity, and drag of regular samples decreased significantly (Table V). However, the intensities of those attributes in flake-containing samples did not follow the same pattern. This suggested that the flakes in nail polish increased the difficulty to remove nail polish. In addition, in most of the regular samples (R2, R6, R7 and R8), the non-basecoat version was found significantly lower than the basecoat

version in coverage during removal. In half of the regular samples (R6, R7 and R8), the non-basecoat version was found significant lower than the basecoat version in drag. This suggests that adding basecoat helps the nail polish to be more resistant to removal, a property that would help in the long lasting, anti-chip characteristics of some nail polishes.

Furthermore, for coverage, color intensity and drag attributes in stage 2, all the non-basecoat regular samples had lower scores than their basecoat version (other than samples R9 and R4) meaning that samples that did not have a basecoat were more easier to remove. This could support the claim for some nail polish products that a basecoat could help nail polish last longer on nails.

In stage 3, all the samples had a score of "0" or close to "0" for coverage and color intensity apart from samples F1, F2, BF2, and BR9. The flake-containing samples were still high in intensity for all the three attributes at this stage. Within the regular category, the non-basecoat samples were not significantly different from their basecoat version in coverage and color intensity, except samples R8 and R9. However, for the attribute drag, except for sample R4, all regular samples had a lower score in their non-basecoat than their basecoat version.

In stage 4, only three flake-containing samples (F1, F2 and BF2) had obvious scores on the attributes evaluated. For the other samples, the scores in coverage, color intensity, and drag attributes were "0" or close to "0" indicating complete removal by this point.

In the PCA map relating to removal of nail polishes (Fig. 2), PC1 accounted for 71% of the variation, and seemed to be highly related to flake-protrusion. PC2 accounted for 14% of the variation, and was associated with the intensity of nail polish residuals.

Unlike the PCA map relating to application of nail polishes, samples in the removal PCA map were different between the basecoat version and a non-basecoat version. For example, BR2 and R2, which positioned closely on the application PCA map, were not located closely on the removal PCA map, and this was further confirmed by the differences in average color intensity and drag attribute values (Table V). However, the flake-containing product was an exception since BF2 was still close to F2 in the removal PCA map. This is likely to show that the flake-containing characteristic affected the sensory removal properties more than the basecoat/non-basecoat application. The samples with flakes were highly separated from the other samples using this lexicon.

A basecoat seemed to be a factor that may add wear resistance, because the basecoat version of a nail polish usually had higher coverage, drag and color intensity scores than the non-basecoat version during removal. Non-basecoat nail polish products could be completely removed with fewer strokes than their basecoat versions before the third stage of removal. Sample F1, F2 and BF2, which contained flakes, seemed to be more difficult to remove from nails than regular samples.

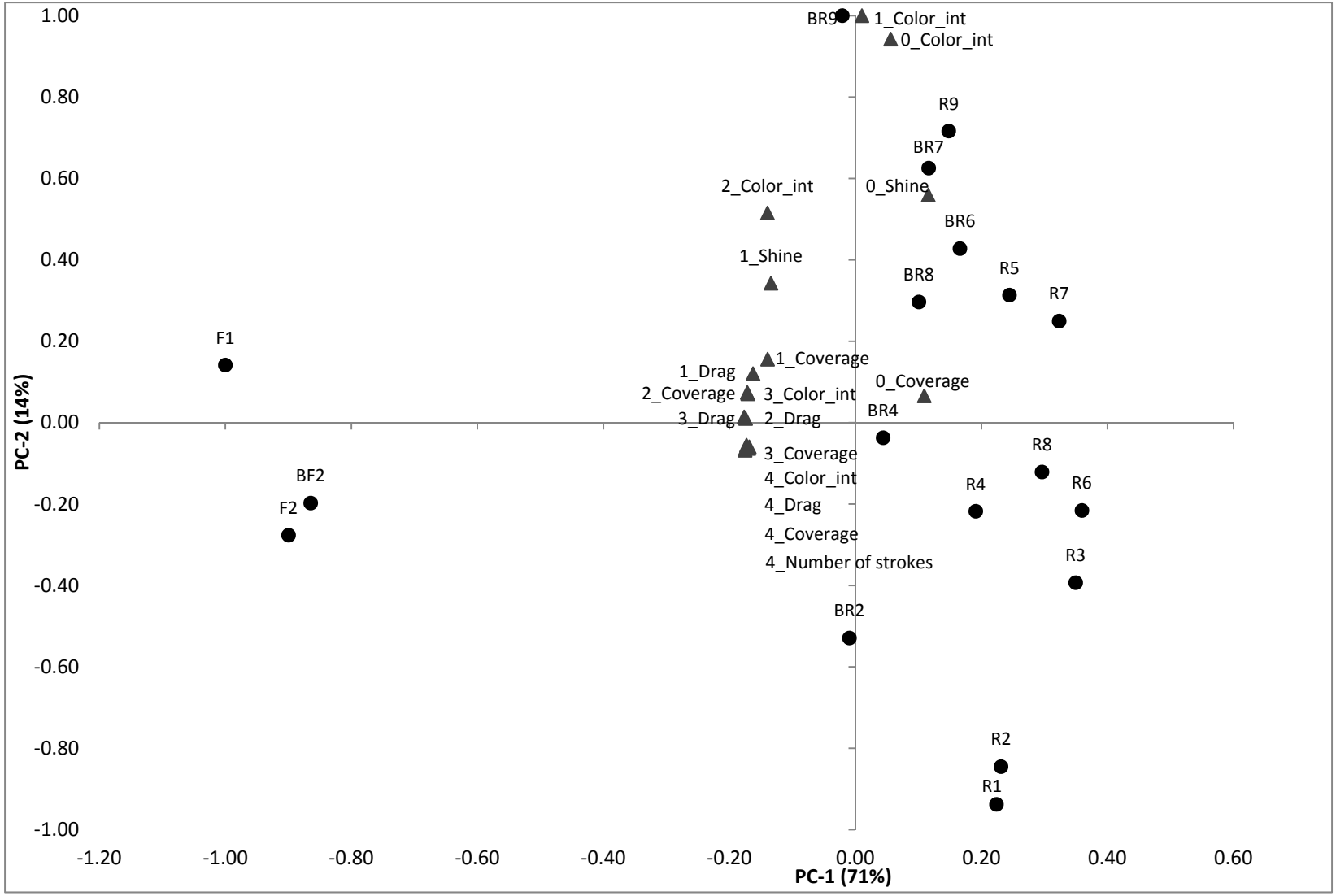

Figure 2 Principal Component Analysis of nail polish samples based on 5 removal attributes in 5 stages (0-4).

(▲ , attributes; ● , products; the number before the attribute indicated the time point that attribute was evaluated.

Conclusions

This study developed a lexicon for understanding the sensory properties of the application and removal of nail polish. For application, twenty-one attributes, which included three initial texture attributes, thirteen initial appearance attributes and five aroma attributes, were noted. For removal, five attributes appeared to be critical to measure as shown over five stages of removal.

The lexicons were validated by a trained panel using descriptive analysis on seventeen nail polish products. These products were from four categories - regular, flake-containing, water-based and gel. Some of the samples were evaluated both with a basecoat and without a basecoat. The results from ANOVA and PCA showed that the attributes in the lexicon separated the different product categories. In addition it was found that basecoat has a bigger effect on removal properties of a nail polish sample than on application properties.

This study provides scientists interested in nail polish an additional tool to describe nail polishes and better understand differences among them. Also, it could provide those who already use descriptive analysis on nail polish more information about the product category. In the future, further studies could look at relating descriptive data from this study to physical and consumer data to provide more comprehensive understanding on nail polish.

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Table I Nail polish samples and sampling plan.

No.	Code[a]	Category	Application	Removal
1	F1	Flake-containing	Yes	Yes
2	F2	Flake-containing	Yes	Yes
3	R1	Regular	Yes	Yes
4	R2	Regular	Yes	Yes
5	R3	Regular	Yes	Yes
6	R4	Regular	Yes	Yes
7	R5	Regular	Yes	Yes
8	R6	Regular	Yes	Yes
9	R7	Regular	Yes	Yes
10	R8	Regular	Yes	Yes
11	R9	Regular	Yes	Yes
12	G1	Gel	Yes	No
13	G2	Gel	Yes	No
14	G3	Gel	Yes	No
15	G4	Gel	Yes	No
16	W1	Water-based	Yes	No
17	W2	Water-based	Yes	No
18	BF2	Flake-containing /Basecoat/Topcoat[c]	Yes	Yes
19	BR2	Regular/Basecoat/Topcoat	Yes	Yes
20	BR4	Regular/Basecoat/Topcoat	Yes	Yes
21	BR6	Regular/Basecoat/Topcoat	Yes	Yes
22	BR7	Regular/Basecoat/Topcoat	Yes	Yes
23	BR8	Regular/Basecoat/Topcoat	Yes	Yes
24	BR9	Regular/Basecoat/Topcoat	Yes	Yes
25	BG1	Gel/Basecoat	Yes_g[b]	No
26	BG2	Gel/Basecoat	Yes_g	No
27	BG3	Gel/Basecoat	Yes_g	No
28	BG4	Gel/Basecoat	Yes_g	No

[a] The letters in this column are short for the category information in the third column.

[b] "Yes_g" means the basecoats of the samples need to be cured.

[c] Topcoats were only used in removal evaluation.

Table II Preparation and evaluation techniques used in application and removal of a nail polish product.

	Preparation Procedures	Evaluation Procedures
Application	If there is a basecoat, it should be applied to an artificial nail in three strokes (middle, left, right). If there is no basecoat, no further action need be done. The basecoat of BG1 need be cured under UV light for 1minute; the basecoat of BG3 need be cured under a UV light for 2 min; whereas the basecoats of BG2 and BF4 need be cured under an LED light for 1min.	At first, invert the nail polish bottle several times in a frequency of once per second for twenty seconds. Secondly, open bottle, and draw brush out against the inside of bottle to remove excess nail polish. Thirdly, turn the brush over and apply on nail with the side of brush with the most polish. Finally, touch brush to top of nail at cuticle; draw brush smoothly over nail to tip without brush stem touching the nail; use one nail for one drag, in the middle of the nail.
Removal	If there is a basecoat, it should be applied to an artificial nail in three strokes (middle, left, right). If there is no basecoat, skip this step and proceed to the second step directly. Secondly, when the basecoat is dry (about 5 min later), apply the first coat of sample in three strikes. Thirdly, 5 min later, apply the second coat of sample in three strikes. Finally, another 5 min later, apply the topcoat if the sample is with a topcoat.	At first, evaluate the attributes shine, coverage and color intensity. Secondly, Take applicator, dump acetone from vial in the center of applicator. Fold applicator from the center and apply applicator to polished nail surface, let sit for 5 seconds. Use 2 fingers on top of applicator and 1 below and pull applicator with firm pressure towards the tip of the nail, covering the while nail with applicator. Evaluate attributes shine, coverage, color intensity and drag. Thirdly, take a new applicator, dump acetone from vial in the center of applicator, and fold applicator from the center. With firm pressure make 5 more strokes from top of nail to tip and evaluate coverage, color intensity and drag. Fourthly, if necessary, take new applicator, dump acetone from vial in the center of applicator, and fold applicator from the center. With firm pressure make 5 more strokes from top of nail to tip and evaluate coverage, color intensity and drag. Finally, if necessary, take new applicator, dump acetone from vial in the center of applicator, and fold applicator from the center. Count strokes to completely remove the product. If the count is higher than 20, stop and evaluate number of strokes, coverage, color intensity and drag.

Table III Definition and reference sheet used by panelists

Initial texture	***Definition and Standard References***
Smoothness	Evenness of the sample; absence of grains, clumps, lumps, etc. References: Morton's Iodized salt=3.0 Arm & Hammer baking soda=6.0 Johnson & Johnson 24h moisturizer=15.0 Preparation: Serve in 1oz cups.
Spreadability	The ease in which the product can be manipulated on the surface of the artificial nail References: Vaseline 100% Pure Petroleum Jelly=5.0 Chapstick (classic)=9.0 Johnson & Johnson 24h moisturizer=13.0 Preparation: Serve Vaseline in 1oz cups. The chapstick was ChapStick Classic Original Skin Protectant / Sunscreen SPF 4. Serve Chapstick as is.
Initial-Drag	The amount of pressure required for the application of the product on nail References: Johnson & Johnson 24h moisturizer=1.0 Zinc Oxide=4.0 Chapstick (classic)=8.0 Sandpaper (fine)=10.0 Sandpaper (rough)=14.0 Preparation: Serve in 1oz cups. Technique: The chapstick was ChapStick Classic Original Skin Protectant / Sunscreen SPF 4. Serve Chapstick as is. Pull product with Q-tip on petri dish; pull Q-tip on sandpaper. Sandpaper (fine) is 3M™ Abrasive Product 336U, 150 C weight The grit size for sandpaper (coarse) is P60.
Initial appearance	
Color intensity	Intensity of the color of the product on the nail References: App. 1 (adopted from Dooley and *et al.* [8])
Wet-appearance	The appearance of looking wet, opposite to dry References: Vaseline 100% Pure Petroleum Jelly (untouched)=5.0 Exposed Vaseline 100% Pure Petroleum Jelly=9.0 Johnson&Johnson Baby oil=14.0 Preparation: Serve in 1oz cups. Serve Vaseline in untouched jar.
Glittery	Sample composed of individual reflective particles that have a sparkling effect References: App. 1 (adopted from Dooley and *et al.* [8])

Pearl-like	A soft, reflective luster reminiscent of a pearl of mother-of-pearl; gives depth. References: App. 1 (adopted from Dooley and *et al.* [8])
Opacity	The degree of opaqueness of the product References: App. 1 (adopted from Dooley and *et al.* [8]) Evaluate: Holding nail tips on top of the reference picture.
Runny	Speed at which sample runs down when brushed against bottle neck References: Johnson&Johnson 24h moisturizer=0.0 Germ-X Hand Sanitizer= 7.5 Johnson&Johnson Baby oil=15.0 Preparation: Serve in 1oz cups. Technique: Tilt cups to observe the movement.
Shininess	The amount of gloss or shine perceived on the surface of the product References: Paintchip Matt (Flat)=2.0 Paintchip Satin=4.0 Paintchip Semi-gloss=6.0 Paintchip High Gloss=8.0 Super High Gloss=13.0 Preparation: The paint chip selected was Sherwin-Williams finish selection for interiors for color SW 6573 juneberry. Spray Krylon Crystal Clear Gloss Acrylic Spray Finish on a paint chip, such as WGR27 or WGR21, let dry, and apply 2nd coat (Super high gloss).
Fatty-edge	A smooth continuous rounded thickening partly or completely bordering the sample References: App. 1
Blisters	A tactile surface rounded protrusion, having impression of trapped air. References: App. 1
Pinholes	A minute tactile surface perforation generally appearing randomly References: App. 1
Coverage	The amount of testing surface covered by the product References: App. 1
Brushlines	Thin, continuous parallel elongations generally appearing in number, resembling bristle drag on a soft surface References: App. 1
Flake-protrusion	A breaking away and an eruption of a metallic flake(s) References: App. 1

Aroma

Petroleum-like	A specific chemical aromatic associated with crude oil and it's refined products that have heavy oil characteristics. References: Vaseline 100% Pure Petroleum Jelly=4.5 Preparation: Weigh 1g of Vaseline in medium snifter, cover.
Acetone	Aroma characteristic of ketones specifically acetone References: Acetone=5.0 Preparation: Put 1 drop of acetone in medium snifter on cotton ball, cover.
Nutty	A non-specific nut-like aromatic note that was a combination of several different nuts such as pecans, hazelnuts, peanuts, etc., unless otherwise described. References: 2-acetyl-pyridine (100ppm dip strips)=7.0(a) Put 1 drop in medium snifter on cotton ball, cover.
Woody	The sweet, brown, musty, flat, dark, dry aromatics associated with the bark of a tree. References: Oil Cedarwood(Sigma, dip strips)=5.5(a) Put 1 drop in medium snifter on cotton ball, cover.
Fruity-Floral	A sweet, floral aromatic blend, reminiscent of a variety of fruits such as cherry, peach, pear, etc. References: trans-2-hexenal (10000ppm, dip strip)=5.0(a) Put 1 drop in medium snifter on cotton ball, cover.

Table IV Results from ANOVA and T grouping in application evaluation based on each attribute.

Part 1.

	Smoothness	Spreadability	Ini_Drag	Color_Int	Wet_Appearance	Glittery	Pearl_like
BF2	9.86^{hi}*	9.61^{fg}	4.39^{a}	6.67^{jk}	7.39^{h}	11.69^{a}	0.00^{c}
BR2	12.83^{cdefg}	12.11^{bcde}	1.81^{efg}	5.92^{kl}	11.72^{bcde}	9.83^{bc}	1.64^{a}
BR4	13.00^{abcdefg}	11.61^{de}	1.81^{efg}	7.69^{ghi}	10.44^{ef}	6.56^{d}	0.00^{c}
BR6	12.92^{abcdefg}	12.25^{bcde}	2.08^{cdefg}	8.33^{cdefg}	11.61^{bcde}	0.00^{f}	0.06^{bc}
BR7	14.36^{a}	13.64^{a}	1.42^{g}	9.25^{bc}	12.56^{ab}	0.72^{f}	0.00^{c}
BR8	13.58^{abcde}	12.92^{abc}	1.81^{efg}	7.83^{fghi}	12.28^{abc}	0.83^{f}	0.06^{bc}
BR9	13.22^{abcdef}	12.33^{bcde}	2.47^{bcde}	10.92^{a}	12.64^{ab}	0.00^{f}	0.00^{c}
BG1	14.22^{a}	13.17^{ab}	1.81^{efg}	6.33^{jkl}	12.31^{abc}	0.00^{f}	0.00^{c}
BG2	13.81^{abcd}	12.64^{abcd}	1.92^{efg}	8.86^{bcd}	12.61^{ab}	0.00^{f}	0.00^{c}
BG3	12.47^{efg}	11.28^{e}	2.67^{bc}	6.58^{jkl}	11.94^{abcd}	0.17^{f}	0.00^{c}
BG4	14.08^{ab}	12.50^{bcd}	1.94^{defg}	8.75^{bcdef}	13.11^{a}	0.00^{f}	0.00^{c}
F1	10.17^{h}	9.44^{fg}	4.33^{a}	6.89^{ij}	3.22^{i}	4.81^{e}	0.00^{c}
F2	8.94^{i}	9.97^{f}	2.61^{bcd}	6.53^{jkl}	6.78^{h}	11.06^{ab}	0.00^{c}
R1	12.72^{edfg}	11.64^{de}	1.89^{efg}	5.92^{kl}	9.42^{fg}	9.33^{c}	0.53^{b}
R2	13.36^{abcdef}	12.44^{bcd}	1.61^{g}	5.64^{l}	10.83^{de}	9.78^{bc}	1.44^{a}
R3	13.56^{abcde}	12.50^{bcd}	1.67^{fg}	6.94^{hij}	11.53^{bcde}	0.00^{f}	0.25^{bc}
R4	13.67^{abcde}	12.42^{bcd}	1.67^{fg}	7.86^{efgh}	11.17^{cde}	6.83^{d}	0.33^{bc}
R5	13.25^{abcdef}	12.00^{cde}	1.89^{efg}	7.92^{defg}	11.83^{abcd}	0.28^{f}	0.00^{c}
R6	13.47^{abcde}	12.53^{abcd}	1.75^{fg}	9.06^{bc}	11.17^{cde}	0.00^{f}	0.11^{bc}
R7	14.31^{a}	13.11^{abc}	1.81^{efg}	9.47^{b}	11.83^{abcd}	0.00^{f}	0.00^{c}
R8	13.67^{abcde}	12.83^{abc}	1.72^{fg}	7.97^{defg}	11.86^{abcd}	0.00^{f}	0.00^{c}
R9	13.97^{abc}	13.17^{ab}	1.83^{efg}	10.94^{a}	12.31^{abc}	0.00^{f}	0.00^{c}
G1	13.94^{abc}	12.53^{abcd}	1.83^{efg}	6.06^{jkl}	12.67^{ab}	0.00^{f}	0.00^{c}
G2	13.97^{abc}	12.86^{abc}	1.61^{g}	9.22^{bc}	12.75^{ab}	0.00^{f}	0.00^{c}
G3	12.22^{fg}	11.61^{de}	2.31^{cdef}	6.44^{jkl}	12.22^{abc}	0.00^{f}	0.00^{c}
G4	13.67^{abcde}	12.78^{abc}	1.92^{efg}	8.81^{bcde}	12.14^{abcd}	0.00^{f}	0.00^{c}
W1	12.00^{g}	11.64^{de}	2.31^{cdef}	3.28^{m}	9.44^{fg}	7.03^{d}	1.44^{a}
W2	9.56^{hi}	8.83^{g}	3.14^{b}	2.78^{m}	8.11^{gh}	0.00^{f}	0.06^{bc}

* Sample means with the same letter in a column are not significantly different ($P < 0.05$).

Table IV Part 2.

	Opacity	Runny	Shininess	Fatty_Edg	Blisters**	Pinholes	Coverage
BF2	9.39^{fghij}	9.14^{fghij}	8.53^{i}	3.44^{cdefghi}	0.00^{b}	0.00^{f}	8.36^{lm}
BR2	8.06^{j}	10.64^{abc}	11.92^{bcde}	4.17^{bcdefgh}	0.00^{b}	0.08^{f}	9.72^{ijk}
BR4	8.72^{hij}	10.00^{bcdef}	11.67^{de}	3.22^{cdefghi}	0.00^{b}	1.11^{bcde}	10.56^{fghij}
BR6	10.17^{defg}	10.25^{bcde}	12.36^{abcd}	2.22^{hi}	0.00^{b}	1.28^{bcd}	11.00^{defghi}
BR7	11.22^{bcd}	9.75^{cdefgh}	12.17^{abcde}	3.00^{defghi}	0.00^{b}	0.94^{bcdef}	12.56^{ab}
BR8	9.47^{fghi}	10.14^{bcde}	12.61^{abcd}	4.89^{bcd}	0.08^{b}	1.31^{bcd}	11.44^{bcdefg}
BR9	12.89^{a}	9.31^{efghij}	12.56^{abcd}	4.17^{bcdefgh}	0.11^{b}	1.22^{bcd}	12.33^{abc}
BG1	11.61^{abc}	8.83^{hij}	13.11^{a}	2.39^{ghi}	0.00^{b}	0.36^{cdef}	12.97^{a}
BG2	10.67^{cdef}	8.78^{ij}	13.03^{a}	4.33^{bcdefg}	0.11^{b}	0.22^{ef}	11.61^{bcdef}
BG3	9.86^{efgh}	9.17^{fghij}	12.67^{abcd}	4.17^{bcdefgh}	0.22^{ab}	3.75^{a}	11.17^{cdefgh}
BG4	11.22^{bcd}	9.36^{efghi}	13.22^{a}	5.44^{b}	0.00^{b}	0.39^{cdef}	12.39^{abc}
F1	4.50^{l}	8.39^{j}	10.17^{fg}	0.11^{j}	0.00^{b}	0.00^{f}	4.94^{n}
F2	8.81^{hij}	9.39^{efghi}	9.25^{ghi}	2.39^{ghi}	0.00^{b}	0.00^{f}	8.64^{klm}
R1	8.08^{j}	9.86^{bcdef}	10.00^{gh}	2.06^{ij}	0.00^{b}	0.11^{f}	9.50^{jkl}
R2	8.11^{j}	10.72^{ab}	11.17^{ef}	3.44^{cdefghi}	0.00^{b}	0.06^{f}	10.78^{efghij}
R3	8.47^{ij}	11.22^{a}	11.72^{cde}	2.56^{fghi}	0.00^{b}	0.17^{ef}	9.86^{hijk}
R4	8.47^{ij}	10.44^{abcd}	11.19^{ef}	4.33^{bcdefg}	0.00^{b}	0.61^{cdef}	10.08^{hij}
R5	8.58^{hij}	10.42^{abcd}	12.50^{abcd}	4.39^{bcdef}	0.00^{b}	1.14^{bcde}	10.19^{ghij}
R6	10.36^{cdefg}	9.97^{bcdef}	11.14^{ef}	3.44^{cdefghi}	0.00^{b}	0.11^{f}	11.97^{abcde}
R7	11.36^{bcd}	9.56^{defghi}	12.28^{abcd}	2.56^{fghi}	0.00^{b}	0.61^{cdef}	12.17^{abcd}
R8	9.14^{ghij}	9.81^{bcdefg}	12.56^{abcd}	4.67^{bcde}	0.28^{ab}	0.61^{cdef}	10.86^{edfghi}
R9	12.19^{ab}	9.89^{bcdef}	13.06^{a}	4.06^{bcdefgh}	0.00^{b}	0.33^{def}	12.61^{ab}
G1	10.33^{cdefg}	8.86^{ghij}	12.94^{ab}	3.17^{cdefghi}	0.11^{b}	0.50^{cdef}	12.17^{abcd}
G2	11.06^{bcde}	8.89^{ghij}	13.17^{a}	5.11^{bc}	0.00^{b}	0.33^{def}	12.14^{abcd}
G3	9.47^{fghi}	9.42^{efghi}	12.75^{abc}	3.94^{bcdefghi}	0.50^{a}	1.78^{b}	10.08^{hij}
G4	10.47^{cdefg}	8.67^{ij}	13.22^{a}	4.56^{bcde}	0.00^{b}	0.58^{cdef}	12.03^{abcde}
W1	6.50^{k}	8.67^{ij}	9.08^{hi}	2.83^{efghi}	0.22^{ab}	0.00^{f}	7.78^{m}
W2	6.22^{k}	7.08^{k}	7.44^{j}	8.00^{a}	0.28^{ab}	1.33^{bc}	7.61^{m}

**Blisters is the only attribute that was not significantly different among all the samples. ($P<0.05$)

Table IV Part 3.

	Brushlines	Flake_Pro	Petroleum_like	Acetone	Nutty	Woody	Fruity_floral
BF2	1.94^{fghijk}	3.64^{a}	0.89^{defghi}	7.06^{abc}	0.58^{cde}	0.39^{efgh}	0.28^{fg}
BR2	3.25^{bcdefghij}	0.25^{b}	0.89^{defghi}	6.94^{abc}	0.50^{cde}	0.47^{efgh}	0.00^{g}
BR4	2.67^{defghij}	0.22^{b}	0.83^{efghi}	7.33^{ab}	0.33^{cde}	0.22^{fgh}	0.22^{fg}
BR6	4.86^{abc}	0.00^{b}	0.69^{ghi}	6.61^{abcde}	0.33^{cde}	0.72^{def}	0.22^{fg}
BR7	1.67^{ghijk}	0.00^{b}	0.94^{defghi}	7.61^{a}	0.11^{de}	0.00^{h}	0.11^{fg}
BR8	4.50^{abcd}	0.00^{b}	0.83^{efghi}	7.36^{ab}	0.17^{cde}	0.17^{fgh}	0.33^{efg}
BR9	4.06^{abcdef}	0.00^{b}	0.78^{fghi}	7.36^{ab}	0.44^{cde}	0.33^{fgh}	0.17^{fg}
BG1	1.33^{jk}	0.00^{b}	1.56^{abc}	5.72^{def}	0.67^{cd}	0.39^{efgh}	0.67^{defg}
BG2	2.22^{efghij}	0.00^{b}	1.81^{a}	2.25^{hi}	1.42^{b}	2.06^{a}	2.06^{abc}
BG3	5.33^{ab}	0.00^{b}	1.39^{abcde}	5.61^{ef}	0.72^{c}	1.11^{cd}	0.75^{def}
BG4	1.61^{ghijk}	0.00^{b}	1.08^{cdefghi}	3.36^{h}	1.94^{ab}	1.86^{ab}	1.33^{cd}
F1	0.00^{k}	4.33^{a}	0.97^{cdefghi}	7.25^{ab}	0.22^{cde}	0.11^{gh}	0.00^{g}
F2	1.44^{hijk}	4.28^{a}	1.28^{abcdefg}	6.78^{abcd}	0.44^{cde}	0.39^{efgh}	0.39^{efg}
R1	6.17^{a}	0.083^{b}	0.56^{i}	6.06^{cdef}	0.33^{cde}	0.33^{fgh}	0.39^{efg}
R2	3.06^{cdefghij}	0.06^{b}	1.06^{cdefghi}	6.33^{bcdef}	0.47^{cde}	0.28^{fgh}	0.33^{efg}
R3	3.67^{bcdefg}	0.00^{b}	0.67^{hi}	6.94^{abc}	0.06^{e}	0.28^{fgh}	0.11^{fg}
R4	2.33^{defghij}	0.22^{b}	0.61^{hi}	7.00^{abc}	0.28^{cde}	0.33^{fgh}	0.11^{fg}
R5	4.17^{abcde}	0.00^{b}	0.83^{efghi}	7.17^{ab}	0.28^{cde}	0.11^{gh}	0.50^{efg}
R6	3.53^{bcdefghi}	0.00^{b}	0.72^{ghi}	7.28^{ab}	0.33^{cde}	0.28^{fgh}	0.33^{efg}
R7	3.61^{bcdefgh}	0.00^{b}	0.89^{defghi}	6.94^{abc}	0.44^{cde}	0.44^{efgh}	0.22^{fg}
R8	3.61^{bcdefgh}	0.00^{b}	0.94^{defghi}	7.56^{a}	0.06^{e}	0.11^{gh}	0.33^{efg}
R9	2.72^{cdefghij}	0.00^{b}	1.03^{cdefghi}	7.00^{abc}	0.44^{cde}	0.39^{efgh}	0.11^{fg}
G1	1.22^{jk}	0.00^{b}	1.33^{abcdef}	5.97^{cdef}	0.67^{cd}	0.67^{defg}	1.03^{de}
G2	1.22^{jk}	0.00^{b}	1.72^{ab}	2.86^{h}	1.83^{ab}	1.89^{ab}	2.28^{ab}
G3	6.17^{a}	0.00^{b}	1.28^{abcdefg}	5.44^{fg}	0.67^{cd}	0.94^{cde}	0.44^{efg}
G4	1.39^{ijk}	0.00^{b}	1.69^{ab}	4.5^{g}	1.3889^{b}	2.19^{a}	0.44^{efg}
W1	4.89^{abc}	0.19^{b}	1.47^{abcd}	2.72^{h}	2.25^{a}	1.33^{bc}	1.94^{bc}
W2	4.03^{abcdef}	0.00^{b}	1.17^{bcdefgh}	1.56^{i}	0.61^{cde}	0.22^{fgh}	2.78^{a}

Table V Results from ANOVA and T-grouping for all samples in removal evaluation based on each attribute.

Part 1.

Sample	0_Shine	1_Shine	0_Coverage	1_Coverage	2_Coverage	3_Coverage	4_Coverage	4_Number of strokes
BF2	9.06gh	8.44b	14.64a	13.78a	11.83a	9.11ab	4.81b	18.83a
BR2	12.33bcdef	7.92bc	14.39a	10.00b	3.86cd	0.69d	0.00c	1.33bc
BR4	12.72abcd	6.78cdef	14.31a	9.56bc	3.78cd	0.75d	0.00c	1.44bc
BR6	13.22a	7.33bcde	14.94a	8.89bcdef	2.67defg	0.08d	0.00c	0.39c
BR7	13.42a	7.31bcde	15.00a	9.61bc	3.53cde	0.50d	0.11c	1.33bc
BR8	13.50a	7.83bcd	15.00a	9.50bcd	3.28cdef	0.56d	0.00c	1.11bc
BR9	13.36a	7.92bc	14.89a	10.44b	4.53c	2.11c	0.00c	2.72b
F1	11.61f	10.00a	9.50b	9.03bcde	8.56b	8.14b	7.36a	19.28a
F2	8.86h	7.78bcd	14.36a	14.00a	11.72a	10.06a	4.61b	19.00a
R1	9.89g	5.67f	14.50a	7.31fgh	1.28gh	0.47d	0.00c	1.06bc
R2	12.11cdef	7.17bcde	14.47a	7.83defg	1.36gh	0.00d	0.00c	0.00c
R3	13.06ab	6.61cdef	14.92a	5.92h	1.17gh	0.00d	0.00c	0.00c
R4	11.94def	6.17ef	14.83a	8.00cdefg	2.22efg	0.28d	0.00c	0.83c
R5	13.03ab	7.83bcd	15.00a	7.67efg	1.92fgh	0.17d	0.00c	0.22c
R6	11.81ef	6.28ef	14.61a	6.89gh	0.53h	0.00d	0.00c	0.00c
R7	12.89abc	6.78cdef	14.83a	7.31fgh	1.28gh	0.00d	0.00c	0.00c
R8	12.89abc	6.56def	14.75a	7.58efgh	1.25gh	0.00d	0.00c	0.00c
R9	12.64abcde	7.11bcde	14.94a	8.97bcdef	3.36cdef	0.08d	0.00c	0.44c

* Sample means with the same letter in a column are not significantly different ($P < 0.05$).

**Each of the attributes in this table was significantly different among all the samples. ($P<0.05$)

Table V Part 2.

Sample	0_Color_int	1_Color_int	2_Color_int	3_Color_int	4_Color_int	1_Drag	2_Drag	3_Drag	4_Drag
BF2	8.06hij	7.44gh	6.81ab	5.58b	3.64b	10.22a	11.83a	11.61a	11.06b
BR2	6.64jk	5.69j	4.14de	0.69def	0.00c	8.19bc	7.50b	4.78b	1.47cd
BR4	8.39gh	7.69gh	5.28bcd	1.28de	0.00c	8.25b	7.06bc	3.53bcd	1.17cde
BR6	10.58bc	8.78cdef	4.89bcd	0.06f	0.00c	8.17bc	5.17defg	2.33defg	0.11ef
BR7	10.92ab	9.67bc	5.14bcd	0.67def	0.11c	7.72bcd	5.83cdef	3.22cde	0.89cdef
BR8	9.50def	8.33defg	4.86cd	1.36d	0.00c	7.33bcde	6.08bcde	3.03cdef	0.72def
BR9	11.67a	10.75a	6.61abc	3.53c	0.00c	7.67bcd	6.58bcd	4.00bc	1.81c
F1	8.14ghi	8.31defg	7.64a	7.08a	5.28a	11.14a	12.39a	12.33a	12.28a
F2	7.53hij	7.53gh	7.31a	6.67ab	3.50b	10.61a	12.17a	11.72a	11.11b
R1	7.22ijk	6.14ij	1.72f	0.44def	0.00c	6.53def	4.47fgh	1.69fghi	0.83cdef
R2	6.56k	5.47j	1.06f	0.00f	0.00c	6.78cdef	4.94efg	1.17ghi	0.00f
R3	8.42gh	7.11hi	1.17f	0.00f	0.00c	5.53f	3.92gh	1.08ghi	0.00f
R4	8.94dfg	7.78fgh	2.58ef	0.72def	0.00c	7.89bcd	5.72cdef	2.19defgh	0.33ef
R5	10.42bcd	9.11bcde	2.53ef	0.06f	0.00c	5.94ef	5.44defg	2.06efgh	0.17ef
R6	9.78cde	8.14efg	0.86f	0.00f	0.00c	5.44f	3.00h	0.53i	0.00f
R7	10.81ab	9.28bcd	1.69f	0.00f	0.00c	6.00ef	3.97gh	1.22ghi	0.00f
R8	8.83fg	8.08fgh	2.75ef	0.00f	0.00c	5.83f	4.44fgh	0.89hi	0.00f
R9	11.56a	10.11ab	5.78abcd	0.08ef	0.00c	8.17bc	5.33defg	2.44defg	0.11ef