The characterization and discrimination of pink and red nail polish lacquers
A preliminary study

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Introduction

One hundred ten pink and red-colored nail polish lacquers of different common brands have been collected. The following examinations have been carried out:

- Visual examination and stereomicroscopy;
- Visible microspectrophotometry;
  => VSC 6000, Foster & Freeman, reflectance mode, ~20 µm spot size, 400-800 nm spectral range.
- Fourier transform infrared spectroscopy;
  => Bruker Hyperion IR microscope, transmittance mode, MCT detector, 4000-650 cm^{-1} spectral range.
- Raman spectroscopy;
  => Bruker Senterra Raman microscope, 20x obj. lens, λ_{exc} = 785 nm, 2000-100 cm^{-1} spectral range.
- Scanning electron microscopy/energy dispersion spectroscopy.
  => Jeol 6490LV SEM with Oxford INCA X-Sight EDS detector, 20kV voltage, 150x magnification, 22 mm working distance, aperture setting of 3, 90s live time.

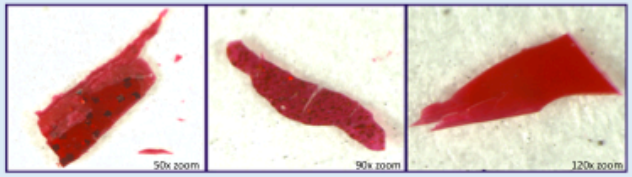
The **goal** of this study was to:
- Detect the different components for the characterization of nail polish lacquers;
- Identify the most discriminating analytical sequence.

Results

Visual/microscopical examination and color measurement

Color was the most discriminating feature. Approaching samples by visual and then microscopical examination allowed for the following observations:

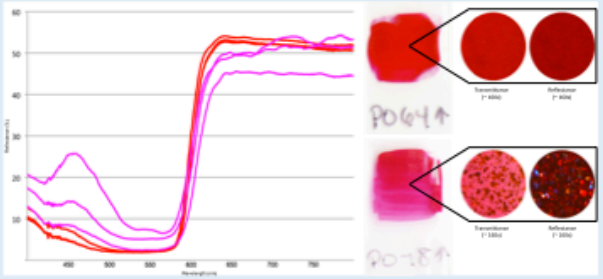
- Although most of the red and pink samples studied could be easily distinguished based on their shades, there were several instances when there was difficulty in determining whether a sample was red or pink.
- Other than the color itself, the presence, the shape, the concentration and colors of **sparkling particles** played an important role as discriminating features.



Distinction of red nail polish samples by means of presence/absence, shape, distribution and color of sparkling particles. Pictures taken using a Leica stereomicroscope

Microspectrophotometry was found to be the most discriminating technique. Of a number of 5995 possible pairwise comparisons, 52 pairs could not be differentiated according to their MSP spectra.

It was also observed that some samples difficult to distinguish by MSP could be differentiated by visual examination. And vice versa. Therefore we confirm that:
⇒ Visual examination and microspectrophotometry are complementary methods

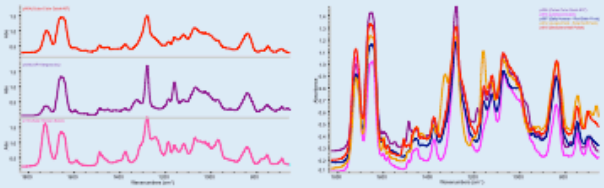


Spectral curves of samples p064 (*L.A. Colors*) (red) and p078 (Sally Hansen) (purple). Samples with sparkling particles may generate spectra with larger intra variability due to their inhomogeneity. This could cause difficulties during inter samples comparisons (even considering average spectra). This emphasizes the important contribution of visual examination with the stereomicroscope.

Fourier transform infrared spectroscopy

Although nail polish lacquers of our dataset were all nitrocellulose-based substances, the presence of additional absorption bands permitted to observe further discriminations.
=> IR discriminated 43 pairs of the 52 indistinguishable with MSP.

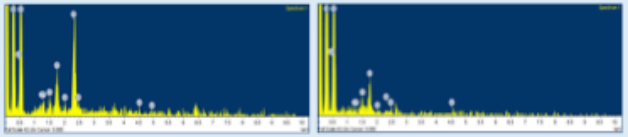
Three main types of spectra have been observed, along with their subclasses:



Examples of comparisons of IR spectra: the three general groups are displayed (left) as well as the detailed comparisons (right). Nitrocellulose bands can be observed at 1650 cm^{-1} and 1280 cm^{-1} and 840 cm^{-1} due to NO_2 symmetric and asymmetric stretches and NO stretch vibration respectively. NCL always contains a plasticizer, (e.g. a phthalate or camphor), to enhance its flexibility and adhesion properties. This explains the presence of the C=O stretch at 1730 cm^{-1}.

SEM/EDS

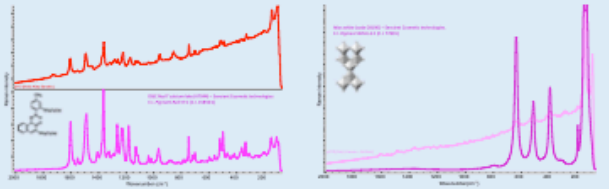
The elemental analysis spectra which were obtained showed a common profile based on silicon, sulfur, titanium, magnesium, aluminum, and phosphorous. Some differentiations of X-ray spectra were observed on the basis of a higher intensity of the sulfur signal (see figure below).
Occasionally, presence of other elements such as bromine or tantalum was observed.



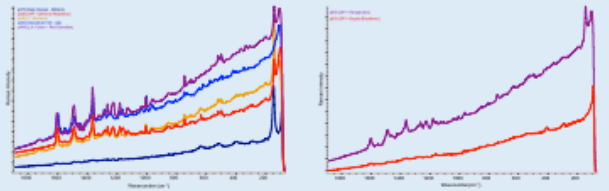
Elemental profiles of pink samples p037 (OPI - *I'm Not Really A Waitress*) (left) and p051 (*Greenbrier Antl'l*) (right). Both profiles present the same elements, but they can be distinguished on the basis of the intensity of the sulfur line. According to these elements, the presence of pigments PR57:1 and TiO_2 is inferred (confirmed by Raman) . Si, Mg and Al may be mica from the sparkling particles. P may be from triphenyl phosphate, a known plasticizer.

Raman spectroscopy

The main pigments which were detected in the samples were:
⇒ C.I. Pigment Red 57:1 (C.I. 15850:1) for red samples;
⇒ C.I. Pigment White 6:1 (C.I. 77891) – titan dioxide – anatase for pink samples.



Additional bands (not attributed to any compound) were observed
⇒ Higher discriminations



Examples of spectra differentiations of groups which were indistinguishable after MSP and FTIR.

Recommended analytical sequence

- *Stereomicroscopy* ➡ Observation of color and sparkling particles
- *MSP* ➡ Color measurement
- *FTIR* ➡ Detection of binder (NCL), plasticizers and additives
- *Raman* ➡ Detection of pigments
  ⇒ Raman resulted to be more selective than SEM/EDS:
  ⇒ Easier pigment identifications;
  ⇒ Higher spectra discriminations.

Acknowledgements

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