

Article

Determining Solubility of Nail Varnishes via HSP

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TAGS: [Decorative Cosmetic](#) [Solvents & Carriers](#) [Nail Varnish](#)

Nail varnish is a solvent-borne system and traditionally is made of approximately:

- 66-83% Solvents (e.g. Ethyl Acetate)
- 15-18% Binder & Film Formers (e.g. Nitrocellulose)
- < 10% Plasticizers (e.g. Camphor)
- 2-5% Pigment (e.g. Bismuth oxychloride and mica coated with titanium dioxide)

When the solvent evaporates, the solids are left behind in a strong film on the nails. They are used for aesthetic purposes, to protect the nails or to deliver active ingredients to the nail.



To remove [nail varnish](#), organic solvents are applied directly to the coating with some mechanical assistance, which is often achieved by immersion or by wrapping the fingertips in solvent-soaked cotton wool.

Is Acetone the best way to remove Nail Varnish?

The most common solvent to be used for the removal of nail polish is acetone. There are many advantages of using acetone, including:

- It has a very low viscosity and molar volume, allowing it to very easily enter the polymer matrix of the binders within the nail polish
- It is fully miscible with water, therefore aqueous blends can be made, which may help to tone down some of the unfortunate properties of acetone
- It is VERY cheap

Despite all these positives, Acetone is not the perfect solution, as:

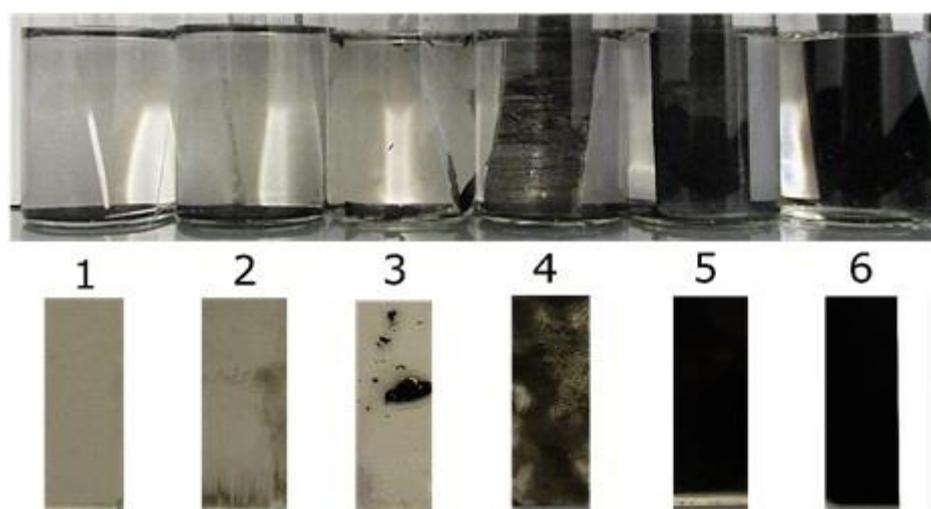
- It has a strong odor
- It makes the skin and nails feel dry after use, and
- It comes with the following hazards:
 - Irritant to the skin and eyes
 - Flammable and airborne vapors may also cause dizziness

How to efficiently find a replacement for Acetone?

Rather than proceeding by trial and error on a large number of solvents, determining the HSP of the nail varnish formulation will [find the most suitable solvents](#) quickly so that further testing and analysis can be performed.

Rather than undertaking a long project of [determining the HSP of each ingredient](#) individually, VLCI used dried nail polish films on glass slides to study the HSP of the entire nail varnish.

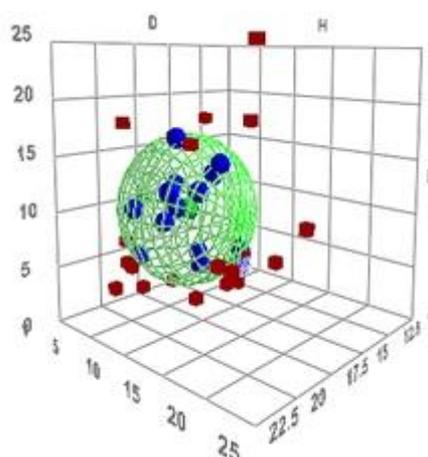
Although the [pigments](#) in nail polish are totally insoluble, the [binders](#) that cement it together are soluble. In good solvents, binder polymers freely dissolve, removing the cohesive strength of the nail polish. This destroys the coating structure and so the pigment particles come away. As the nail varnish will not fully dissolve, the qualitative ranking of 1-6 was redefined to fit this purpose.



Ranking of Nail Varnish Samples

The data recorded from this qualitative evaluation of the nail varnish slides, was entered into the HSPiP software and the following sphere parameters were determined:

HSP of a Budget Nail Varnish	
δD	16.72
δP	9.87
δH	6.96
Radius	7.1



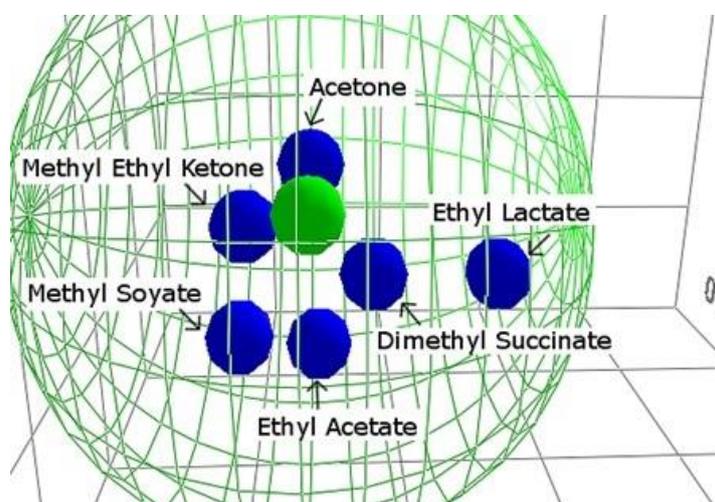
From this HSP, it is then possible to determine which solvents will be able to dissolve the nail varnish effectively! To this selection of solvents, extra criteria can be applied such as; no hazard warnings, low viscosity, cost, etc.

Finding Solvents Dissolving Nail Varnish via Hansen Solubility Parameters

There are examples of acetone-free nail varnish removers on the market already with various claims (e.g. Plant-based, bio-based, eco, sensitive, and prenatal). Some of the solvents used instead of acetone are:

- [Dimethyl Succinate](#)
- [Ethyl Acetate](#)
- [Ethyl Lactate](#)
- [Methyl Soyate](#)

By comparing the HSP of these solvents to the HSP of the nail varnish, we can see that these are all suitable choices and lie within the nail varnish's solubility sphere.



HSP of Bio-based and Normal Solvents in comparison to the HSP of Nail Varnish

Conclusion

By practically determining the Hansen Solubility Parameters of an entire nail varnish film, VLCI was able to quickly and accurately find a wide range of solvents that were suitable to be used as an acetone replacement for a nail varnish remover.

The use of HSP and HSPiP Database speeds up the R&D process enormously! Such a HSP workflow can be followed for your formulated products too, including the creation of solvent blends to achieve the best HSP while using solvents with your ideal characteristics.

Future Ideas - UV Cured Nail Varnish?

UV/LED cured nail varnishes work by **polymerizing various types of methacrylate monomers** while on the nails. This results in a much stronger coating that is longer lasting but also harder to remove.

<https://cosmetics.specialchem.com/tech-library/article/hsp-of-nail-varnish>

Currently, UV cured nail varnish is filed straight off the nail or soaked in acetone for a long time and forced off mechanically. HSP could be the key to determining a better solvent than acetone to remove UV Cured nail varnish.