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Article

Using HSP to Improve the Dispersibility of Pigments and Fillers

Sander van Loon & Beverley Fricker – Nov 29, 2018

TAGS: **Dispersing Agents**

The selection of a suitable dispersant for a filler or an insoluble pigment can be difficult and time-consuming due to both the variety of dispersants and nature/surface treatment of the solid particle.

Discover an effective method as practically implemented by **VLCI**. This turns the complex selection task into a predictive, data driven test method, by applying Hansen Solubility Parameters (HSP) to your paint, coating or ink formulation.

The validity of this screening process has been proven using the more conventional optimum dispersant concentration (ODC) test methodology.

As you will see in this article, the more HSP data you build up about particles and dispersants, the quicker you can formulate, by screening effective combinations.

Selection of Dispersants: How is it Done in the Industry?

The Most used but Least Efficient Method: Optimum Dispersant Concentration (ODC)

When a **suitable dispersant** is introduced into a pigment dispersion, there is a dramatic reduction in the viscosity of the paste or slurry, as the particles become more mobilized in the solvent (usually water). As the dispersant is gradually added into the slurry under mixing, there can be a fairly rapid decrease in the viscosity, which is visually seen as a larger vortex develops.

So, one dispersant is added to the slurry and then its effect on the viscosity is tested. Then repeat with the next dispersant, and the next dispersant, until you have tested a wide range. With so many dispersants and filler combinations to choose from, combining them drop wise in the slurry, wastes a lot of time and material.

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An Improved Method Available to All

In a tutorial by **Jochum Beetsma**, we show how to rationalize your dispersant selection process by starting with looking at Technical Datasheets and limiting your compatibility study to candidates that have matching characteristics.

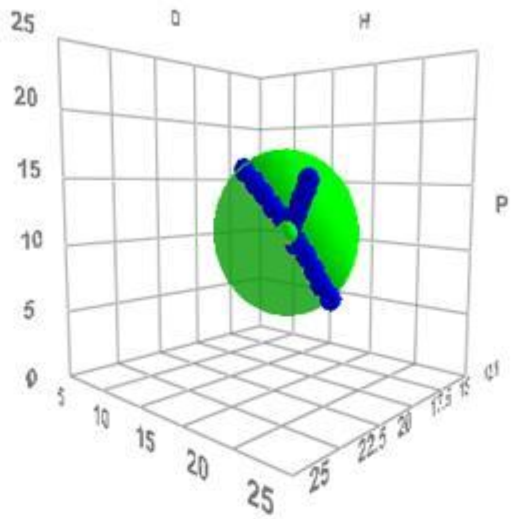
This method will allow you to work with fewer candidates, and to start with an estimation of the loading needed.

Watch tutorial now!

Predictive Selections Using HSP

This selection method is based on the use of Hansen Solubility Parameters (HSP) to get accurate predictions of the compatibility between solid particles & dispersants, as well as between dispersants and solvents. The goal is to take into consideration the chemical and physical characteristics of particles and dispersants, to predict the relative compatibilities of particle-dispersant combinations.

To learn more about the theory behind HSP see Professor Steven Abbott's **tutorial**.



Determining HSP of Pigments, Fillers & Dispersants

In the article **Practical Determination and Application of HSP**, we discuss the fundamentals of practically determining the HSP of any product, which covers the test methods used for this article.

Although the determination of HSP can be done manually, at VLCI we use **High-Throughput equipment**, to speed up sample preparation allowing HSP data to be collected within 2 days as opposed to over a week.

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HSP for Pigments & Fillers

The measurement of the HSP of particles is achieved by comparing the sedimentation rate of the particles in different solvents. On the sample tubes a grid is applied, which gives a fixed height over which the particle's descent can be timed.

The velocity of these particles descent is subject to the viscosity and density of the **solvent** medium in which it is suspended. Taking those into account, a correction is made, to determine a Relative Sedimentation Time (RST) for each solvent. Differences in the RST values for the solvents inform us about their relative affinities for the surface of the particles.

Lower RST values reflect more rapid sedimentation, and indicate poorer affinities between solvents and particles, so that higher RST values suggest solvents that are better suited to the **preparation of stable dispersions** with that specific particle.

These scores can be used as inputs into the HSPiP software, to determine the HSP that characterizes the surface of the particle.

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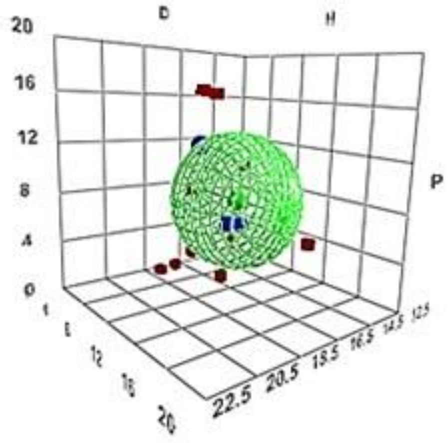

Finntalc M15 from Mondo Materials	
δD	17.89
δP	8.29
δH	10.34
R	5.3

The HSPiP Analysis of Finntalc M15 from Mondo Minerals

HSP for Dispersants

HSP of several dispersants were measured by observing their differences of miscibility in known HSP solvents.

Example Visual Differences in the Samples

This can be done relatively, using ranks from 1 to 6, or in a binary fashion (1 or 0) depending on whether the dispersant is perfectly or imperfectly dissolved/mixed with the reference solvent. These solubility scores are then inputted into the [HSPiP software](#) for analysis.

Calculation of Particle-Dispersant Distances

Particle-Dispersant Distances

Once the HSPs have been measured for a particle and a range of dispersants, it is then possible to calculate the HSP distances between each dispersant and the test particle. This is calculated using the HSP Distance equations:

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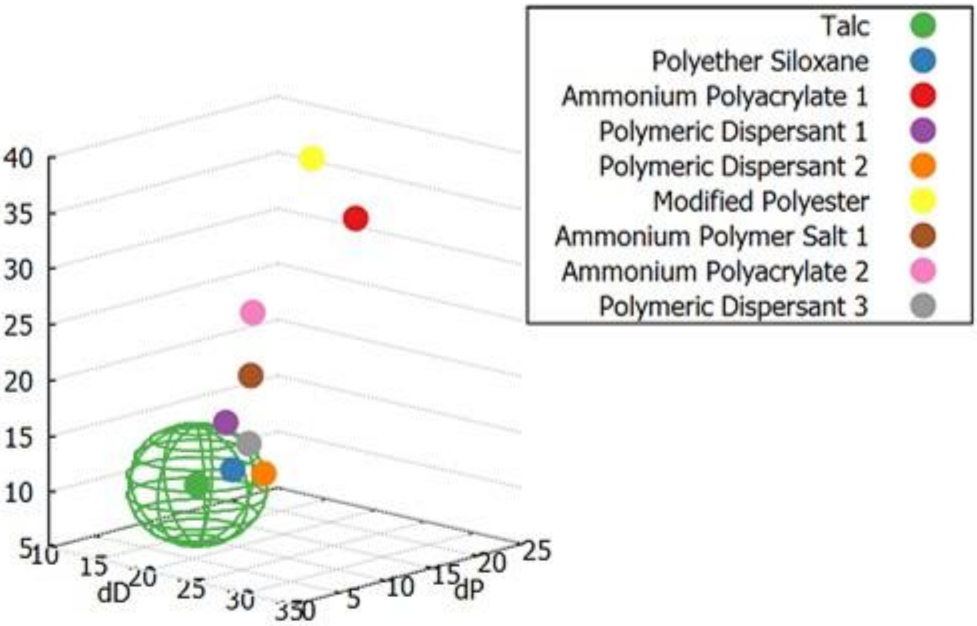
$$Dist_{HSP} = \left(\sqrt{4(\delta D_1 - \delta D_2)^2 + (\delta P_1 - \delta P_2)^2 + (\delta H_1 - \delta H_2)^2}\right)$$

HSP distance

The shorter the HSP distance between materials, the greater the affinity for one another. The closeness of HSPs can be visualized by the plot below:



HSP plot for Talc and Dispersants

Particle-Dispersant Sphere Separation Distances

However, the HSP distance value does not take into consideration the radii of the HSP spheres, which show the breadth of compatibility of two materials. By one simple modification to the HSP distance equation we can improve its predictive power.

$$Dist_{Sep} = \left(\sqrt{4(\delta D_1 - \delta D_2)^2 + (\delta P_1 - \delta P_2)^2 + (\delta H_1 - \delta H_2)^2}\right) - (R_1 + R_2)$$

HSP distance including radii (Sphere Separation Distance)

By introducing the values of the two HSP radii to the distance equation, it now effectively quantifies the distance between the surfaces of the two spheres.

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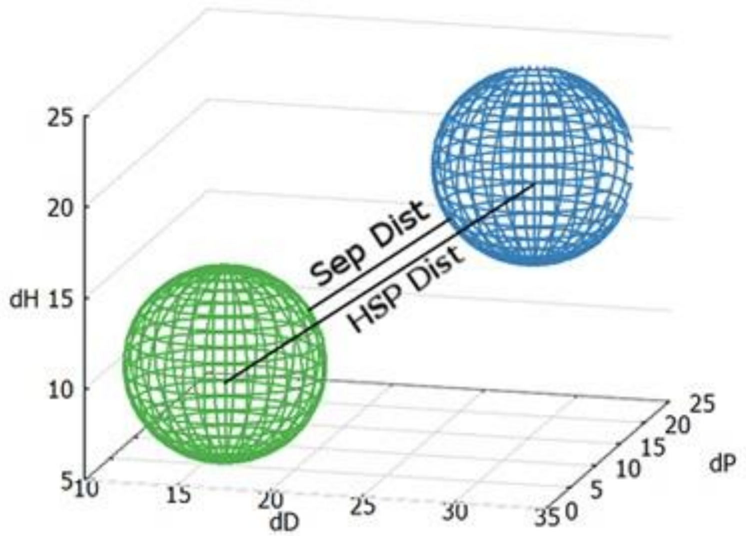

Negative values signify that the spheres are overlapping – the more negative the value, the higher the degree of overlap. A larger amount of sphere overlap predicts better compatibility of materials.

Example Data

As part of a case study, the HSPs of 7 dispersants are compared and then their HSP Distances and Separation Distances from the product of interest (Talc) are calculated. This data is presented below:

Dispersant	dD	dP	dH	Radius	$Dist_{sep}$
Polyether Siloxane	18.1	11.48	11.14	15.6	-14.55
Ammonium Polyacrylate Dispersant 1	22.8	19.83	32.81	18.6	6.35
Polymeric Dispersant 1	12.2	17.04	12.99	14.9	-3.75
Polymeric Dispersant 2	19.3	13.56	10.58	8.1	-4.11
Modified Polyester 1	17.9	20.31	37.05	19.9	6.81
Ammonium Polymer Salt 1	18.0	13.54	19.11	12.1	-4.38
Ammonium Polyacrylate Dispersant 2	18.7	12.95	25.07	6.1	6.99

HSP Data for a Selection of the Dispersants Tested

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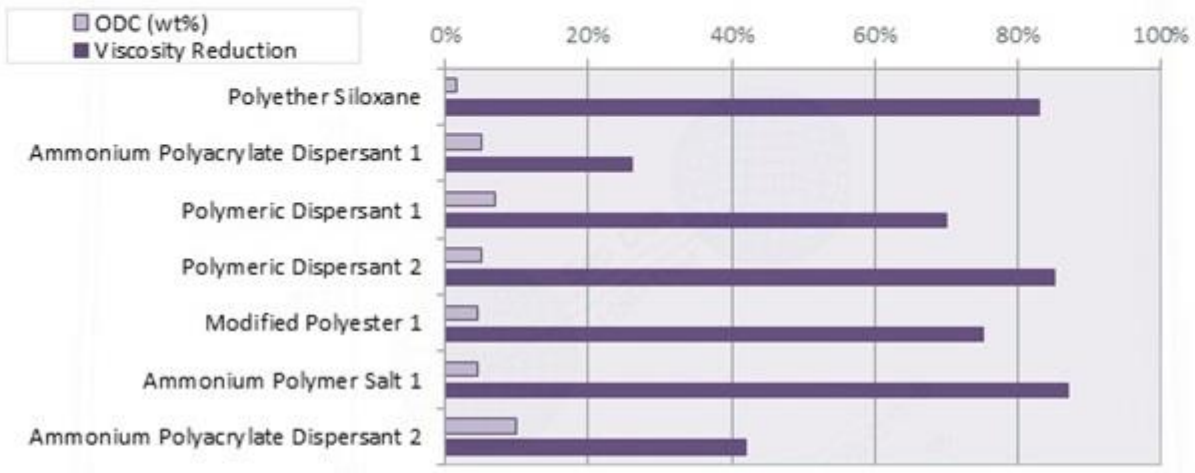
Based upon the HSP data the following dispersants are predicted to be more suitable for the particle in question:

- Polyether Siloxane (Considered the best)
- Polymeric Dispersant 1 & 2
- Ammonium Polymer Salt 1

To test the HSP predictions, an ODC study was performed by monitoring viscosity reductions upon stepwise additions of each dispersant in talc slurry:



ODC Results Overview for Talc

Dispersant	ODC (wt%)	Viscosity Reduction	Performance
Polyether Siloxane	1.5%	83%	++
Ammonium Polyacrylate Dispersant 1	5.0%	26%	--
Polymeric Dispersant 1	7.0%	70%	+
Polymeric Dispersant 2	5.0%	85%	++
Modified Polyester 1	4.5%	75%	+
Ammonium Polymer Salt 1	4.5%	87%	++
Ammonium Polyacrylate Dispersant 2	9.9%	42%	-

ODC Results Overview for Talc

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Validation of HSP with ODC

The results of the ODC study can now be compared to the HSP predictions:

Dispersant	$Dist_{sep}$	ODC Performance
Polyether Siloxane	-14.55	++
Ammonium Polyacrylate Dispersant 1	6.35	--
Polymeric Dispersant 1	-3.75	+
Polymeric Dispersant 2	-4.11	++
Modified Polyester 1	6.8	+
Ammonium Polymer Salt 1	-4.38	++
Ammonium Polyacrylate Dispersant 2	6.99	-

Dispersants with negative HSP Separation Distances (i.e. overlapping spheres) tend to offer better performance in ODC tests. In particular, Polyether Siloxane gives, in this case, the most suitable ODC profile, as well as the highest degree of overlap.

Savings with HSP-based Dispersant Selection Method

Determining HSP for both solid particles & dispersants is an investment, but the data can be reused for all future projects, so will save time and money!

All HSP's can be used in combination for screening, e.g.

4 Dispersants and **1** Particle = **4** sets of distance values.
4 Dispersants and **2** Particles = **8** sets of distance values.
4 Dispersants and **4** Particles = **16** sets of distance values.

So, every extra HSP that is determined gives many more predictions and speeds up the screening process. Also, using these values the HSP of mixtures can be calculated, which allows blending of dispersants to get a closer HSP match to the particle, further improving the compatibility.

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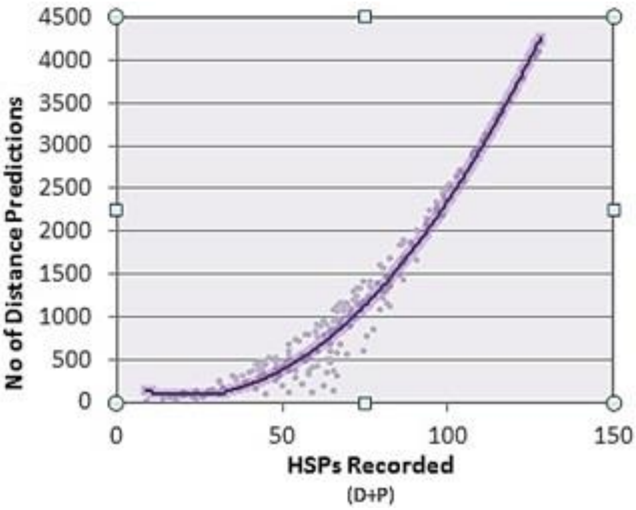
Knowledge Increases with HSPs Tested!



In general:

As you measure more and more HSPs the predictive power rapidly increases. This means:

- More knowledge
- Fewer experiments
- More savings – in time and money!

Conclusion

Hansen Solubility Parameters were successfully used to predict the best dispersant for a specific pigment/filler, as confirmed by the results obtained with more traditional screening...and **once you create a HSP database of your ingredients, you can make predictions about your raw materials almost instantaneously!**

Some raw material suppliers now provide HSP data with their products, if all suppliers did then everyone could formulate faster and with more precision!