Formulating cleaning products – Future high performing vehicle shampoos and industrial cleaners

In our first issue of Formulating cleaning products we discussed the evolvement of ingredients into today's more bio-based alternatives. Still and by far the synthetic based products dominate, however particularly in the Nordic region of Europe there is a proactive strive towards using ingredients with less impact to the environment.

In this issue we will cover industrial degreasers, also referred to as shampoos or cleaners. Often one might start thinking about the particular "application", however we encourage people to think more on the side of soil and substrate (surface), i.e. what is going to be cleaned and from what? In doing so the connection in between e.g. vehicle and industrial cleaners as the soil and substrate many times are of the same nature.

So let´s dive into the formulation and the best approach to illustrating performance is likely to present an exact formulation. Here we go!

The representative formula and why

Percentage (w/w)*	Ingredient	Function
7	Berol 360	Wetter/Emulsifier
7	Berol 366	Emulsifier/Wetter
10	Berol Surfboost AD15	Co-surfactant/Hydrotrope
3	Berol 185 PO	Wetter/Hydrotrope
3	Perlastan SCG 38 PF	Foam booster/Co-surfactant
10	Dissolvine GL-47-S	Complexing agent
1	Ampho PAS	Dispersant/Anti-scalant
10	Bio-based Propylene Glycol	"Solvent"/Hydrotrope
49	Demineralized water	Media

* All percentages are product percentages, not actives

The above recipe/formulation provides a high-performing water based industrial degreaser concentrate. Recommended dilution is from 1:10 up to 1:40, possibly even higher, depending on the actual soiling degree and the nature of the same.

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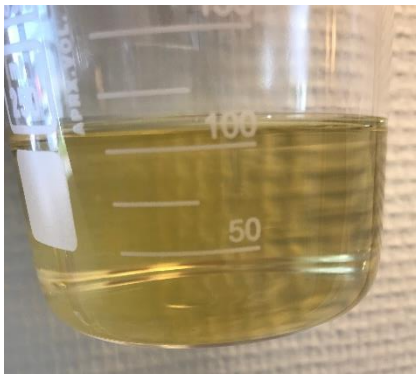

The concentrate has the appearance of a slightly yellow and viscous liquid. Optionally one can add colorant, thickener and others.

The presented concentrate will, according to our mapping, carry the health hazard statement H318[1], Causes serious eye damage and thus the GHS05 pictogram.

So, how does one justify the basic build-up of this concentrate and what does each component contribute to:

Berol 360, Berol 366 and Berol Surfboost AD15 form the surfactant base. This is the backbone of the degreasing part, working well as is, however is not optimized. Berol 360 and 366 are the work horses when it comes to removal of hydrophobic soil. They represent the major wetting and emulsification function. Berol Surfboost AD15 has the primary function of boosting the cleaning performance in allowing greater access to soil (Co-surfactancy). Berol Surfboost AD15 will not act on its own but there is a co-dependency in between Berol 360, 366 and Surfboost AD15. Besides performance boosting Berol Surfboost AD15 is the major hydrotrope, allowing Berol 360 and 366 to co-exist in aqueous solutions together with more polar ingredients (e.g. Complexing agents).

Berol 185 PO and Perlastan SCG 38 PF are there to boost two important properties, wetting and foaming, respectively. Berol 185 PO provides alternative wetting to foremost Berol 360 and allows otherwise difficult soil to be removed more quickly. Perlastan SCG 38 PF boosts foaming properties in that it keeps the foam stable and in a more "collapsible format". The primary function of foam, in this context, is to provide continuous access to fresh cleaning liquid. This takes a foam with high liquid content (a more wet foam) to continuously collapse to the surface. Perlastan SCG 38 PF enables the formulation to do so.

Dissolvine GL-47-S and Ampho PAS provide what is normally referred to as the builder system. The first function is to be able to remove bi-valent ions such as Calcium and Magnesium for two reasons: 1, soil is kept together by them 2, to prevent scale formation. The first reason is for cleaning performance and the second more for the end result. Scale will be readily visible on surfaces, which is of cosmetic nature in most cleaning applications, in contrast to water treatment where it can cause technical issues.
The second function is dispersion. Dissolvine GL-47-S is the primary ingredient breaking up soil particles for the Ampho PAS to be able to disperse. This function is related to anti-redeposition of cleaned soil. If the dispersion function is absent there is a significant risk of re-deposition of particles. One common example in vehicle cleaning is "traffic film", an insufficient builder system struggle to break electrostatic interactions and to keep particles in dispersion.

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Last, but not least, the Propylene Glycol. The propylene glycol provides altered properties of the continuous phase, the overall solvent. Unfortunately, water is an enemy of hydrophobic soil and altering the properties of the aqueous phase provides a more balanced behavior of the same. Besides this propylene glycol also acts a bit like an organic solvent, but since it is water soluble it also contributes to the co-hosting of ingredients, *i.e.* hydrotropy.

All in all, the ingredients in co-operation provide a high performing aqueous industrial degreaser. We have all the respect for the difficulty in formulating so we chose to present a complete formulation for use as is or for further optimization.
To touch upon further optimization the first thing to consider is the balance in between the surfactant and builder parts. For more hydrophobic soil the surfactant system is key and for more particulate (inorganic) soil the Builder system is key. It is always a balance and the limitation is really how far you are ready to optimize.

Anything missing?

The active formulator might recognize the absence of caustic, the end result normally referred to as alkaline or high alkali cleaners. Let´s think about it: What does high pH do in the system which is not covered by the function of other ingredients? To elaborate a bit let´s consider from where the recommendation of alkali addition originates. In our experience, besides nowadays not even being questioned, the addition of caustic comes from the intention of chemically hydrolyzing natural fats and oils. The key is chemical reaction, and this can also be applicable for other things besides fats and oils of course. So, think about it, what chemical reaction can occur between caustic and synthetic oils, greases etc…?
A not directly related function is the introduction of ion-strength. This is good for preventing agglomeration of particles but can also be achieved by non-alkaline conditions (other ions). Why add caustic?

On the bad side of things, high pH will force the often so feared scale to precipitate, making it even worse and in addition the ion-strength, presented by hard ions, will put unnecessary strain to your formulation. The latter resulting in you having to use more hydrotrope than otherwise necessary, adding cost as well.

Of course, there are applications where caustic come in handy, such as in food processing cleaning. However, in these applications you actually make use of the chemical reaction(s) with hydroxide ions.

So, pH does not matter? Well, actually it does, however in our experience the pH needed to achieve the desired properties and performance is 10 to 10.5. There are some functionalities which are preferentially maintained in their basic form for soil removal.

Still not convinced? We do not blame you but recommend you to test for yourself. Does alkali contribute to typical industrial degreasing?

Testing of the formulation

There are endless ways to test formulations, however for the purpose of this article let´s stay with a few basic lab tests.

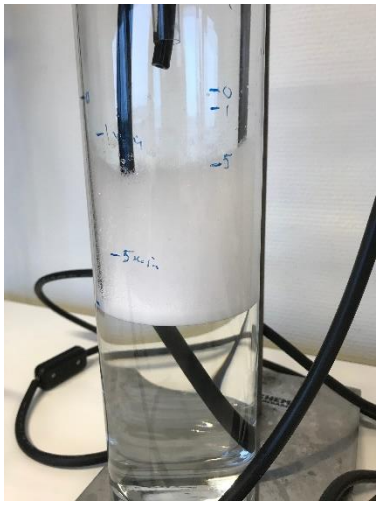
Formulation stability:

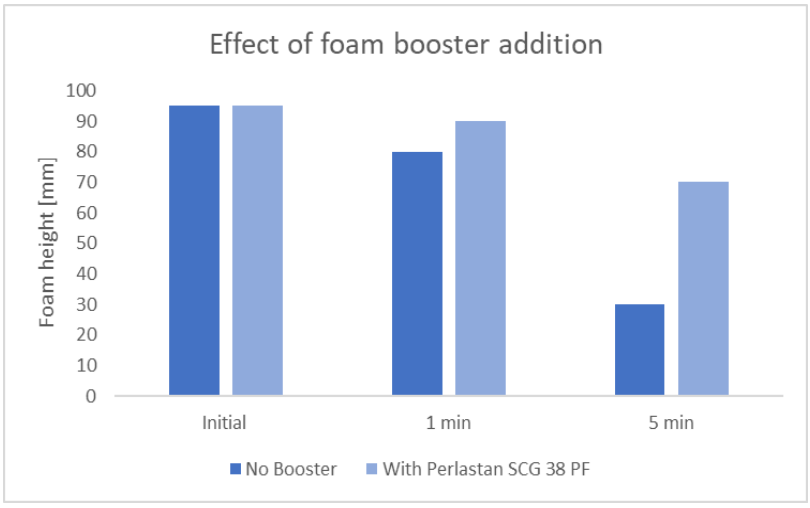
How is your product going to be distributed? Most likely it will be as a concentrate and if so can you guarantee certain transport and storage conditions? Changes in temperature are known to cause issues with formulation stability and it is important to make sure the formulation is stable.

A common feature of formulation with non-ionic surfactants is related to clouding. Clouding appears at a certain temperature when a poly-alkoxy-based product changes it´s polarity due to the temperature. The exact temperature can be altered by using more or less hydrotrope, more or less of hydrophobic components and more or less of ions. Nonetheless the important thing is to know when this happens, as should it happen close to ambient conditions there is a risk for your product separating. For the formulation concentrate presented above the cloud point was measured to be around 32°C, which means at 32 degrees some of the wetters and emulsifiers start to separate out. It was also found that the formulation is stable at least down to 8°C. The freeze-thaw cycles were not tested in this case. However, if there is a risk for extreme temperatures we encourage further testing of formulation stability.

Foaming:

As presented above Perlastan SCG 38 PF is added as a foam booster. The major reason is not to increase the foam, but to make the foam more liquid containing and more stable. Foam with low liquid content will only be for shows and even be consuming performance otherwise spendable on doing the cleaning work. In the figures below a snapshot from foam testing as well as the results with and without the addition of Perlastan SCG 38 PF are presented. It is clear that the addition of the Perlastan contributes to foam stability, even if the absolute foam height is not impacted. During the test it is also evident that the type of foam formed is significantly impacted (with Perlastan a more dense and stable foam).





The test is performed in an in-house designed and build foam tester, based on circulating foam formation. The tests are performed in 1% solutions of the product in demineralized water.

Cleaning performance testing:

We always test the cleaning performance of industrial degreasers using what we refer to as the "black box test". We employ steel plates painted with car paint and a soil with the following basic composition, as used in below testing:

Component percentage	Component
10	Wooden ash
5	Black Wax
2	Wheel bearing grease
9	Diesel

The soil is applied to the painted steel plate. Various dilutions are applied to the top of the slightly tilted soiled plate, the solution allowed to run vertically down the soiled plate and left for one minute. After one minute the plate is extensively rinsed with water.

The basic intention with this test is to distinguish in between various formulations and dilutions. Normally a representative product for comparison is included, however for the purpose of the reference concentrated hand dish wash, was included.

The soil difficulty can be regulated by increasing/decreasing the ratio of individual components and the toughest component being the wheel bearing grease, followed by Diesel and Black Wax.

In this testing round we performed two series: 1, Concentrate, 1:10 and 1:20. 2, Concentrate 1:10, 1:20, 1:40. The reference was included in the second round. The result is displayed in the picture below. The product is seemingly effective in dilutions up to 1:40, even though the effect becomes less with dilution. The reference, concentrated hand dish wash is showing no effect whatsoever on this type of soil.

For the purpose of real life testing, repetitive testing and also random distribution of products and dilutions on the plate(s) are employed to eliminate any uncertainties. Also, a representative bench mark should be included for reference. The ‘‘reference’’ in our case: We are well aware hand dish wash is not designed to cope with this particular soil, but it was included to be a representative baseline, justifying the soil.

From left: Concentrate, 1:10, 1:20, Concentrate, 1:10, 1:20, 1:40 and Hand dish wash (Concentrate).

From testing the recommendation would be a dilution of 1:10 for heavy soiling and up to 1:40 for moderate soiling. If to be used as a ‘‘Summer Shampoo’’ and for light soiling dilutions up to 1:80 are likely to be effective.

A glance at the Nordic Ecolabel considerations and calculations needed

We looked at the Nordic ecolabel criteria for car, boat and train care products. We matched it against a Shampoo and looking at two relevant criteria these are the results:

Critical Dilution Volume (CDV):

Component	DID-No	Active content	% in conc	g/L (use)	DF	TF (DID or calcd)	Actual TF	CDV
Berol 360	2156	100	7	6,4	0,05	0,15	0,15	2121
Berol 366	2156	100	7	6,4	0,05	0,15	0,15	2121
Berol 185 PO	N/A	90	3	2,7	0,05	0,01	0,01	19481
Perlastan SCG 38 PF	2031	38	3	2,7	0,05	0,24	0,63	218
Berol Surfboost AD 15	N/A	65	10	9,1	0,05	0,01	0,02	22727
Dissolvine GL-47-S	2510	47	10	9,1	0,05	0,10	0,21	2136
PAS	2524	40	1	0,9	0,05	0,41	1,03	44
Bio-PG	2581	100	10	9,1	0,05	32,00	32,00	14
Water	N/A	100	49	44,5	0	0,00	0	0
			100	90,9				48863

A Shampoo according to version 6 criteria can have a CDV of maximum 50.000, which means a 1:10 (11x dilution) will pass the criteria.

Volatile organic compounds (VOC):

The criteria state that:

$$\frac{\sum m_1 \cdot POCP_1 + m_2 \cdot POCP_2 + ..}{m_{product}} \leq 12\ g\ C_2H_2\ equivalents\ /\ kg$$

In the formulation in question and at the highest recommended concentration we have 9.1 g/L (~g/kg) of Propylene glycol, the only ingredient subject to VOC calculations.

As it is also stated in the version 6 criteria:

For solvents not included in Appendix 5, the calculation may be based on the POCP values derived from completed tests. Alternatively, the worst case for the VOC group in Appendix 5 may be used.

We use the POCP-value of 0.5 from the Glycol VOC group. The Value of Ethylene equivalents thus becomes 4.5 eq/L (~4.5 eq/kg), which is well within the maximum limit of 12 eq/kg.

There are as you probably know various additional criteria for the current example, however we chose to bring up the two "variable" ones, that can be impacted by exact formulation and concentration in use.

Summary

We hope that through this short article we have raised your interest for the particular high performing industrial degreasing product and the ingredients discussed. We also hope that the formulation as such comes to use, either as is or in a further developed shape. Our continuous ambition is to guide you as a formulator on the way towards more and more sustainable products while maintaining performance! Stay tuned for the next edition of "Formulating cleaning products".

Contact your sales representative should you require a sample or for further inquiries and questions.

[1] There is no claim this is the complete labelling. Additional labelling might be required.