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Introduction

The demands of high performance cleaning especially in high electrolyte cleaning products can require uncommon surfactant properties to be effective in both consumer household and industrial and institutional (I+I) applications. In particular, highly alkaline formulations are shown to be most effective for removal of stubborn greasy or burnt on stains. However, such alkalinity also destabilizes many common surfactants, making the formulation of concentrated alkaline cleaners challenging; a problem similarly faced where high chelating agent loads are desired. We present findings from the development of two cleaner ingredients – Berol LFG 61 and Berol DGR 81 which have very different behaviours in use that can provide formulation performance-enhancement to many challenging applications. In this article, we will show these products deliver excellent performance in high caustic soda or chelating agent formulations – with one providing medium/high foaming, and the other very low/no foaming. We will provide framework formulations and performance-in-use data for a variety of representative application conditions to exemplify this behaviour. These high-activity ingredients are also mild, with excellent environmental properties which are compliant with EU Ecolabel standards.

The Cleaning Challenge

1. Degreasing Mineral Oil, Naturals Fats/Grease and Charred Fat

In industrial cleaning, and some household applications, dirt usually contains oil/grease and particles. To emulsify oil/grease, the pH is not so important, but to have good removal of soils and dispersion of the particles, the pH should be >11. When the oil/grease is charred, excellent wetting is required to release the difficult soil from the surface and enhance its emulsification together with a high amount of caustic to boost performance.

2. Particle Removal and Dispersing

To remove particles and to keep them dispersed in solution so they do not re-deposit onto the surface is important in all cleaning applications. For example, in vehicle cleaning dirt contains a lot of particles, not only from the road but also from pollution from the air. These particles, "traffic film", are extremely small and very difficult to remove in touchless/brushless machines, which have become more and more common today.

Ingredients for Extreme Clean

When tough soils and stains demand the use of highly alkaline or highly acidic formulations, the choice of available surfactants that can be incorporated to create stable formulations is limited, posing a challenge to the formulator. Two ingredients have been developed at Nouryon that offer differing foam profiles to provide the formulator with options to meet the requirements of their application.

Foaming Properties – Your Choice

Different cleaning scenarios demand different foam profiles for optimized performance. To allow the formulator to improve the foam profile of the final formulation in-use, Nouryon combines the unique properties of alkylglucosides and narrow range fatty alcohol ethoxylates together to offer two unique products with very different foaming profiles, whilst maintaining exemplary performance-in-use. By combining the synergistic properties of these two classes of nonionic surfactants, we now offer:

Berol DGR 81 – high performance blend for optimized degreasing with foaming

Berol LFG 61 – high performance blend for very low foam cleaning

In **Fig. 1**, we show these differing foam profiles in a typical food and beverage application where proteinaceous contam-

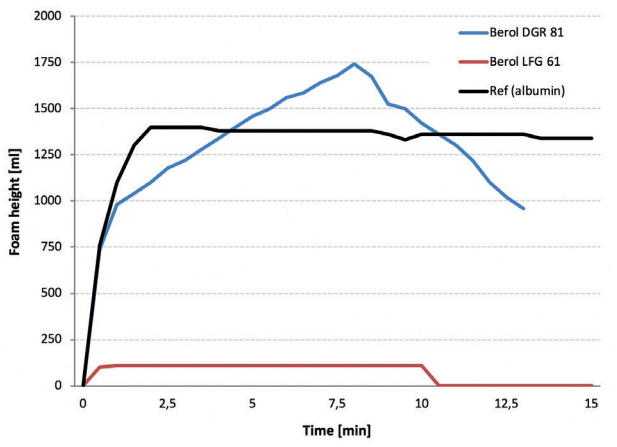

Fig. 1 Foaming profile for the different blends when tested in the circulation method (with circulation halted after 10 minutes). Albumin was used as foaming agent and the graph shows that Berol LFG 61 provides anti-foaming properties in this system, whilst Berol DGR 81 provides foaming.

Fig. 2 Black box test of ceramic tiles soiled with Lambert soil.

ination is present – Berol LFG 61 is defoaming in this study. In standard Ross-Miles foaming tests, Berol DGR 81 shows a moderate foaming profile (immediately: 62mm, after 5 min: 16mm), whilst Berol LFG 61 has low/no foam (immediately: 8mm, after 5 min: 0mm).

Good Wetting in High Electrolyte

Under standard Draves Wetting (25°C, 0.1% surfactant), Berol DGR 81 and Berol LFG 61 may not be the best wetting agents – 20s and 600s respectively. However, in the extreme conditions of high caustic, very few surfactants will remain stable in solution, and therefore the ability to wet soil surfaces to allow effective contact of caustic to soil is a very important performance characteristic of these products.

This is illustrated in **Fig. 2**, which shows a white ceramic tile that has been treated with Lambert soil – a standard soil simulating household-type applications. A black box test is used, where a standard amount of cleaning solution is poured onto an angled, soiled tile without mechanical action and lightly rinsed with water. A simple cleaning formulation of sodium hydroxide (NaOH) at concentrations of 10, 20 and 30 wt% in water is used to treat the tile, both with and without Berol DGR 81 at 5%.

As can be clearly seen, the presence of the surfactant allows the soil to be wet by the solution, the sodium hydroxide to contact the soil, and together with the surfactant synergistically emulsify the oily-soil and remove it from the surface. Without surfactant, virtually no soil is removed by the NaOH solution alone. This is attributed to the fact that concentrated NaOH solutions have high surface tension, so almost no wetting of the soil can occur, with the soil remaining in place.

In **Fig. 3**, we show a typical IKW mechanical cleaning test which was performed on a white tile treated in the standard manner. In this case, mechanical action with sodium hydroxide alone does provide some cleaning performance, but as in the black box test, the addition of the surfactant cleaner provides clear improvement, thus reducing the amount of time the cleaning agent must contact the soil before removal is attempted, and/or minimizing the amount of energy input required to achieve satisfactory cleaning.

Unusually, the higher sodium hydroxide level significantly encourages performance from the cleaning solution, removing the soil almost completely from the white tile where the solution contacted. For these products, caustic soda itself is acting synergistically, boosting the dissolution and performance of the surfactant – a very helpful characteristic for alkaline cleaning.

Few other surfactants can be stable in such high caustic conditions. Berol LFG 61 and Berol DGR 81 are both stable to >40% NaOH. Further, Nouryon has optimized the ratio of surfactants in these performance blends to give the formulator the best cleaning in extreme conditions, where either no foam (Berol LFG 61) or medium/high foam (Berol DGR 81) is required. This means the formulator need not seek secondary surfactants to boost cleaning performance, and can instead focus on developing the other elements of a successful alkaline cleaner formulation.

Incorporating Chelating Agents with Ease

Secondary ingredients such as chelants are often used to enhance cleaning performance also. It is believed that dications (such as Mg^{2+} and Ca^{2+}) act as bridging agents between the soil and negatively charged surfaces to which the soil adheres, binding it strongly to these surfaces. Chelants strip away such binding agents from the soil, allowing the surfactants to penetrate and remove the soil more effectively.

However, like with caustic soda, chelants are electrolytes, and can cause destabilization of surfactants solutions (i.e. lower-

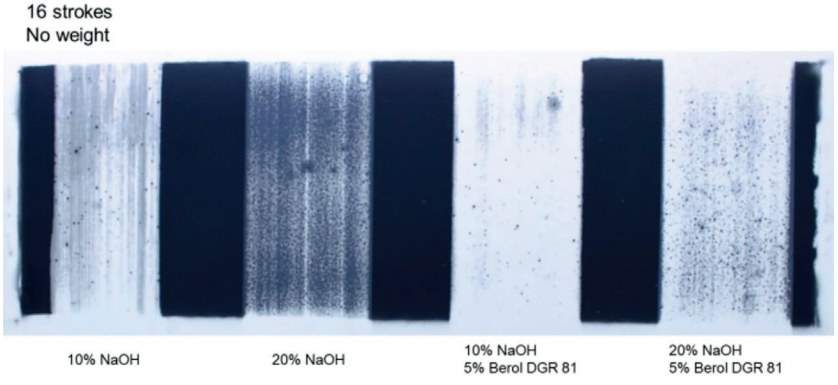

Fig. 3 IKW cleaning tests with high caustic and Berol DGR 81-treated cleaning solutions.

NaOH (%)	Dissolvine GL-47-S (%)	Demineralized water (%)	Berol LFG 61 or Berol DGR 81				
			1%	2%	3%	4%	5%
7.5	1	90.5–86.5					
10	1	88–84					
12.5	1	85.5–81.5					
15	1	83–79					
20	1	78–74					

Hazy or separated Clear

Tab. 1 Stability of Berol LFG 61 and Berol DGR 81 cleaning solutions incorporating caustic soda and chelating agent.

ing cloud points or causing phase separation), even if caustic soda is not present. **Tab. 1** gives an example of how easily chelants, such as bio-based Dissolvine GL-47-S (L-glutamic acid N,N-diacetic acid, tetra sodium salt (GLDA)) – a vegetable-origin biobased chelating agent, can be incorporated into high caustic cleaning formulations containing either Berol LFG 61 or Berol DGR 81, without causing any stability issues.

Even with very high caustic soda loading, a chelating agent can easily be incorporated, with very limited impact on surfactant stability, with solubility increasing with higher electrolyte. The stability behaviour of both Berol LFG 61 and Berol DGR 81 are very similar, with improvements in product solubility seen as NaOH concentration rises.

Enhanced Surfactant Solubility with Higher Caustic Load

Many surfactants will salt-out of solution as higher electrolyte amounts are added into aqueous formulations, with the effect of reducing cloud point. Unusually, this is not the case with either Berol LFG 61 or Berol DGR 81. With these products, the inclusion of sodium hydroxide will salt-in the surfactants into solution. **Fig. 4** gives an example of this phenomenon on the cloud point of a simple Berol LFG 61-containing high-chelant alkaline cleaning solution.

The benefit of this property being to provide very stable and effective alkaline cleaning solutions for a variety of cleaning scenarios, examples of which follow.

Typical Applications

Berol LFG 61 – low foam

- CIP (cleaning in place)
- Highly alkaline cleaners
- Machine dishwash
- Brewery and dairy cleaning
- Rinse aid

Berol DGR 81 – medium/high foam

- OPC (open plant cleaning)
- Highly alkaline cleaners
- Traffic film removal
- Offshore cleaning
- Engineering cleaning
- Oven cleaning
- Smokehouse cleaning

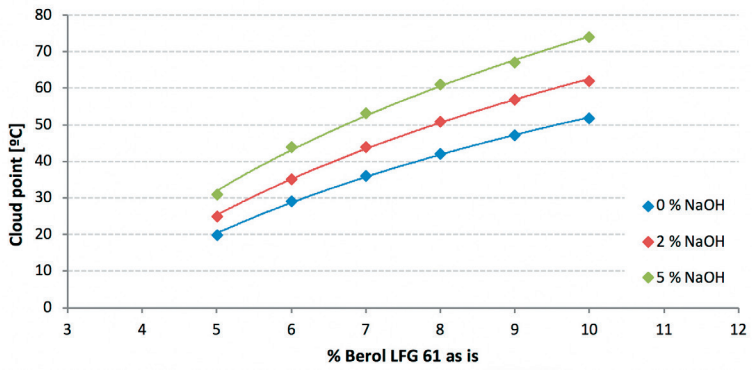

Fig. 4 Impact on cloud point of varying NaOH and Berol LFG 61 concentrations in a 10% GLDA chelating agent solution in demineralized water.

Example Formulations

Alkaline Cleaner

5-10%	Berol DGR 81 or Berol LFG 61
3-5%	Complexing agent
5-40%	Caustic
Balance	Water
Use concentration	1:10 - 1:40

Acid Cleaner

4%	Berol DGR 81 or Berol LFG 61
20%	Phosphoric, citric or hydrochloric acid
Balance	Water
Use concentration	As is

Sustainable Raw Materials / EU Ecolabel Compliant

In line with Nouryon's sustainability aspirations, these innovative products are produced from renewable raw materials whenever possible, which can include both the surfactant hydrophile and the hydrophobe. Our company is a member of the Roundtable on Sustainable Palm Oil (RSPO) and certifies our finished products accordingly, an important element in EU Ecolabel compliance.

Both Berol LFG 61 and Berol DGR 81 are recognized as compliant with EU Ecolabel standards, a system set up to encourage products that are kinder to the environment.
Both products are also high activity materials (95%), minimizing packaging and distribution costs and allowing customers to reduce stocking space for these ingredients on site. Both products are mild, with low toxicity and are readily biodegradable.

Conclusions

Berol LFG 61 and Berol DGR 81 offer the formulator excellent cleaning properties for inclusion in highly alkaline cleaning formulations for both household and I+I cleaning. These synergistic blends provide exceptional compatibility, effectively degreasing in a variety of cleaning scenarios, either with or without secondary mechanical action. Where mechanical action is available, both a low/no foam option (Berol LFG 61) as well as a moderate foam (Berol DGR 81) variant are available to the formulator from which to build final formulations. Such formulations can qualify for EU Ecolabel certification as both products are produced from benign ingredients with excellent environmental properties.

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