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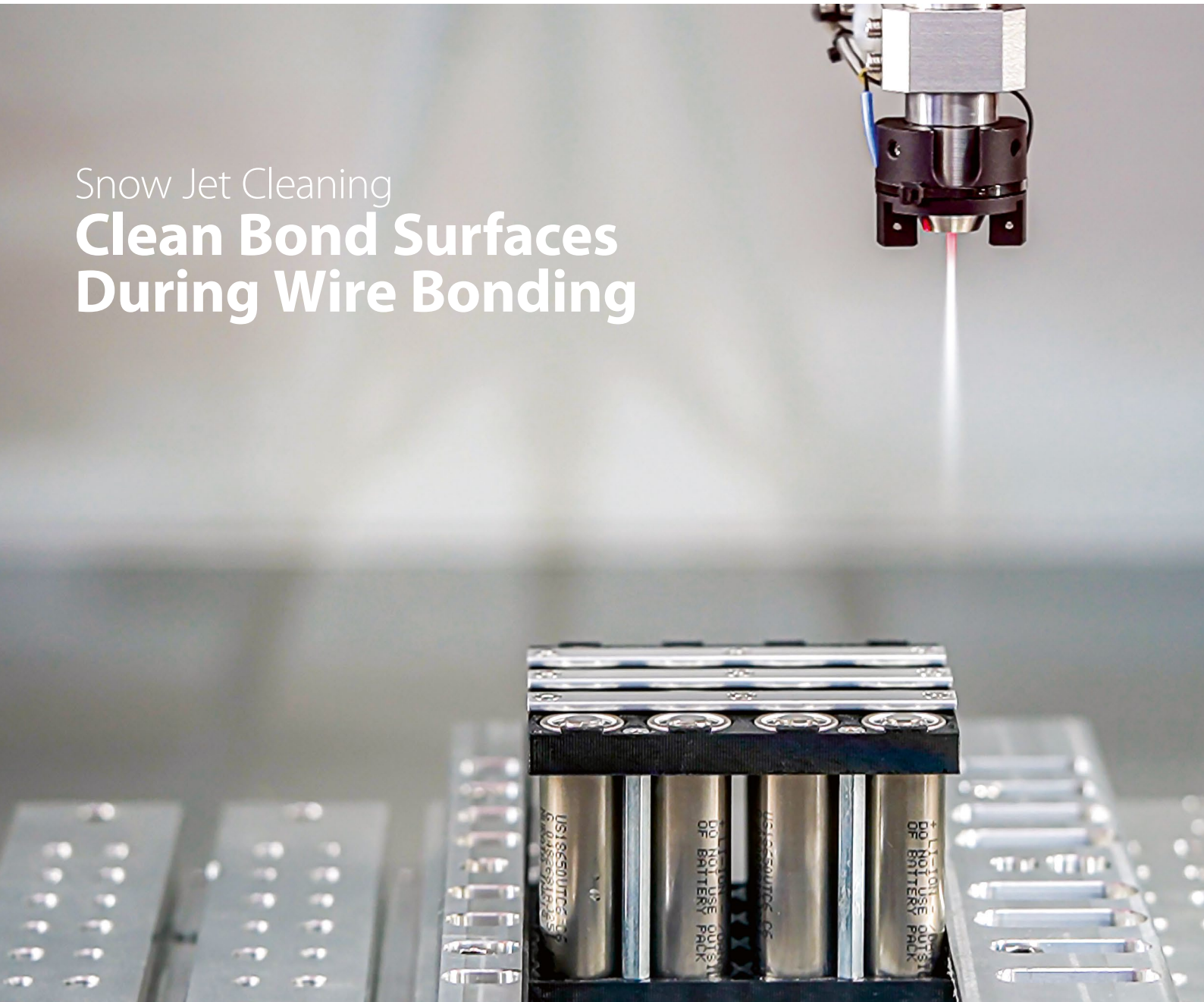

Snow Jet Cleaning

Clean Bond Surfaces During Wire Bonding

Surfactant Class With Multifunctional Properties

Alkyl ether carboxylic acids are highly modular surfactants that perform several functions in metal cleaner formulations. Particularly noteworthy is the significant increase in the cleaning efficiency of particulate soils.

Dr. Thomas Myrdek

Modern cleaner formulations are complex mixtures and consist of a large number of very different substances. These each fulfill a specific purpose. Typical ingredients are:

- pH regulators set a specific pH value of the cleaner. Typically, one uses sodium, potassium hydroxide for highly alkaline cleaners (pH >11), amines for alkali-free neutral cleaners (pH between 11 and 5) or phosphoric acid for acidic cleaners (pH <5).
- Inorganic salts such as tetrapotassium pyrophosphate and sodium metasilicate or organic complexing agents such as methylglycine diacetic acid trisodium salt are supposed to intercept the calcium and magnesium ions from the tap water.
- Surfactants wet the surface, dissolve the dirt and stabilize it in the cleaner after removal. Non-ionic surfactants represent the most important surfactant class in terms of quantity.
- Other adjuvants include hydrotropes, which dissolve insoluble components; biocides, which are designed to protect the cleaner from fungal and bacterial attack; and corrosion inhibitors, which prevent the cleaned workpiece from being attacked by corrosion.

Due to ever new regulations, for example the Biocide Regulation and REACH, the number of substances that can be used is constantly decreasing. Consequently, manufacturers of cleaning agents are forced to constantly adapt and optimize their formulations. Accordingly, multifunctional products are of particular interest.

Modular surfactants

Anionic surfactants in particular are capable of taking over or supporting several properties, for example hydrotropy or hard water stability, in metal cleaners. alkyl ether carboxylic acids, which are marketed by Kao Chemicals under the name Akypo, among others, have a modular structure that allows specific properties to be set, *equation 1*.

The basic component of all alkyl ether carboxylic acids is a fatty alcohol. This can vary greatly in its C-chain, starting with butanol (C4) and ending with oleyl alcohol (unsaturated C18). This is the first parameter in the molecule to set a desired polarity in the surfactant. 90 % of all alykl ether carboxylic acids available from Kao Chemicals are ethoxylated. The length of the polyether chain influences, among other things, the water solubility. Furthermore, there are some Akypos that also have PO (propylene oxide) between the alkyl and EO chains. These so-called extended surfactants exhibit particularly high surface activity, and emulsions stabilized with these surfactants are characterized by particularly high stability. At the end of the molecule is the carboxylic acid function, which is either not charged or negatively charged, depending on the pH value.

Thus, Akypos can exhibit the functionality of a non-ionic surfactant at low pH values, or they act as an anionic surfactant at higher pH values. Thus, alkyl ether carboxylic acids (Akypos) combine the advantages of non-ionic surfactants and fatty acids. Furthermore, most Akypos are readily biodegradable and thus meet the template of the European Detergent Regulation for surfactants.

$$R\text{-}(PO)_m\text{-}(EO)_n\text{-}O\text{-}CH_2\text{-}COOH$$

Equation 1 General structure of an Akypo (alkyl ether carboxylic acid), R = C4 to C'18, m = 2 to 6, and n = 2 to 11.

Multifunctional properties

Due to the modular structure of the Akypo molecules, they can be tailored to perform several or specific tasks in a cleaner formulation. For example, they can be

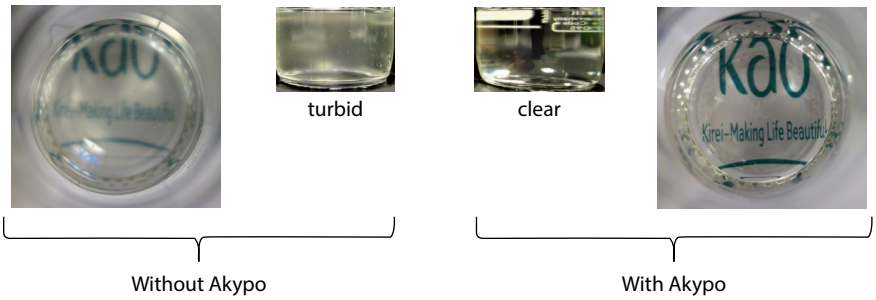

Figure 1 > Stabilization of a defoamer in a cleaner concentrate, on the left unstable solution without Akypo, on the right stable solution with Akypo.

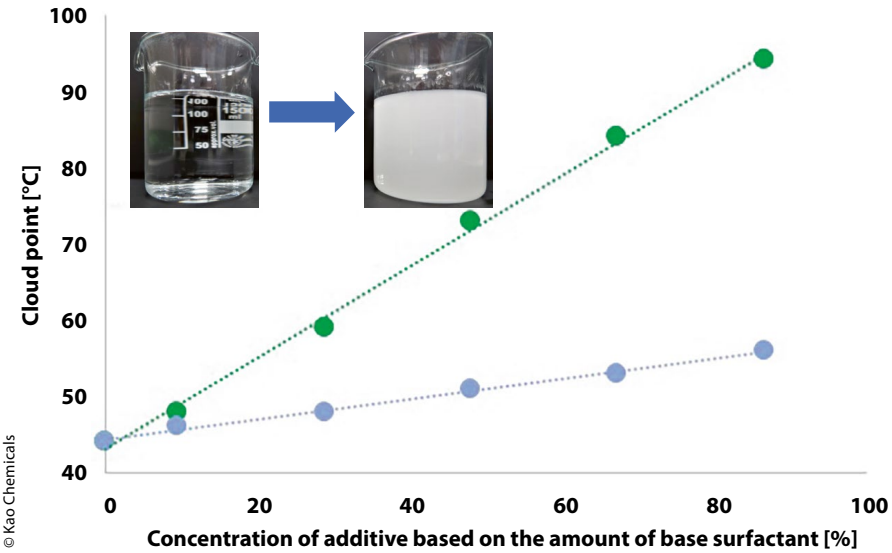

Figure 2 > The cleaner formulation has a cloud point of 44 °C. This can be increased by adding an additive. As can be seen from the figure, Akypo has a significantly higher influence on the cloud point than a non-ionic surfactant (C1315 EO9).

Basis of cleaner formulation	Volume of Ca^{2+} – water [mL]
Non-ionic surfactants	4,5
Non-ionic surfactants + Akypo	11,5

Table 1 > Volume of Ca^{2+}-water [80° dH] before turbidity occurs in the cleaner formulation.

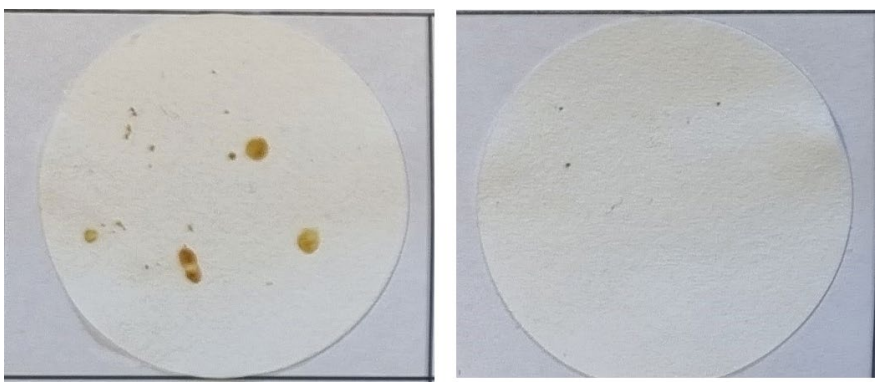

Figure 3 > Corrosion protection behavior of different cleaner formulations according to DIN 51360-2. The right picture shows a combination of Akypo and an amine in the cleaner, which have formed a temporary corrosion protection. The left picture is from a cleaner based on non-ionic surfactants.

used as hydrotropes, which means they dissolve insoluble components in the formulation and stabilize them, *Figure 1*.
This stability has been proven to be present at both higher and lower temperatures. Thus, an improved solubility of the defoamer in the cleaner concentrate is achieved. Another advantage is that the cloud point of the diluted cleaner can be adjusted by adding Akypo, *Figure 2*.
In addition to improved stability and significant influence on the cloud point, Akypos also increase the tolerance of detergent formulations to hard water. The Ca^{2+} and Mg^{2+} ions present in hard water react with components, such as fatty acids, in the cleaner formulations and cause turbidity. This turbidity leads to the instability of the cleaner. A cleaner formulation containing only non-ionic surfactants, in contrast to one containing non-ionic surfactants and Akypo, tolerates significantly less Ca^{2+} water before turbidity occurs, *Table 1*.
The addition of Akypo increases the tolerance to hard water and at the same time leads to an extension of the service life of the cleaning baths. Furthermore, alkyl ether carboxylic acids (Akypos), in suitable combination with amines, form a temporary corrosion protection similar to fatty acids, which protects the workpiece for a certain time, *Figure 3*.

Cleaning properties improved for particulate dirt

In addition to the properties already mentioned, Akypos also increase the cleaning efficiency of the formulation. A major challenge for modern cleaning systems is dirt that is loaded with particles. Depending on their charge, morphology and chemical composition, these particles can be difficult to remove from a metal surface. In particular, applications in which hardly any mechanical forces act or which are difficult to access due to the complex structure of the parts benefit especially from improved cleaning efficiency.
In a simple cleaning test, it was proven that Akypos are particularly good at removing particle-containing dirt from a metal surface. A specific dirt was created for this test. This contains hydraulic oil (HLP 68), which contains 37 w/w% iron oxide powder. 0.25 g of dirt was applied to metal sheets (Q-Lab QD 36) by means of a painter's roller and distributed ho-

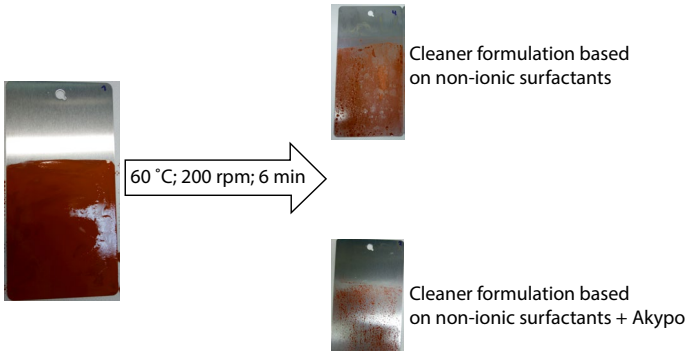

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Figure 4 > Increased cleaning efficiency of Akypo against dirt containing particles.

mogeneously. The soiled sheet was then immersed in the cleaner formulation in a beaker at 60 °C, 200 min^{-1} and cleaned for 6 min, *Figure 4*. This improved efficiency was also demonstrated and reproduced with other particle types, for example activated carbon and alumina-based grinding paste.

Summary of technical possibilities

Considering all available parameters in the surfactant molecule, alykl ether carboxylic acids (Akypos) exhibit a high degree of modularity, flexibility and multifunctionality. Thus, for any technical request, one can recommend an Akypo type among others:

- Low foaming with good wetting properties and strong cleaning efficiency, Akypo IN-0202, Akypo LF 2 & Akypo LF 4
- Strong foaming with stable and moist foam Akypo Foam LM-25 or Akypo Foam RL 40
- Formation of temporary corrosion protection and improved hard water stability Akypo RO 20 VG and Akypo RO 50 VG
- Strong hydrotropic action combined with increased tolerance to hard water and improved cleaning efficiency against particulate dirt, Akypo RLM 45 CA and Akypo TD-70. //

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