Breaking the caking habit

Ivan Gilgado, KAO Corp., Spain, examines an attempt to design more environmentally-friendly anti-caking agents.

The chemical industry has been attempting to introduce measures and products that lessen its impact on human health and the environment. This has been mirrored by efforts from European authorities to minimise the release of microplastics in all aspects of chemical production and consumption. For example, heavy non-soluble polymers have been directly affected by new laws that will ban their use in the near-future.

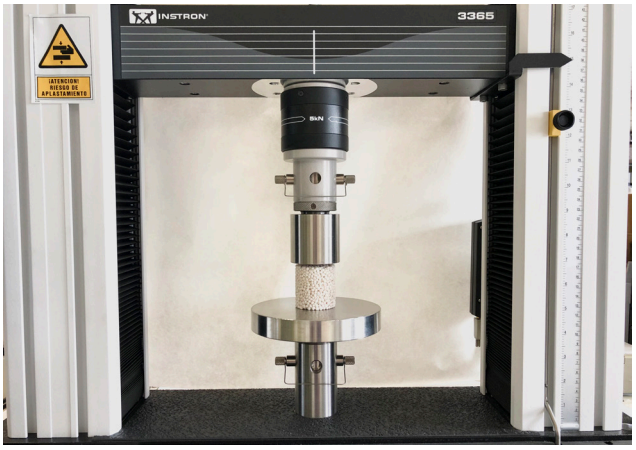

Figure 1. Device for measuring crushing strength on samples with 100% caking.

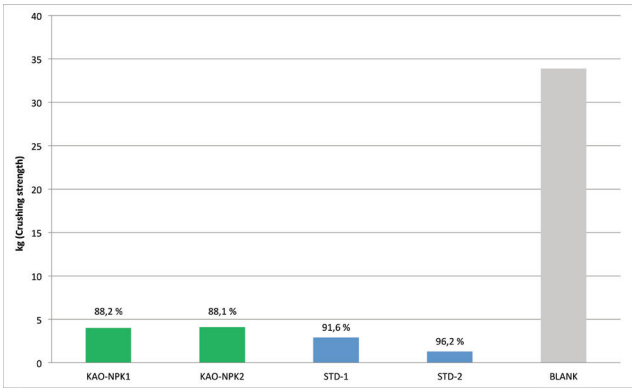

Figure 2. Accelerated caking test on AN-based NPK with addition of anti-caking at a dosage of 1 kg/t.

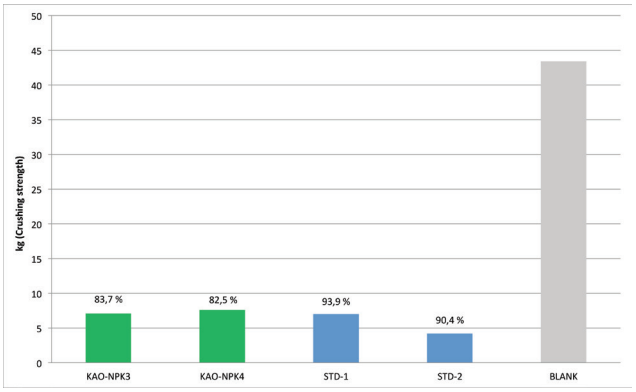

Figure 3. Accelerated caking test on AN/U-based NPK with addition of anti-caking at a dosage of 0.75 kg/t.

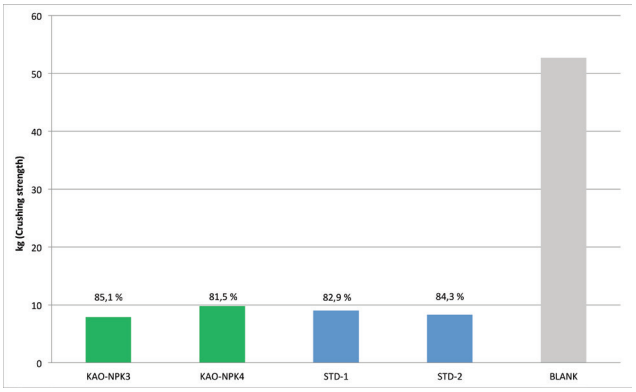

Figure 4. Accelerated caking test on U-based NPK with addition of anti-caking at a dosage of 1.5 kg/t.

The products directly targeted by these restrictions that are of relevance to the fertilizer industry are polymers used as control-releasing additives and some anti-caking agents that use this type of non-soluble heavy molecule. In that respect, KAO's anti-caking additives are intended to be an alternative to these polymers as anti-caking agents.

SK FERT® formulations have high stability at high temperatures due to their hydrocarbon base, and perform well at low dosage due to their active ingredients and high melting points. However, these formulations tend to be non-biodegradable – something the company is aiming to address.

The fertilizer industry has been conscious of the need to minimise the effects of fertilizers on the environment while ensuring the quality and stability of their products. As such, the company has formulated anti-caking agent prototypes designed to have a biodegradable natural base with a low eco-toxicity and bioaccumulation profile. The active ingredients are also non-hazardous and the melting point is lower, thus reducing the carbon dioxide (CO_2) emissions associated with production, transport and application.

In order to assess the comparative performance between existing anti-caking agents and the eco-friendly formulations being developed, this article will discuss a study that analysed three types of nitrogen, phosphorus and potassium (NPK) fertilizer. It is hoped that this research may form a basis for the further development of suitable additives that are competitive and economically viable.

Accelerated caking test

The three types of NPK fertilizer analysed were:

- Ammonium nitrate (AN)-based NPK with anti-caking dosage of 1 kg/t.
- AN/urea (U)-based NPK with anti-caking dosage of 0.75 kg/t.
- U-based NPK with anti-caking dosage of 1.5 kg/t.

The fertilizer was placed in a closed probe and a specific pressure was applied. The sample was then 'stressed' under the following climatic conditions:

- 8 hr at 20°C and 80% relative humidity (RH).
- 72 hr at 40°C and 20% RH.

The probe was then opened and the state of the sample checked to see whether it was free-flowing and to establish the degree of caking. If soft caking had occurred, the lumps that had formed were weighed and the percentage of caking was measured. Finally, the crushing strength was measured (Figure 1).

In all the cases, the final state of the sample was complete caking so the crushing strength was then measured. The results for the test of the first fertilizer are shown in Figure 2. The percentages on the bars express the caking protection as a correlation between the crushing strength of the sample against the blank one.

As can be seen, the caking protection that prototypes KAO-NPK1 and KAO-NPK2 provide are in line with mineral-based standard formulations, taking into account that AN-based NPK is one of the fertilizer types

Table 1. Comparative thermal analysis of standard anti-caking formulations vs eco-friendly prototypes

KAO anti-caking agent	Melting point by DSC (5°C/min.)
NPK1	72.8°C
NPK3	69.5°C
STD-1	84.4°C
STD-2	81°C

with the greatest tendency towards caking. A caking protection level of close to 90% is significant, given that the climatic conditions were extremely harsh in these tests.

In the case of AN/U-based NPK samples, prototypes KAO-NPK3 and KAO-NPK4 performed well, achieving a caking protection similar to one of the company's standards (Figure 3).

With the sample of U-based NPK, prototypes NPK3 and NPK4 also performed well, with fewer differences between the same samples when compared to the standard formulations' results (Figure 4).

Differential scanning calorimetry analysis

The differential scanning calorimetry (DSC) analysis of NPK1 and NPK3, when compared with the results of STD-1 and STD-2 (Table 1), highlights the advantages of lower melting point formulations, such as the reduction of CO_2 emissions throughout the process from production to consumption. Importantly, a lower melting point improves the stability of the active ingredients, since they do not have to be exposed to critical temperatures that could compromise their effectiveness if not managed properly. From an economic perspective, these lower melting formulations decrease the cost of transport and storage of the product, particularly if it is stored for a long period of time or delivered to markets with cold climates and far from the factory.

Conclusion: the next steps

The anti-caking performance of eco-friendly prototypes is promising and in line with current anti-caking additives in the market. Further testing is required however, especially on the long-term efficiency and stability of these new formulations, and the frequency of industrial trials has indeed increased exponentially in recent years. The dust control abilities of the eco-friendly prototypes, although not the main focus of the study, were found to be akin to those of current additives, with the added benefit that the new sustainable active ingredients used are efficient in breaking the crystalline bridges that create caking while not affecting the fertilizer surface.

Although a paradigm shift may not be immediate, the increased pressure to improve sustainability and human safety is likely to force all producers involved in the industry to respond. WF