**Environmental compliance**
Reducing SOx emissions has become increasingly challenging in many parts of the world. Depending on the location, SOx emission limits are defined at the refinery level as bubble limits; at the individual emissions source; or, in some cases, by the concentrations in the atmosphere in the vicinity.

In light of these challenges, many refineries have successfully used SOx additives for reducing overall sulfur emissions. The United States Environmental Protection Agency supports their use, and they are documented as a best-available technique in the European Union’s Best-Available Technology Reference documents.

The strength of SOx additives lies in their inherent flexibility. Additives readily reduce SOx emissions without capital investment. Their usage rates can be increased to make it economically feasible to capture opportunities for processing higher-sulfur feedstocks that would otherwise be unviable owing to sulfur emission limit constraints.

**The KDSOx advantage**
Magnesium is the backbone of functional SOx reduction additives like KDSOx. Sulfur is captured in the FCC regenerator by the formation of magnesium sulfate on the surface of the additive particles.

KDSOx has been commercially proven for over a decade to deliver cost-effective SOx reduction. Its key to success lies in Albemarle’s proprietary hydrotalcite technology, which forms the bulk of the additive mass. The chemical formulae illustrated in Figure 1 show that hydrotalcite has a higher magnesium/aluminum ratio than competitive spinel-based technologies. This translates directly into a greater adsorption advantage for KDSOx.

Data from competitors’ product data sheets indicate that their products contain only about half as much elemental magnesium as KDSOx, and therefore offer lower performance.

**Figure 1:** Hydrotalcite SOx additives have a higher magnesium (active ingredient) to aluminum ratio than spinel-based additives.

**Typical product properties**

<table>
<thead>
<tr>
<th>Additive name</th>
<th>KDSOx</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>SOx reduction additive</td>
</tr>
<tr>
<td>Attrition index, % wt</td>
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</tr>
<tr>
<td>Average bulk density, g/cm³</td>
<td>0.82</td>
</tr>
<tr>
<td>Surface area, m²/g</td>
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</tr>
<tr>
<td>Particle size distribution (0–40), %</td>
<td>10</td>
</tr>
<tr>
<td>Particle size distribution (0–20), %</td>
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</tr>
</tbody>
</table>

**KDSOx HAS BEEN COMMERCIAL PROVEN FOR OVER A DECADE TO DELIVER COST-EFFECTIVE SOx REDUCTION.**
Commercial successes

More than ever, refiners are realizing the advantages provided by the inherent flexibility of additives. Whether during structural or opportunistic use (such as during scrubber maintenance, periods of sour feeds, pretreater upsets or scheduled outages), KDSOx performs consistently, as evidenced by the commercial examples in figures 3–5.

![Figure 3](image1.png)

**Figure 3:** A recent trial to verify KDSOx’s ability at an addition rate of 60 kg/day (3% of daily steady-state emissions) to reduce flue gas SOx levels below their future emissions limit without capital investment.

![Figure 4](image2.png)

**Figure 4:** A recent four-week opportunistic use of KDSOx to minimize scrubber variable costs. The green shaded area indicates an 80% SOx reduction at less than 3% of additive in inventory. Note how the activity is significantly retained after additive use stopped (gray-shaded area).

![Figure 5](image3.png)

**Figure 5:** A new structural user of KDSOx. The shaded area indicates a 50% SOx reduction for a lower addition rate than a competitor’s product (unshaded area). The annualized cost saving realized by this refiner after switching to KDSOx was approximately $150,000.

Lowest cost of SOx reduction

Refiners around the world have been realizing the benefits of using KDSOx simultaneously with or even, at times, in place of their wet gas scrubbers. The flexibility of an additive solution enables refiners to reduce their scrubber operating expenses during times of high caustic costs.

Furthermore, KDSOx can be employed to keep the feed rate to the FCC unit up during periods of wet gas scrubber maintenance or prolonged outages. KDSOx also provides a low-cost alternative to purchasing sweeter feeds or increased feed hydrotreating, the two other common methods of SOx reduction.

KDSOx is the recommended solution for units in these situations:

- full combustion
- SOx reductions between 50 and 90%
- to offset scrubber caustic consumption
- to reduce existing daily additive costs.

For more information on this or other Albemarle products and technologies, please contact your Albemarle representative.

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