ALBEMARLE®

CATALYSTS

KETJENFINE 880 STARS®

The highest hydrogenation NiMo ULSD catalyst

Today's ULSD objectives require top-performing catalysts

Diesel hydrotreating upgrades low-value refinery intermediates to high-value, on-specification transportation fuels. Two primary objectives of ultra-low-sulfur-diesel (ULSD) operations are maximum processing of distressed feedstocks and maximum product volume swell. And both lead to more barrels of ULSD for the market.

The introduction of new generations of catalysts is driven by the need for higher activity, better selectivity and lower costs. Refiners benefit from improved catalysts via higher throughput, increased processing of low quality feedstocks, improved product quality and/or reduced expense per unit of cycle length.

Albemarle's objective is to collaborate with our clients to maximize their operating profit. To achieve this, Albemarle utilizes STAX® optimization technology to develop new premium catalysts, the latest of which is KF 880 STARS®, Albemarle's top performing supported NiMo catalyst for medium- to high-pressure and high-pressure middle distillates hydrotreating.

New from Albemarle R&D: KF 880 STARS — A more intelligent catalyst

Employing STAX kinetic technology, we fine-tuned the catalyst functionalities of KF 880 STARS to deliver best-in-class hydrogenation activity (HYD RVA). Increased HYD RVA boosts conversion of nitrogen, sterically hindered sulfur and aromatics.

KF 880 STARS catalyst delivers the highest HDS/N/A activity of all of Albemarle's supported NiMo catalysts. The result is improved product quality via aromatics reduction, leading to cetane uplift and volume swell.

The application sweet spot for KF 880 STARS is in medium- to high-pressure and high-pressure operations with good hydrogen availability. Application benefits include increased distressed feedstocks upgrading, increased volume swell, increased feed rate and improved cycle length.

"KF 880 STARS is the first catalyst we created utilizing our STAX kinetic engine technology. STAX technology enables fine tuning of catalyst formulations to optimize key kinetic functionalities. KF 880 STARS is a breakthrough supported NiMo catalyst providing first-in-class performance in medium- to high-pressure and high-pressure ULSD service."

Andrea Battiston
Business Director, VGO FCC-Pretreatment

KF 880 STARS >125% RVA HDS

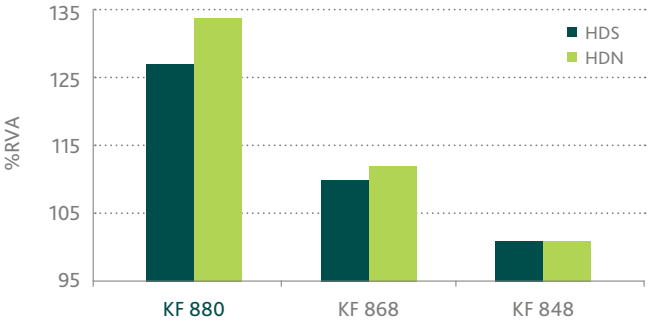


Figure 1: KF 880 STARS RVA vs NiMo ULSD STARS®

An extensive ULSD catalyst portfolio for any objective

Albemarle's ULSD catalyst portfolio contains an extensive array of catalyst functionalities that enable customizable catalyst system solutions to fit any possible combination of unit performance objectives and constraints.

Albemarle employs our STAX technology (optimal catalyst system design technology) to generate tailored solutions for specific customer requirements.

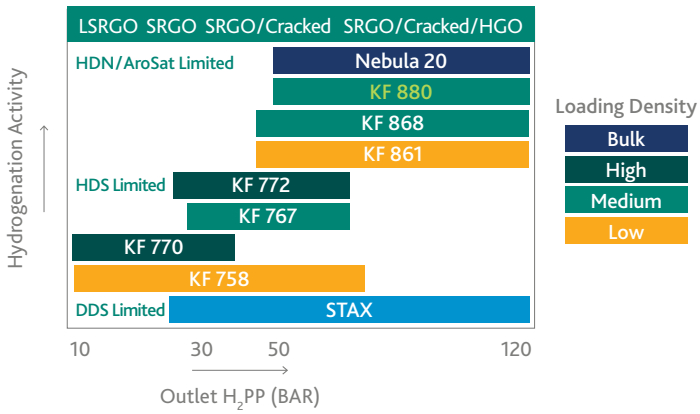


Figure 2: Albemarle's distillate hydrotreating portfolio

Albemarle's ULSD STAX® concept

In the past, the traditional approach to diesel hydrotreating catalyst system design was to fill the first ~ 5-15% of reactor volume with guard/grading catalysts while the remaining reactor volume was filled with a single active catalyst.

Today, Albemarle utilizes a state-of-the-art proprietary catalyst system design approach known as STAX technology. This technology is continuously being refined based on our 15+ years of ULSD R&D and our experience with over 2,000 ULSD commercial cycles. This body of knowledge enables the STAX approach to be markedly different from the traditional approach.

The underlying principle of STAX is that the chemistry is continuously evolving as the hydrocarbon phase travels axially through the reactor volume. The reactor volume can thus be segmented into zones based on primary chemistry similarities and then the catalyst with the best selectivity for each zone can be applied.

Albemarle's approach to catalyst design for ULSD hydrotreating segments the reactor volume below the guard/grading layers into three zones (Figure 3). Depending on the feed quality and specific operating conditions, these zones can vary in length and location.

1. **In Zone 1,** the inhibition effect of basic-N and PNAs is very significant and primarily easy sulfur species are converted by the direct desulfurization (DDS) route. For high-pressure ULSD, Albemarle recommends KF 861 STARS®, a low-density, high metal dispersion catalyst with low affinity for coke precursor adsorption.
2. **In Zone 2**, refractory sulfur species are converted via the two-step hydrogenation desulfurization (HYD) route. This route is inhibited by organic N and aromatics that compete for the same HYD sites. High HYD/HDN activity is thus crucial in Zone 2. For maximum HYD/HDN performance in high-pressure ULSD, Albemarle recommends our highest hydrogenation NiMo catalyst, KF 880 STARS.
3. **In Zone 3**, the absence of organic N boosts HYD route HDS, as well as HDA of mono aromatics. For high-pressure ULSD units with ample H2 availability, we recommend KF 880 STARS with maximum HYD activity. When extraordinary performance is desired, Albemarle recommends its highest activity bulk base metal catalyst, NEBULA 20 (figure 4).

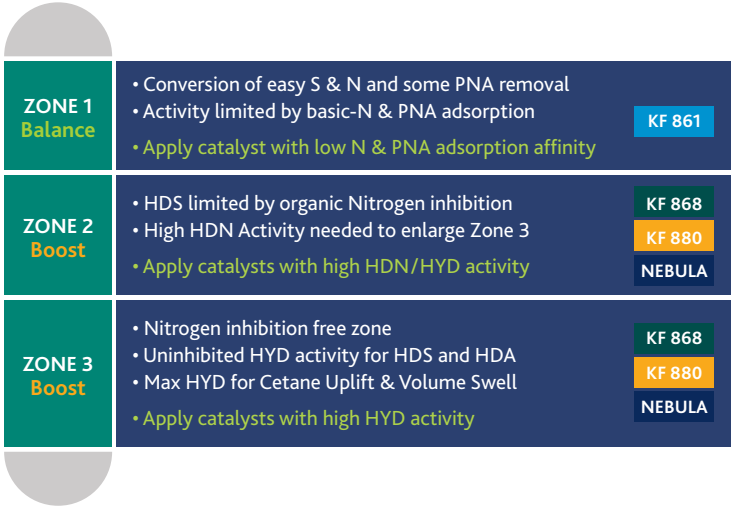
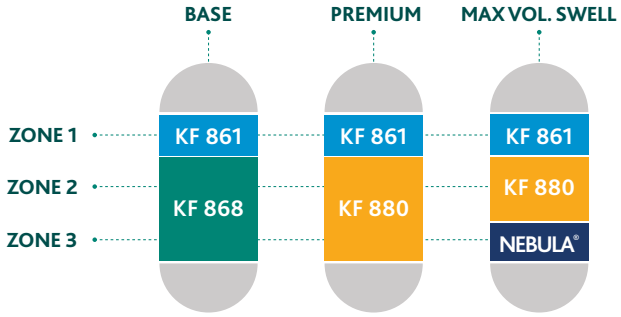


Figure 3: Concept behind DHT STAX Technology

High-pressure ULSD STAX solutions to exceed your unit's objectives



Performance	Base NiMo	Premium NiMo	Max Volume Swell
RVA HDS	Base	+15%	+35%
Cetane Uplift	Base	+1-1.5	+3
Volume Swell (+LV%)	Base	+0.3-0.5	+0.7-1.0
T95 Reduction (C°)	Base	-1	-2

Figure 4: High-pressure ULSD STAX solutions & benefits

FOR MORE INFORMATION ON THIS OR OTHER ALBEMARLE PRODUCTS AND TECHNOLOGIES, PLEASE CONTACT YOUR ALBEMARLE REPRESENTATIVE.

AMERICAS: 13100 Space Center Blvd • Houston, TX 77059 • USA • Tel: +1 281 480 4747 • Email: catmaster@albemarle.com
EUROPE AND AFRICA: Nieuwendammerkade 1–3 • 1030 BE Amsterdam • The Netherlands • Tel: +31 20 634 7300 • Email: catmaster@albemarle.com
MIDDLE EAST AND INDIA: PO Box 293774 • 6W Block A, Office 512 • Dubai Airport Free Zone • Dubai • Tel: +971 4 701 7770 • Email: catmaster@albemarle.com
ASIA PACIFIC: Room 2208, Shui On Plaza • No. 333 Huai Hai Zhong Rd • Shanghai 200021 • China • Tel: +86 21 6103 8666 • Email: catmaster@albemarle.com

www.albemarle.com