



DENALI™

The latest FCC catalyst family from Albemarle

To help refiners' profitability climb to new heights, Albemarle has introduced its latest catalyst family: **DENALI**. The competitive landscape and challenges to profitability have never been greater. More refined products are being distributed by an increasing number of refiners to every region of the globe and squeezing margins. Feedstocks are becoming more difficult and growing in molecular complexity and diversity. New regulations demand new approaches to integrating refinery operations and know-how. Even FCC, the heart of a refinery, is being tested to maintain its dominant position in the refining hierarchy. A key tool for conquering these challenges is new technology. Albemarle's latest technological discoveries are manifested in **DENALI** catalysts and are made using the company's next-generation **GRANITE™** technology platform, which is also the foundation for **EVEREST™** catalysts.

Novel matrix-binder and zeolite technologies

Two innovative technological advances drive the improved performance of **DENALI** catalysts. First is **ADM™-85**, a proprietary matrix-binder specially developed to both improve performance and work complementarily with Albemarle's proven **ADM™-20** (bottoms cracking) and **ADM™-60** (Ni tolerant, coke selective) matrices. One function of **ADM-85** is to provide additional binding without pore plugging, thereby enabling **DENALI** to maintain the same high accessibility with additional active components. The extra binding increases formulation flexibility and, together with high accessibility, increases the ability to disentangle activity from hydrogen transfer, which is critical for maximizing olefins and preserving primary products.

Another key deliverable of **ADM-85** is improved matrix-generated cracking. This matrix is inherently coke selective with an improved pore size distribution that facilitates cracking efficacy and access to larger molecules. Furthermore, **ADM-85** also arrests the formation of zeolite defects, which increases the zeolite's stability to enhance selectivities and activity further.

The second pioneering advancement in **DENALI** catalysts is **ADZT™-600**, a cutting-edge zeolite technology providing multiple benefits. One benefit is higher intrinsic zeolitic stability and retention, which provides a second tool for extricating and controlling activity versus hydrogen transfer. In addition, acid sites have been optimized with less non-framework alumina for fewer undesired reactions, particularly lower coke and gas. Lastly, more mesoporosity has been incorporated to increase zeolitic contact

Real Performance. Where It Counts.

with reactants and result in fewer secondary reactions owing to faster disengagement. Overall, **ADZT-600** delivers improved yields, especially improved coke selectivity and more selective cracking of larger molecules to assist in bottoms cracking.

Two innovative products employing these new technologies are **DENALI** and **DENALI ACTION®**.

Best coke selectivity and lowest bottoms at constant coke among Albemarle catalysts

One catalyst in this new family is **DENALI**, the next-generation product to succeed Albemarle's **UPGRADER™** and **AMBER™** catalysts. Utilizing Albemarle's inventive **ADZT-600** zeolite technology and **ADM-85** matrix-binder, **DENALI** has demonstrated exciting success in laboratory testing using a full range of feedstocks and various deactivation conditions.

Table 1 shows the improved catalyst properties for **DENALI** compared with **UPGRADER** after cyclic deactivation and the addition of 3000 ppmw each Ni and V. In this example, more active ingredients (indicated by the higher surface area) were added to **DENALI** yet its attrition index was 40% lower than **UPGRADER's**. Moreover, even with additional binding via the new **ADM-85** matrix-binder, pores were not plugged and the industry-leading high accessibility was maintained. Even more impressive is the large improvement in zeolite retention, which manifests itself in a much improved yield slate. (It should be noted that the matrix surface area retention is lower; however, the total matrix surface area for **DENALI** remains higher and mechanistically some **ADM-85** is expended protecting the zeolite.)

	UPGRADER	DENALI
Fresh surface area, m ² /g	220	270
Fresh matrix surface area, m ² /g	112	141
Fresh zeolite surface area, m ² /g	108	130
Surface area retention, %	57	67
Matrix surface area retention, %	66	58
Zeolite surface area retention, %	47	76
Fresh rare earth oxide, wt%	2.6	3.3
Fresh attrition index	Base	0.6 × base
Albemarle Accessibility Index	12	12

Table 1: Catalyst properties illustrate positive effects of novel technologies

The first notable yield benefit with **DENALI** is a much improved coke selectivity (ACE testing), as shown in **Figure 1**. The unique zeolite and matrix technologies combined with the ability to formulate more aggressively without deterioration in attrition enable a nominal 15% improvement in coke selectivity for **DENALI** versus **UPGRADER**

DENALI also delivers significantly lower bottoms yield at constant coke. The improved pore size distribution combined with the selective cracking from **ADM-85** and **ADZT-600** drive this improved performance.

DENALI ACTION for superior butylene yields, best coke selectivity and lowest bottoms at constant coke with Albemarle catalysts

DENALI ACTION, another catalyst employing this new technology platform, merges the new **ADZT-600** zeolite technology in **DENALI** catalysts with the shape-sensitive, butylene-selective zeolite technology system (**ADZT™-100**) used in conventional **ACTION** catalysts to generate even higher levels of butylenes. Moreover, the binding power of **ADM-85** permits the application of increased levels of zeolite technologies to increase butylenes and other targeted yields further.

ACTION is recognized as the industry leader in butylene production and selectivity. Now, even higher butane-butylene olefinicity (**Figure 2**) and improved butylene-to-propylene selectivity (**Figure 3**) are achievable with **DENALI ACTION**. This impressive performance demonstrates the step-out change in hydrogen transfer control when assimilating the clever, novel zeolite and matrix technologies in the **DENALI** family of catalysts with the innovative butylene-generating zeolite technology in **ACTION** catalysts. Specifically, combining the increased use of more-stable, acid-site-optimized, larger-pore **ADZT-600** zeolite technology

bound with the selective, highly accessible **ADM-85** matrix-binder and integrated with butylene-discriminating zeolite technology creates superior butylene yields.

DENALI catalysts deliver superior performance

Albemarle has developed the **DENALI** catalyst family incorporating innovative zeolite and matrix technologies. This breakthrough provides new catalyst solutions to help customers increase profitability and fortifies Albemarle's leadership position in the FCC catalyst market.

Compared with other Albemarle catalysts, **DENALI** and **DENALI ACTION** increase value through

- the best coke selectivity
- the lowest bottoms make at constant coke
- the highest leading butylene yields
- an expanded formulation window
- greater control of hydrogen transfer
- a lower (better) attrition index
- high accessibility.

DENALI catalyst is available for commercial use; initial FCC unit trials are expected in the second quarter of 2018.

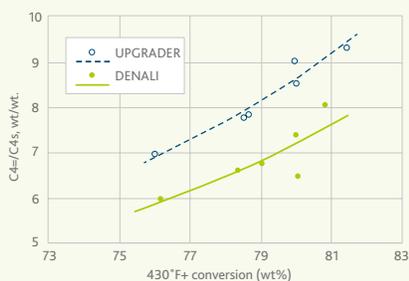


Figure 1: Coke selectivity improves by 15% with DENALI.

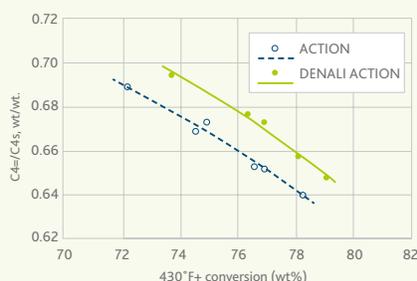


Figure 2: DENALI ACTION increases butylenes beyond the industry-leading ACTION.

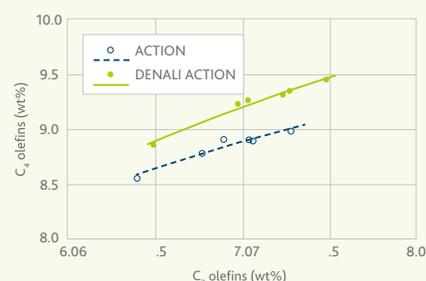


Figure 3: Higher butylene-to-propylene selectivity with DENALI ACTION.

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