Latest Innovation in Catalyst and Additives to Maximize Propylene Yields from the FCC

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Abstract

The growth in the demand for petrochemicals is expected to exceed that of transportation fuels. As a result, many refineries are adopting operating strategies that target production of petrochemical feedstocks in order to maximize profits. One such strategy is to leverage the Fluid Catalytic Cracking Unit (FCCU) to produce propylene. W. R. Grace & Co. is the market leader in providing refiners with catalyst solutions to maximize valuable C3= from the FCCU.

To maximize C3= from the FCCU, it is important to optimize both the Y-zeolite (base) catalyst and ZSM-5 technologies to the feed, constraints, and yields of other products. On the base catalyst side, to maximize LPG olefins and RON, it is desirable to use catalysts with low hydrogen transfer characteristics. Applications seeking to maximize LPG olefins from resid are especially challenging since this feed is usually lower in hydrogen, limiting the max propylene potential, and contains high levels of vanadium and nickel which promote zeolite destruction and dehydrogenation and coking reactions. Grace solutions tackle these challenges. Grace's latest innovation is RIVE® catalyst with Molecular Highway® Y-Zeolite™ technology. This special zeolite facilitates the diffusion of hydrocarbon molecules into and out of the zeolite resulting in a more favourable yield structure.

To achieve maximum yields of propylene in the FCC unit, a high level of ZSM-5 activity is required. A preferred approach has been to increase the activity of the additive through incorporation of increasingly higher contents of ZSM-5. However, there is a practical limit to this approach, so Grace has developed ZAVANTI™ catalyst, our newest generation of ZSM-5 technology that enhances the activity of the ZSM-5 zeolite itself.

In this paper, we will share our most recent commercial experience showing the benefits of our newest technologies, including RIVE® and ZAVANTI™ catalysts, for customers that seek to maximize C3= form the FCCU.

Introduction

Fluid Catalytic Cracking Units (FCCUs) play an important role in meeting the worldwide demand of propylene by supplying 30% of this important feedstock. The global demand for propylene has expanded in line with the economic growth of newly developing countries and regions such as China, India, and the Middle East. The demand for propylene is projected to increase by 3 - 4% per year in the next seven years [1], primarily driven by a rapid increase in polypropylene demand.

To keep up with growing propylene demand, technology licensors have developed hardware solutions to maximize the yields of propylene. For instance, PMcc® technology exists that can yield >20 weight percent propylene. [2] This technology employs bed cracking or a second riser for naphtha recycle (or both). Further, a metathesis unit (olefins conversion generating propylene from ethylene and butylene) or an olefin oligomerization unit can be integrated with an FCCU to further increase the yield of propylene. Finally, an FCCU can be modified to crack olefinic naphtha vs. traditionally VGO or resid feeds.

Grace continues to innovate and lead in the commercialization of max-propylene FCC catalyst technology. This includes work on both the Y-zeolite catalyst and the ZSM-5 additive fronts. In this article, we will focus on RIVE® and ZAVANTI™ technology, our latest innovations in Y-zeolite catalyst and ZSM-5 technology, respectively.

Grace philosophy to maximize LPG olefins from the FCC

Feedstock properties, catalyst formulation and operating conditions all play a role in determining the yields of light olefins from an FCC unit. Propylene yield increases when using feeds with high H-content and low naphthenic content. Increasing the FCCU hydrocarbon partial pressure decreases propylene and increases coke, so that there is a trade-off between maximizing throughput and maximizing propylene selectivity. Increasing reactor temperature increases propylene but also increases dry gas. Optimizing the catalyst formulation and the reaction temperature may improve propylene yield while staying under the wet gas compressor constraint.

With respect to catalyst formulation, to maximize LPG olefins and RON it is desirable to use catalysts with low hydrogen transfer characteristics to preserve gasoline range olefins. These catalysts usually comprise:

- Catalysts of low unit cell size,
- Catalysts containing coke selective matrix, and
- RIVE® catalysts containing Molecular Highway Y-Zeolite (MHY™) zeolite which improves the diffusion of reactants into and products out of the MHY™ zeolite vs. conventional zeolite and therefore minimizes hydrogen transfer

A ZSM-5 additive is added to the formulation to then crack these gasoline range olefins into LPG olefins. This concept is illustrated in figure 1 below.

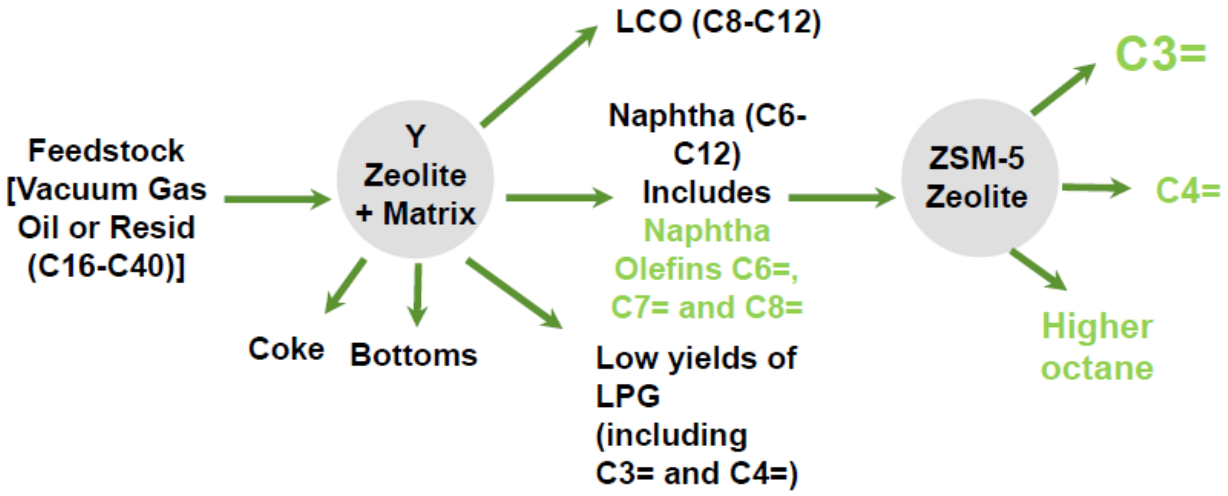


Figure 1. Catalytic approach to maximize LPG olefins from the FCC which includes both a low hydrogen transfer catalyst along with a ZSM-5 additive

Applications seeking to maximize LPG olefins from resid are challenging for several reasons:

- Feed is usually lower in hydrogen, limiting conversion and propylene potential from the feed
- Feed contains high levels of vanadium and nickel. V promotes Y zeolite destruction especially in the presence of sodium, and Ni promotes dehydrogenation and coking reactions

The Grace approach is two-fold: first, the need for conversion is balanced against minimizing hydrogen transfer reactions. This is accomplished by carefully tuning the unit cell size of the catalyst and then introducing coke selective matrix, RIVE® catalyst with MHT, and/or use of Ni passivating aluminas along with V-traps in order to limit the destruction of the zeolite under the challenging resid conditions.

The second part of the Grace approach is to use a ZSM-5 additive with the highest activity, meaning that the additive delivers the highest LPG olefin make per unit of additive. As a result of the high LPG olefin yields in max C3= units (>11wt% C3= targets are not uncommon), a high addition rate of ZSM-5 is used. Since, ZSM-5 additive mostly cracks gasoline range molecules, adding a large amount of ZSM-5 additive results in dilution of the Y-zeolite catalyst activity, needed for cracking larger molecules. The main benefit then of using the highest activity ZSM-5 additive is to minimize the dilution of the base catalyst activity versus the use of a lower activity ZSM-5 additive.

RIVE® FCC Catalysts

Maximizing diffusion of feed into and products out of an FCC catalyst is critical to unlocking the full value potential of an FCC unit in which the riser residence time is only a few seconds. RIVE® FCC catalysts incorporate Molecular Highway® Y-zeolite (MHY™) technology, which engineers a precise series of mesopores into the Y-zeolite framework, the primary active component of all FCC catalysts. This technology enhances diffusion of molecules into and out of the catalyst.

Since 2010, Rive Technology, Inc.and Grace have jointly developed and commercialized Molecular Highway® Y-zeolite (MHY™) technology for use in FCC units throughout the world. The MHY™ zeolite has a vast network of intermediate-sized (~40 Å) mesopores, which significantly enhances diffusion of the feed and cracked products. The interconnected network of mesopores permits access for larger feed molecules that vaporize in the FCC unit at temperatures above 950°F to the strong acid sites in the zeolite framework. These acid sites can crack the larger feed molecules much more selectively than conventional active matrix materials. The improved diffusion within the zeolite drives bottoms upgrading into LPG olefins, gasoline, and LCO, without coke or gas penalties that are often associated with alternate technologies. Additionally, the MHY™ zeolite helps to channel the valuable cracked products out of the catalyst before the products succumb to potentially undesirable reactions such as over-cracking into dry gas, olefin saturation via hydrogen transfer, or coke formation via condensation reactions. These concepts are illustrated in Figure 2.

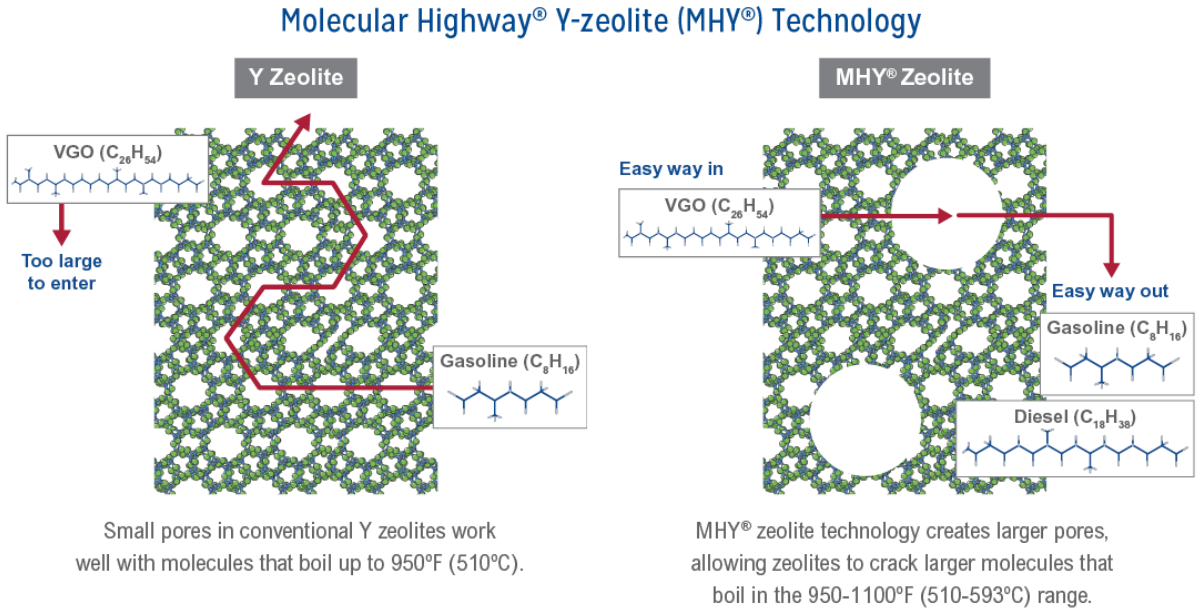


Figure 2. Overview of MHY™ Zeolite Technology.

In June 2019, Grace acquired the assets of Rive, including its patented MHY™ zeolite technology. This strengthened Grace's catalyst portfolio by enabling more rapid deployment of the technology across new catalyst frameworks. Through our flexible manufacturing technology, Grace can control the amount of mesoporosity in MHY™ zeolite to help refiners optimize their profitability. Alternative catalyst technologies claiming high mesoporosity lack the ability to engineer controlled, ordered, and interconnected mesoporosity in the zeolite itself.

Grace's MHY™ zeolite technology is protected by more than 40 patents around the world and has been applied successfully to more than 10 FCC units globally since 2011. Catalysts containing MHY™ zeolites typically provide the highest value in FCC units processing heavier feedstocks, particularly if the refinery is challenged by unit constraints such as maximum regenerator temperature, wet gas compressor rate, or air blower rate. However, refineries processing lighter feeds have still gained substantial uplift (>$0.50/BBL) from the diffusional improvements facilitated by MHY™ zeolite technology.

In Figure 3, the picture on the left shows a Scanning Electron Microscope (SEM) image of a conventional Y-zeolite. Each crystal face contains ~106 micropores of 7.5 Å diameter, which cannot be observed even at 100,000x magnification. The picture on the right shows a micrograph of MHY™ zeolite at similar magnification. While the micropores still cannot be seen at this magnification, the extensive network of MHY™ mesopores is clearly visible. Mesopores in MHY™ zeolites are homogeneously distributed and interconnected within the zeolite.

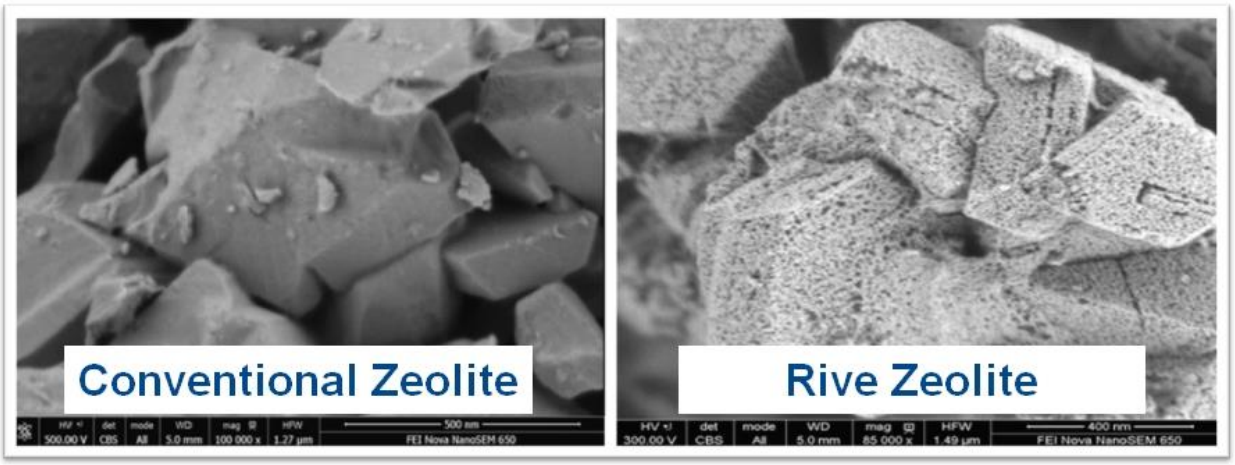


Figure 3. Scanning Electron Microscopy (SEM) image of conventional Y-zeolite (left) and MHY™ zeolite (right). Micropores are visible in the MHY™ zeolite image.

Researchers at Stockholm University used novel imaging techniques to investigate the internal architecture of MHY™ zeolite. Electron tomography and rotational electron diffraction were utilized to provide an unprecedented, three-dimensional view inside the zeolite crystal, as shown in Figure 4. These images show clear evidence that MHY™ mesopores are homogeneously distributed and interconnected within the zeolite crystal, enabling enhanced diffusion of molecules into and out of the zeolite, thereby improving catalytic performance. [3]

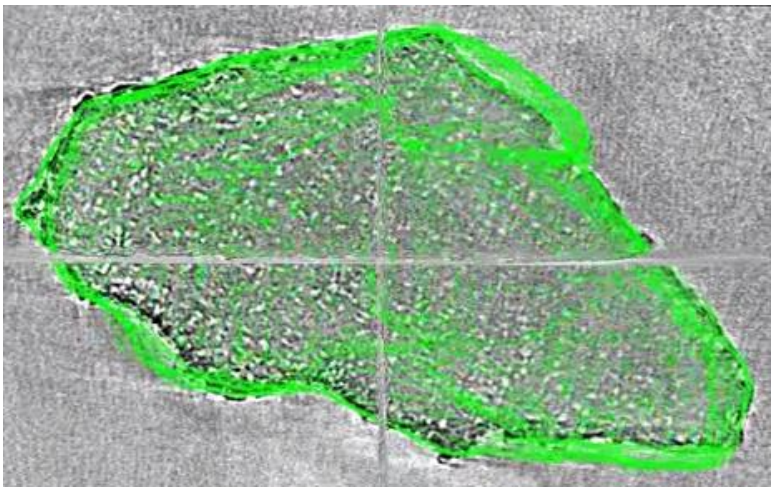
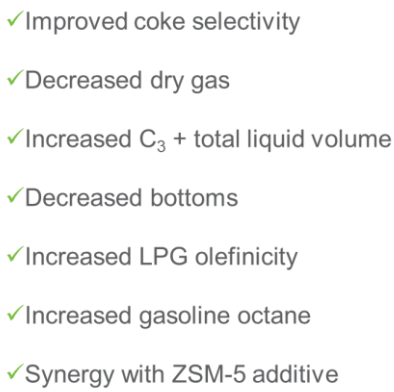


Figure 4. Molecular "highways" in MHY™ zeolite: electron tomography and rotational electron diffraction by Stockholm University show that the network of mesopores are interconnected and extend throughout the MHY™ zeolite.

Commercial Experience with RIVE and Value Delivery

The benefits in commercial units using RIVE® technology have been well documented. As a result of the mesoporosity of the MHY™ zeolite technology, RIVE® catalysts vs. conventional catalysts are expected to show the following benefits:



A great example, previously published by AFPM (2017-17-47), is the value captured at the former Motiva (now Shell) refinery in the Gulf Coast region of the United States. [4] This FCC unit processes a mix of VGO, heavy coker gas oils, and resid. The feed rate of 10-15 KBPD typically pushed to a maximum air blower / supplemental oxygen limit. The catalyst circulation rate could be increased by approximately 10% over base levels before meeting the maximum allowable circulation rate. API and CCR generally remained in similar ranges as before the trial. The RIVE® FCC catalyst demonstrated notable improvements in coke selectivity, dry gas selectivity, LPG olefinicity, bottoms reduction and C3+ Total Liquid Volume (Table C). The value delivered to the refinery was in the range between $0.40 and $1.20/bbl depending on feed and operating conditions.

Table 1. Commercial Data Summary

	Predictions	Actual
Decrease coke selectivity	-10% (rel)	-10%
Increase total liquid volume	+ 2.3 vol% (abs)	+ 1.8%
Increase C_3 olefinicity	+ 2% each (rel)	+ 2%
Increase C4 olefinicity	+ 2% each (rel)	+ 4%
Decrease dry gas yield	- 10% (rel)	- 6%
Decrease hydrogen in coke	- 10% (rel)	- 15%
Increase FCC profitability	> $1.00/BBL	$0.40-$1.20/BBL

RIVE® Technology and Sustainability

Advanced technologies such as RIVE® catalyst deliver value to refineries by generating a more profitable yield slate. We refer to this as traditional value. Recently, however, with increasing emphasis on sustainability, refineries are looking for ways to reduce their carbon footprint. With respect to the FCC, the coke generated during the cracking process generates CO2 and this is a direct emission from the FCC. In some jurisdictions, a carbon tax ($/ton of CO2) is applied to these direct emissions. Therefore, reducing coke yield not only allows a refiner to produce fuels in a more sustainable manner but it also helps reduce the refinery's carbon tax liability. We refer to this value generated as "low carbon value" to distinguish it from traditional value.

Recently, Grace presented an example of the low carbon value that improved coke selectivity can deliver to a refiner. [5] For a refinery with a reduced coke yield and CO2 emission as shown in Table 2 below and

a carbon tax price of ~60euros per MT, the low carbon value that can be unlocked is approximately 870k euro/year. As can be seen, the low carbon value is sizable.

Table 2. Example of lower coke yield slate with optimized catalyst

		BASE	Yield Slate with optimized Catalyst
Coke Yield	Wt. %	Base	**-0.17**
CO_2	kMT/a	Base	**-14.5**
Liquid Products	Wt. %	Base	**+1.0**

We expect that in the future, more jurisdictions will adopt regulatory measures to reduce carbon emissions and as a result, refineries will come under increasing pressure to reduce their carbon footprint. As one of the major benefits of RIVE® FCC catalysts compared to conventional Y-zeolite FCC catalysts is reduced coke yield (improved coke selectivity), RIVE® technology has promise to not only deliver a more profitable yield slate but also to help reduce CO2 emissions from the FCC.

ZAVANTI™ Additive Technology

Our newest ZSM-5 technology is ZAVANTI™ additive and features

1. Maximum LPG olefin activity
2. Excellent activity retention
3. Maintain physical properties

We describe each features in detail below.

1. Maximum LPG olefin activity

The LPG olefin make activity of a ZSM-5 additive has been traditionally increased by adding more ZSM-5 to the additive particle. This has been the case for OlefinsUltra® additive grades. This approach is not trivial since it is increasingly difficult to bind larger quantities of zeolite in an additive particle and yet retain good physical properties (attrition resistance) and zeolite stabilization. However, this approach has limited potential since it is very difficult to add more zeolite beyond a certain point.

At Grace we decided that in our next generation ZSM-5 additive technology, our approach would have to be different: at minimal to no increase in the zeolite quantity we would target to increase the activity of the zeolite itself. Our R&D program was focused on this goal. In Figure 5 below, we show a comparison of the relative propylene activity of ZAVANTI™ technology vs. our family of OlefinsUltra® additives. As can be seen, we achieved a step-out increase in activity in ZAVANTI™ technology.

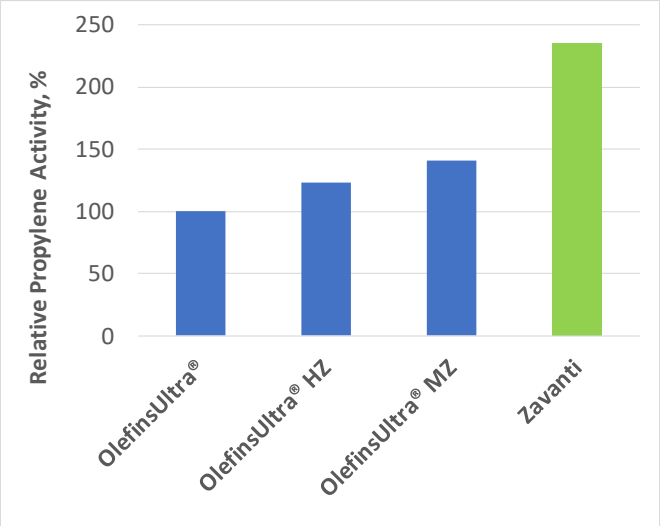


Figure 5. Propylene yield in OlefinsUltra® ZSM-5 additives (previous generation) increases with increasing the zeolite content of the additive. In ZAVANTI™ technology, the step-out increase in activity is due to an increase in the activity of the zeolite itself.

2. Excellent activity retention of the ZAVANTI™ technology

The higher severity conditions typical of max propylene units pose a challenge to the stability of ZSM-5, in terms of its surface area, acid site density and activity retention. Therefore, a second objective of our R&D program was to develop an additive that shows superior stability vs. our OlefinsUltra® family of additives.

Surface area and activity retention can play a key role in the effective activity of an additive to maximize propylene yield in unit. For two additives having equal starting LPG olefin make but different activity retentions, the additive with the best activity retention will have a higher effective activity in unit.

3. Superior physical properties

Physical properties such as attrition resistance, apparent bulk density (ABD), surface area, and particle size distribution are key for the retention in unit and catalyst circulation and therefore performance of a catalyst in FCC units. The newly developed ZSM-5 additive, ZAVANTI™, has the same superior physical properties (Table 3), as the OlefinsUltra® additive family.

Table 3. Physical Properties of ZAVANTI™ vs OlefinsUltra® MZ Additives

	ZAVANTI™ Additive	OlefinsUltra® MZ Additive
ABD, g/cm3	0.72	0.72
DI:	5	5
0- 40 %:	7	7
APS µm:	80	78
Surface Area, m2/g	180	180

The features of ZAVANTI™ additives are illustrated by a study conducted by Grace R&D and described in more detail below.

Laboratory deactivation of ZSM-5 additives and test results for ZAVANTI™ technology

To simulate deactivation of ZSM-5 additives in the field, the time-temperature protocol to deactivate ZSM-5 additives in the laboratory is different vs. that for catalyst containing Y-zeolite. This is because ZSM-5, due to higher silica-to-alumina ratio vs. Y-zeolite, has better thermal and hydrothermal stability compared to Y-zeolite. Most of the laboratory deactivation protocols are designed to simulate the field deactivation of base FCC catalysts, and may not properly simulate the field deactivation of ZSM-5 additives. Therefore, it is important to identify a laboratory deactivation protocol which will mimic the deactivation of ZSM-5 additives in commercial units.

The approach to identify a suitable deactivation protocol is to compare the performance of ZSM-5 additive deactivated under several conditions against the performance of ZSM-5 additive deactivated in the field and then selecting the protocol that most closely matches the unit deactivated ZSM-5 additive in terms of performance and properties. The unit deactivated ZSM-5 is isolated from the equilibrium catalyst or Ecat from an FCCU using ZSM-5 additive by sink-float density separation technique as described by Boock et. al. [6] Samples of OlefinsUltra® additive were exposed to 100% steam at 1500°F for 5 hours, 10 hours and 25 hours. The properties and performance of the steamed samples were then compared against a sample of OlefinsUltra® additive deactivated in a commercial FCC unit. For performance testing, the laboratory-deactivated ZSM-5 additives were blended with a common, non-ZSM-5 containing Ecat at constant additive level and then tested in an Advanced Catalytic Evaluation (ACE) unit. As shown in Figure 6, the propylene yield from the laboratory-deactivated sample aligns with that from the unit-deactivated sample after 20 hours of hydrothermal steaming. Therefore, to match the performance of a unit- deactivated sample, the ZSM-5 additive in the laboratory must be steamed for a minimum of 20 hours in 100% steam at 1500°F. These deactivation conditions are severe vs. those for Y-zeolite catalyst, but for the development of new ZSM-5 additives, it is important to use a protocol that will simulate the deactivation that ZSM-5 additives will undergo in commercial units.

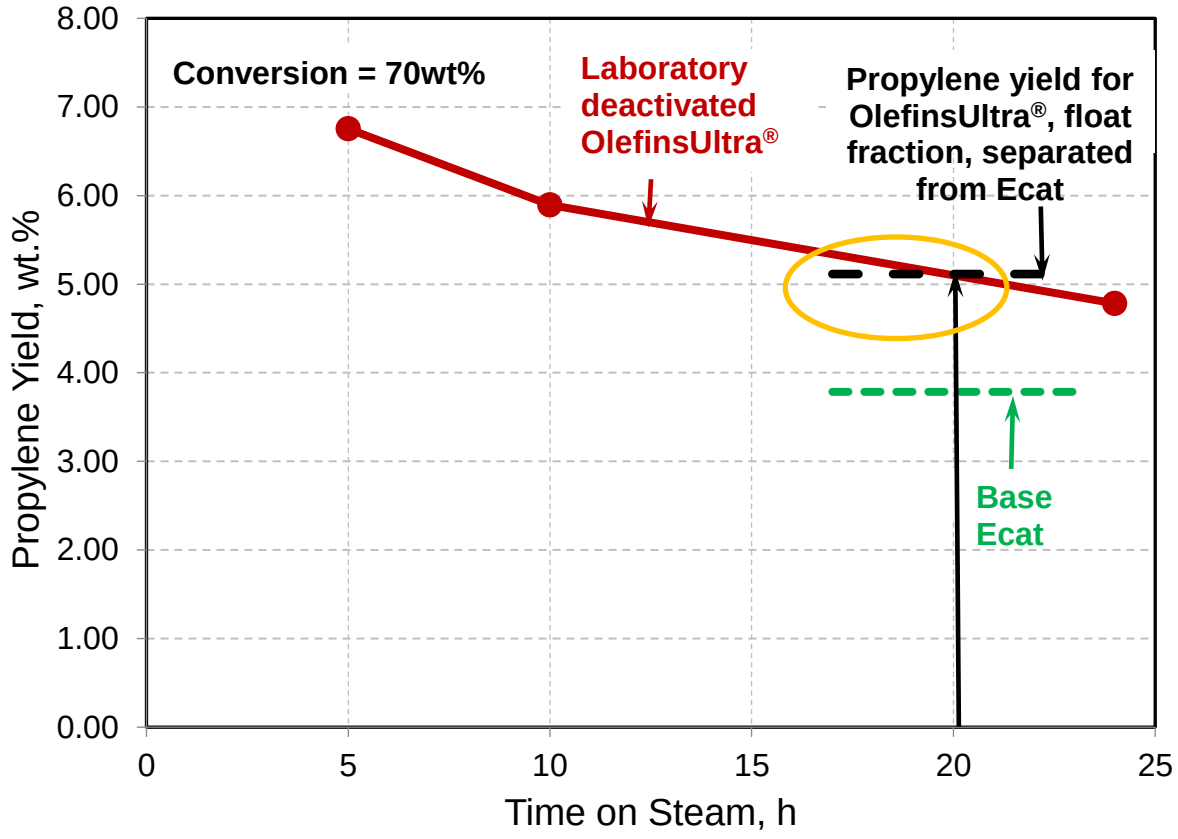


Figure 6. Propylene activity of laboratory deactivated OlefinsUltra® additive compared against commercially deactivated OlefinsUltra® additive, isolated by density separation method. The laboratory sample was deactivated at 1500°F in 100% steam for various times. Additives were blended at 2.5wt% level and tested in ACE at constant conditions.

Performance Testing of ZAVANTI™ vs. OlefinsUltra® MZ additives

To illustrate the benefits of ZAVANTI™ additive, we conducted a side-by-side performance test vs. OlefinsUltra® MZ additive. The base catalyst chosen for this study is a low rare earth catalyst to minimize hydrogen transfer reactions and maximize gasoline olefins. The additive type and amount were varied. The performance was measured both by ACE and Davison Circulating Riser (DCR) using VGO feed.

For this study, we deactivated the ZSM-5 additive with 100% steam for 24 hours at 1500°F, separately from the base catalyst. The steam-deactivated olefins additive is then blended at 12 wt% and 23 wt% level with separately deactivated base FCC catalyst and tested in ACE. We decided on these high percentages of ZSM-5 additive since max propylene FCCUs additive usage percentage is typically high. Table 4 summarizes the pilot plant DCR data, at constant conversion, as deltas in wt% between olefins additives and the base FCC catalyst. The data reveals that the ZAVANTI™ additive makes higher propylene yield compared to the industry leading OlefinsUltra® MZ technology at both blend levels. The higher activity of ZAVANTI™ additive is also reflected in higher yields of C2- and C4-olefins. A corresponding decrease in gasoline is observed, which is due to cracking of gasoline range olefins to light olefins. At 12wt% blend in the base catalyst, the ZAVANTI™ shows ~30% increase in delta propylene yield over the current best technology in the market, OlefinsUltra® MZ. At higher blend level (23wt%), ZAVANTI™ additive still shows about 20% higher delta propylene yield over OlefinsUltra®MZ technology. The advantage of

ZAVANTI™ additive is lower at high additive level due to the depletion in the gasoline olefin pool: less gasoline range molecules are left for cracking and the remaining olefins are C5- and C6- olefins which are more difficult to crack vs. C7 and C8 olefins. [7] The results indicate that greater yields of LPG olefin yields can be obtained at constant additive level of ZAVANTI™ versus OlefinsUltra® MZ additives, or similar LPG olefin yields can be obtained by using lower percentages of ZAVANTI™ additive versus OlefinsUltra® MZ additive. The lower usage of olefins additive in max-propylene units will help to maintain the high activity of base catalyst by minimizing the dilution effect and will lower the operation cost.

Table 4. DCR Performance data delta yields in wt% Olefins additives minus base FCC catalyst.

	12wt% OlefinsUltra® MZ vs. Base Catalyst	12wt% ZAVANTI™ vs. Base Catalyst	23wt% OlefinsUltra® MZ vs. Base Catalyst	23wt% ZAVANTI™ vs. Base Catalyst
C2= wt%	0.4	1.0	0.9	1.8
Dry Gas, wt%	-0.2	0.4	0.2	1.2
C3 wt%	0.2	0.4	0.3	0.7
C3= wt%	6.1	8.4	8.4	10.0
Total C4 wt%	4.5	5.0	5.5	5.9
iC4 wt%	0.6	0.6	0.4	0.5
Total C4= wt%	3.8	4.3	5.0	5.2
iC4= wt%	1.8	2.1	2.3	2.5
Gasoline wt%	-10.5	-14.2	-14.5	-17.6
RON	1.8	2.0	2.3	2.5
MON	1.2	1.5	1.5	1.7
LCO wt%	-0.4	-0.4	-0.7	-0.6
Bottoms wt%	0.4	0.5	0.7	0.7
Coke wt%	-0.2	-0.1	-0.2	-0.3

Performance of ZAVANTI™ additive under severe deactivation conditions

Recent innovations in hardware design to maximize propylene from FCC type units (for example Deep Catalytic Cracking or DCC and High Severity FCC or HSF-FCC) involve higher severity conditions vs. FCCUs. For instance, reactor temperature, reactor pressure and steam conditions in DCC and HS-FCC units are typically more severe vs. FCCUs. To compare and show the superiority of ZAVANTI™ additive over the industry leading OlefinsUltra® MZ technology, we increased the severity of the steam deactivation. The steaming time was increased from 24 hours to 50 hours under 100% steam at 1500°F. The performance of severely steamed samples was then compared in ACE at various blend levels. Table 5 summarizes the ACE data, at constant conversion, as deltas in wt% between olefins additives and the base FCC catalyst. The data reveal even under high severity deactivation conditions the ZAVANTI™ additive makes higher propylene yield compared to OlefinsUltra® MZ technology. The data demonstrate that the ZAVANTI™ additive formulated with Grace's proprietary binding and stabilization technology, delivers improved propylene yield over the industry leading OlefinsUltra® MZ technology and is the clear choice for max-propylene units.

Table 5. ACE performance data delta yields in wt% Olefins additives minus base FCC catalyst.

	5wt% OlefinsUltra® MZ vs. Base Catalyst	5wt% ZAVANTI™ vs. Base Catalyst
Ethylene	0.6	0.8
Dry Gas	0.5	0.60
Propylene	5.4	6.5
Propane	0.4	0.4
Isobutylene	1.3	1.5
Total C4=s	11.3	11.8
IsoButane	0.4	0.4
Total C4s	3.1	3.4
LPG Wt%	8.8	10.4
Gasoline	-9.4	-10.9
RON	1.6	1.6
MON	0.8	0.9
LCO	-0.4	-0.4
Bottoms	0.4	0.5
Coke	0.0	0.1

Field experience with ZAVANTI™ additives and value delivery

In a recent article we reported on the performance of ZAVANTI™ technology against the incumbent ZSM-5 additive in the Saudi Aramco TOTAL Refining & Petrochemicals FCCU. [8] Table 6 below summarizes the shifts in yields both for the raw data and the data normalized for operating and feed conditions via FCC SIM modeling. The OlefinsUltra® HZ additive in inventory was slightly higher than that of the ZAVANTI™ technology test run. Despite this, as can be seen, the raw data indicates higher LPG olefin yields with ZAVANTI™ vs. OlefinsUltra® HZ additives and the modeling work indicates that once the test run conditions are normalized, ZAVANTI™ technology outperforms further. It is worth noting that in the table below, the C2- off gas delta is comprised of C2=.

Table 6. Raw data and FCC SIM comparison shifts.

Reactor Product	Raw Data Yield Shifts: ZAVANTI™ minus OlefinsUltra® HZ additive, wt%	FCCSIM Yield Shifts: ZAVANTI™ minus OlefinsUltra® HZ additive, wt%
C_2- Off Gas Yield (C_2=)	+0.20	+0.18
C_3=	+0.41	+0.65
Total C_4=s	+0.33	+0.39
Gasoline	-0.94	-1.22

Using the yield shifts in Table 6 above with the generic price set in Table 7 below we can estimate the value uplift delivered by ZAVANTI™ additive over OlefinsUltra® HZ additive.

Table 7. Generic price set for various refinery products.

Product	Price, US$/MT (Generic)
C_2=	700
C_3=	989
Total C_4=s	531
Gasoline	483

Assuming typical specific gravity values for various products, we project uplift of between $0.38/bbl and $0.58/bbl. As can be seen, maximizing LPG olefins can be highly profitable for a refiner and ZAVANTI™ additive technology can be a tool for refineries with this objective to unlock that value.

Conclusions and path forward

In response to the trend in the refining industry to maximize the yield of petrochemicals, Grace is prioritizing the development of catalyst technologies that help refineries capitalize on this important trend. ZAVANTI™ additive is the newest innovation in ZSM-5 technology from Grace. It shows higher LPG olefins yield versus the OlefinsUltra® family of additives while retaining the excellent stability and physical properties that refiners have come to expect from Grace.

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