Clariant innovative technologies enable plastic recycling and low-carbon ethylene production

科莱恩创新技术助力塑料循环和低碳乙烯生产



York Wang
BU Catalysts
Business Development
29.10.2026

OVERVIEW 概览

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❖**Clariant plastic recycling solution**

科莱恩塑料循环解决方案

❖ **Oxidative Dehydrogenation of Ethane EDHOX™ Technology & OxyMax® E catalyst**

乙烷氧化脱氢制乙烯**EDHOX™**技术及**OxyMax® E**催化剂

CLARIANT

科莱恩塑料循环解决方案
CLARIANT Plastic Recycling Solution

Greater chemistry

Purification of hard-to-treat feedstocks and upgrading are at the core of our experience 难处理原料的净化和升级是我们的核心经验

Adsorbents 吸附剂

hard-to-treat feedstocks 难处理原料

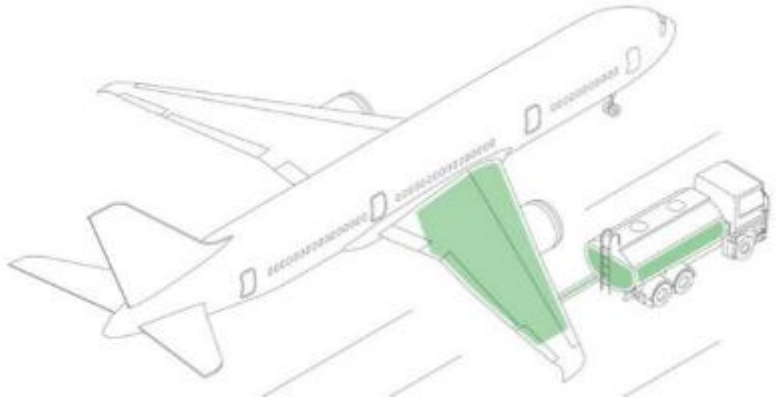
- Edible oils (e.g. olive husk oil) 食用油（例如橄榄壳)
- Waste oils and fats for SAF production 用于 SAF生产的废油脂
  - Used cooking oils 废弃烹饪油
  - Animal fats 动物脂肪

Advanced Catalysts 先进催化剂

gas and liquid streams 气相和液相

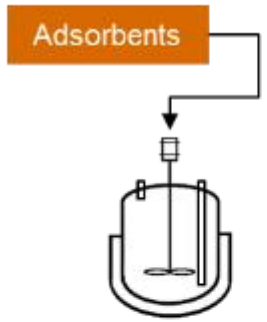
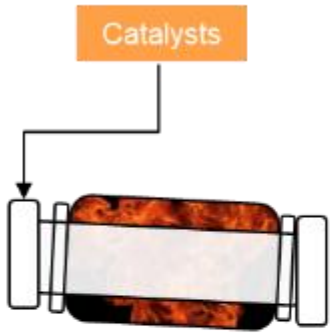
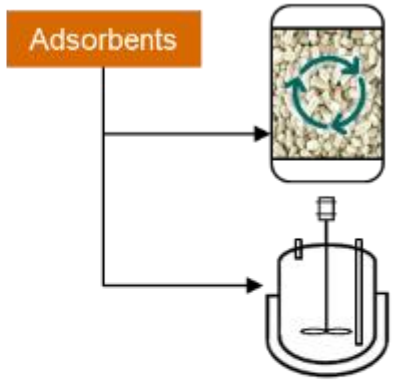
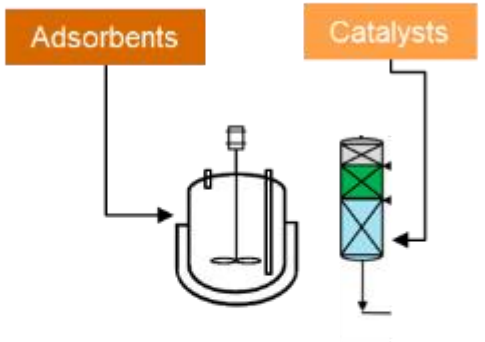
▪ Styrene 苯乙烯	▪ Synthetic fuels 合成燃料
▪ Dewaxing 脱蜡	▪ Steam cracker feedstock 裂解
▪ Steam reforming 蒸汽重整	▪ ODH 乙烷氧化脱氢
▪ Ammonia 氨	▪ SAF 生物航油





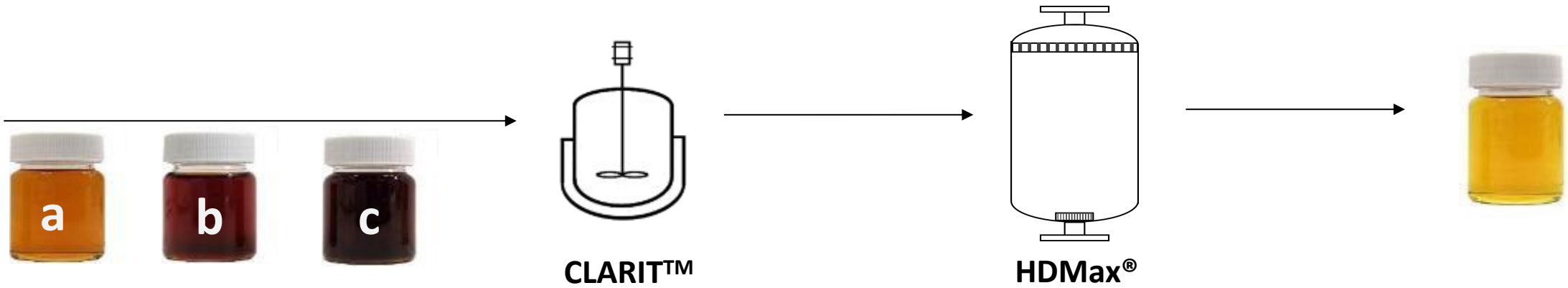


4 ways: Clarit™ and HDMax® enabling physical and chemical recycling
科莱恩的 Clarit™ 和 HDMax® 材料通过四种方式支持物理和化学回收

Dissolution 解聚	PyOil Catalysis 催化裂解	PyOil Purification & Stabilization 裂解油净化/稳定	Adaptable PyOil Upgrading 裂解油油品升级
			
Clarit Solve™	Clarit Pyrolyze™	Clarit Protect™	Clarit Protect™ + HDMax®

Clariant adaptable pyoil upgrading solutions to produce steam-cracker compatible feedstock and realize plastic recycling

科莱恩定制化的热解油升级解决方案能生产与裂解装置兼容的原料，真正实现塑料循环



Feedstock in different qualities:
from high quality (a) to low quality (c)
不同品质的原料：
从高质量 (a) 到低质量 (c)

ADSORPTION UNIT
吸附单元:

- Adaptable choice of material: high acceptance level of incoming quality 材料选择适应性强：来料质量接受度高
- Adaptable dosage: minimization of spent material and costs
剂量可调：最大限度地减少材料消耗和成本

HYDROGENATION UNIT
加氢单元:

- No gum formation 无结焦
- Selective phosphorous and silicon removal
选择性除磷和除硅
- Adaptable hydrogenation deepness
加氢深度适应性强

RESULT
产物:

- High quality product
高品质热解油
- Steam-cracker compatible
兼容蒸汽裂解装置
- Achieved from different pyoil qualities 能从不同品质的油中获得

Clariant adaptable upgrading solution: Successful pilot test results
科莱恩适应性强的油品升级解决方案：成功的中试装置



Validation 验证

All customer relevant specifications achieved and validated across multiple pilot tests
所有与客户相关的规格要求均已达到，并在多次中试中得到验证。



Commercially proven 商业化

Pre-treatment process demonstrates adaptability to input quality and is **commercially proven in similar applications** 预处理工艺展现出对原料质量的适应性，并在类似应用中得到了商业验证。



Competitive advantage 优势

Hydrogenation step shows **competitive advantage** with **single-reactor design** and **zero gum formation** (unlike competitive technologies)
加氢步骤采用单反应器设计且不会产生焦质，展现出优势（与其他竞争技术不同）



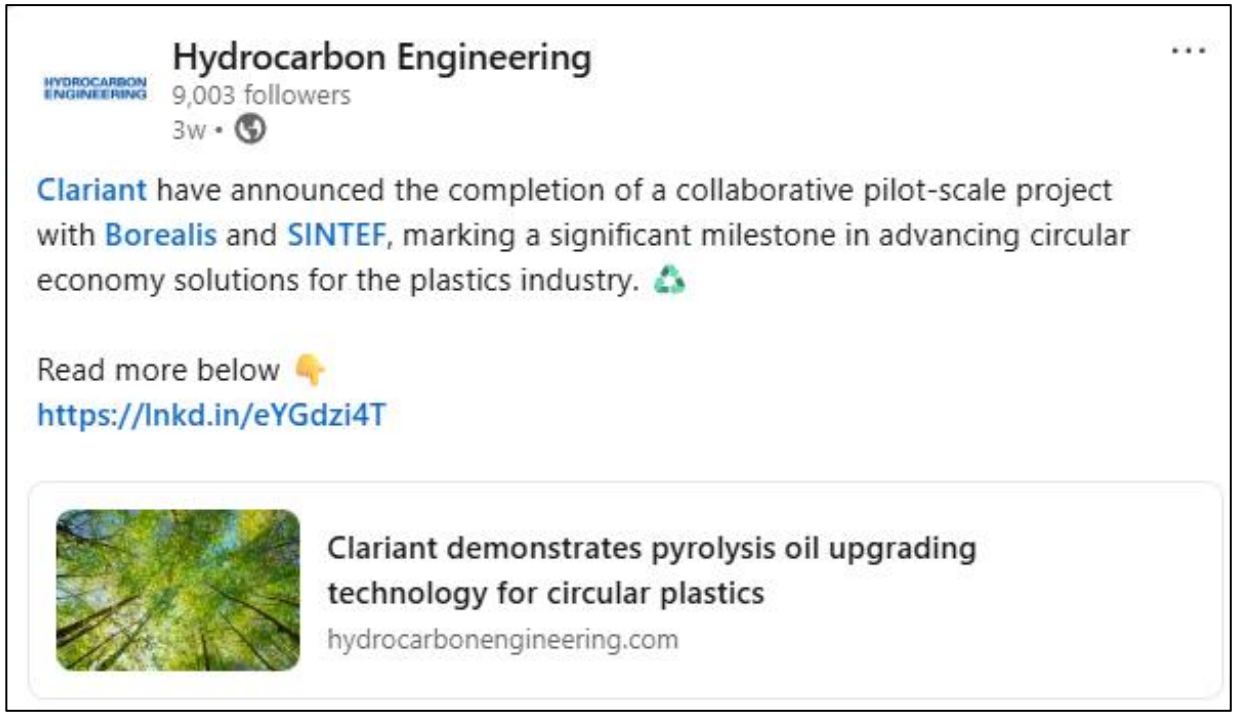
Qualification 认可

Catalyst solution **technically qualified** and **approved** by customers
催化剂解决方案已通过客户技术验证和认可

Comprehensive pilot testing conducted at Clariant facilities and customer site consistently delivered products that **fully meet specifications**.
在科莱恩工厂以及客户现场进行的**完整中试**能**完全达到产品所需规格**

Successful cooperations with major customers: 与欧洲主要客户的成功合作

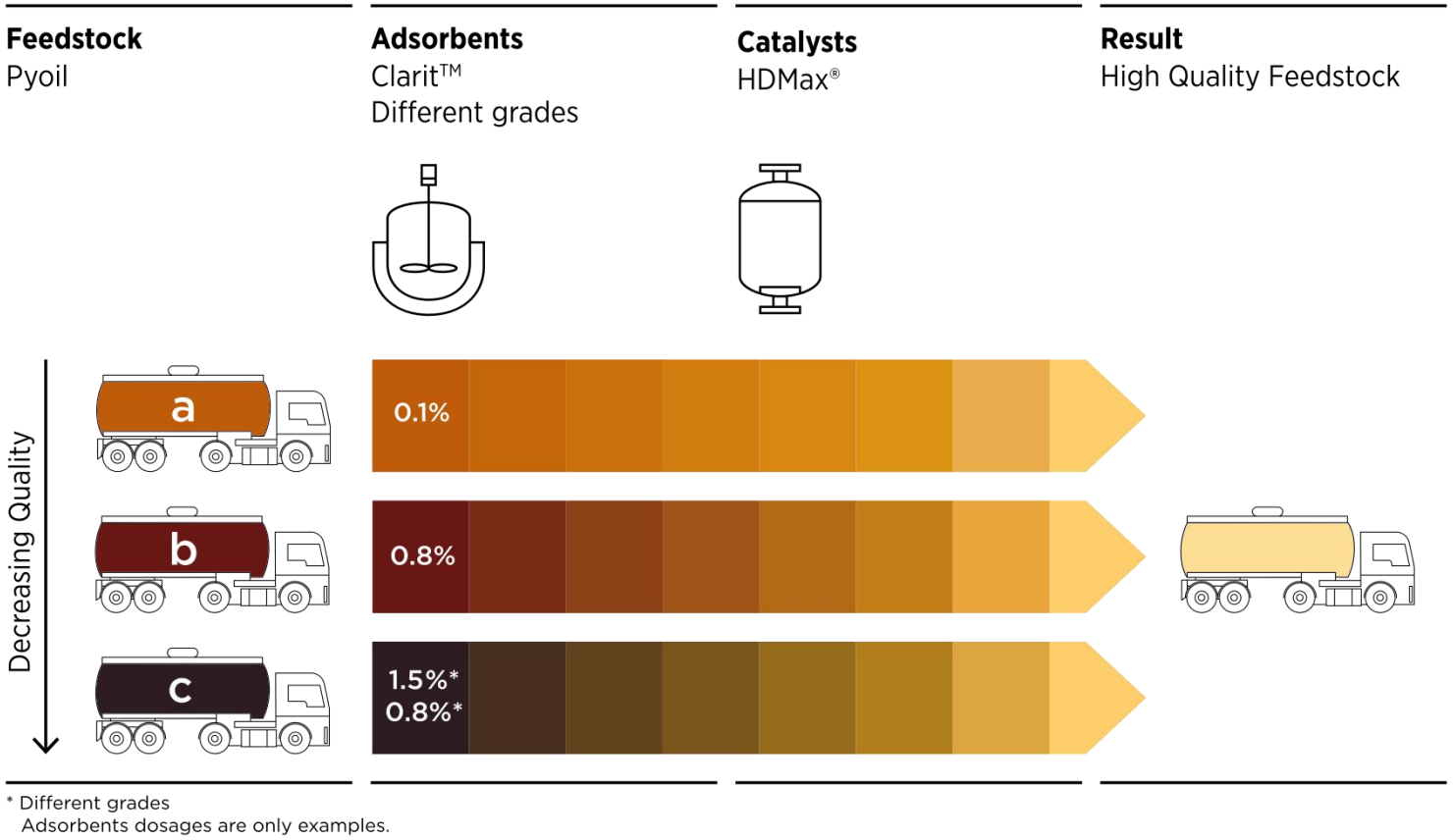




Cooperation with Borealis and SINTEF leads to successful demonstration of pyoil upgrading technology

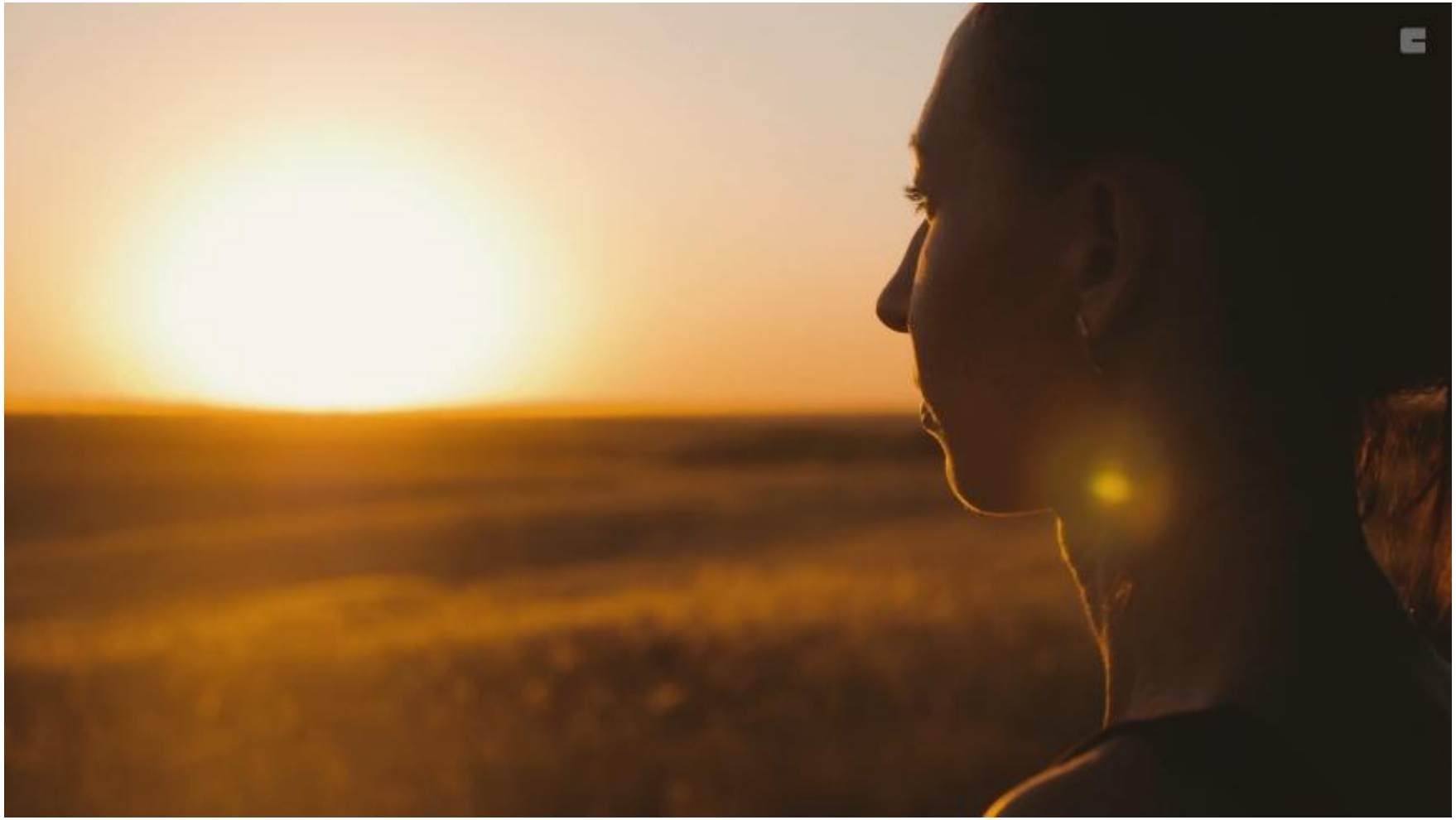
与北欧化工和SINTEF的合作使我们的热解油提质技术得以成功展示

Clariant collaborate with domestic engineering partner to provide Pyoil upgrading solution to plastic recycling customers in China
科莱恩与国内工程合作伙伴携手为中国废塑料回收客户提供塑料裂解油品升级完整解决方案



- Comprehensive solution for pyoil upgrading
  针对塑料裂解油升级的综合解决方案
- Domestic engineering experience plus Clariant catalyst/adsorbents advantage 工程经验和科莱恩催化剂吸附剂优势
- Growing with China customer through agility
  快速响应与中国客户共同成长

Plastic recycling video 塑料回收 视频动画





CLARIANT

Oxidative Dehydrogenation of Ethane
乙烷氧化脱氢制乙烯
EDHOX™ 技术 & OxyMax® E 催化剂

Greater chemistry

EDHOX™ Ethylene Technology- Oxidative Dehydrogenation of Ethane
EDHOX™乙烷氧化脱氢制乙烯技术

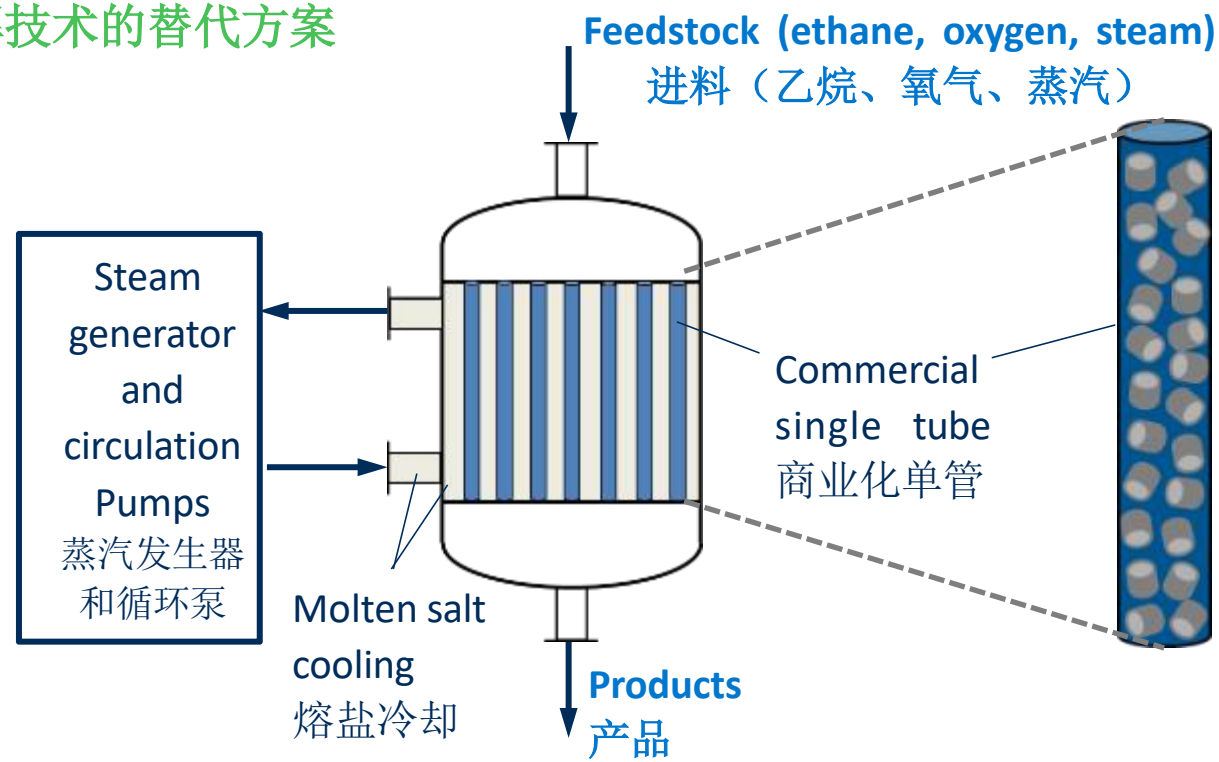
Alternative Concept to Ethane Steam Cracking 乙烷蒸汽裂解技术的替代方案

Oxidative Dehydrogenation of Ethane 乙烷氧化脱氢

- $C_2H_6 + 0.5\ O_2 \rightarrow C_2H_4 + H_2O$
- $C_2H_6 + 1.5\ O_2 \rightarrow CH_3COOH + H_2O$

EDHOX™ – Ethane DeHydrogenation, Oxidative

- Selective catalytic process for Ethylene & Acetic Acid
  生产乙烯和醋酸的选择性催化流程
- Mild conditions (300 - 400°C, moderate pressure)
  反应条件温和（ 300 - 400°C，压力适中）
- No thermal cracking, exothermic 无热裂解，放热反应
- Only CO2 and CO as minor by-products 少量副产品CO2和CO
- results in simplification of separation & purification 分离和净化单元简单

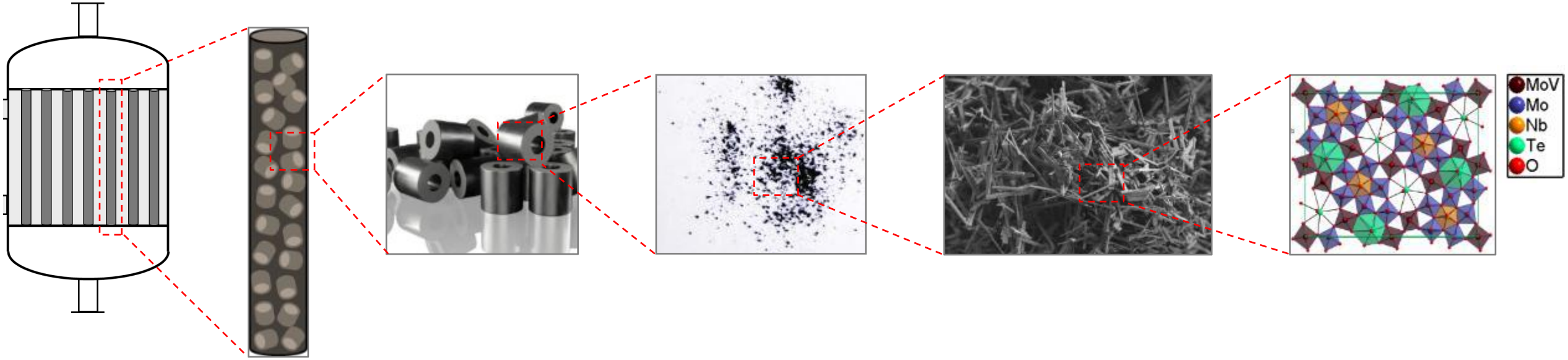


* Catalyst and Reactor are the core elements 催化剂和反应器是核心要素

* Catalyst by Clariant, new development 科莱恩催化剂新研发成果

* Reactor by DWE, multiple oxidation technologies references
DWE 反应器，拥有多个氧化技术的业绩

OxyMax®E and EDHOX™: Multi-year systematic development with close alignment between process, reactor, and catalyst successfully completed
OxyMax® E 催化剂和EDHOX™ 工艺：历经多年系统性的研发及工艺、反应器和催化剂的紧密配合使得技术成功实现



Commercial EDHOX reactor 商业化反应器	Commercial reactor tube 商业化的反应管	Catalyst 催化剂	Catalyst powder 催化剂粉末	Crystal form and shape 晶体形态	Catalyst crystalline structure [a] 催化剂晶体结构

[a] Melzer at al, 2016, Angew. Chem., 128, 9019 –9023

Scale-up – From Lab to Pilot Plant & Closed Loop Setup
放大- 实验室到中试装置&全流程建立

Pilot Reactor 中试反应器

- Cooled tubular reactor concept of DWE(MAN-ES) 管式反应器方案
- Molten salt cooling 熔盐冷却
- Full commercial tube size 商业化的反应管尺寸
- Full catalyst tablet testing 完整的催化剂片测试
- Commercial catalyst bed design incl. activity grading 商业化催化剂床的设计

Pilot Plant 中试装置

- Pilot reactor representing commercial design and basis for scale-up
  中试反应器代表商业化设计，是放大的基础
- Gas Clean-up and separation section 气体净化和分离
- Ethane recycle 循环乙烷
- Commercial EDHOX process represented (w/o AARU) 商业化的EDHOX 工艺（不含醋酸）

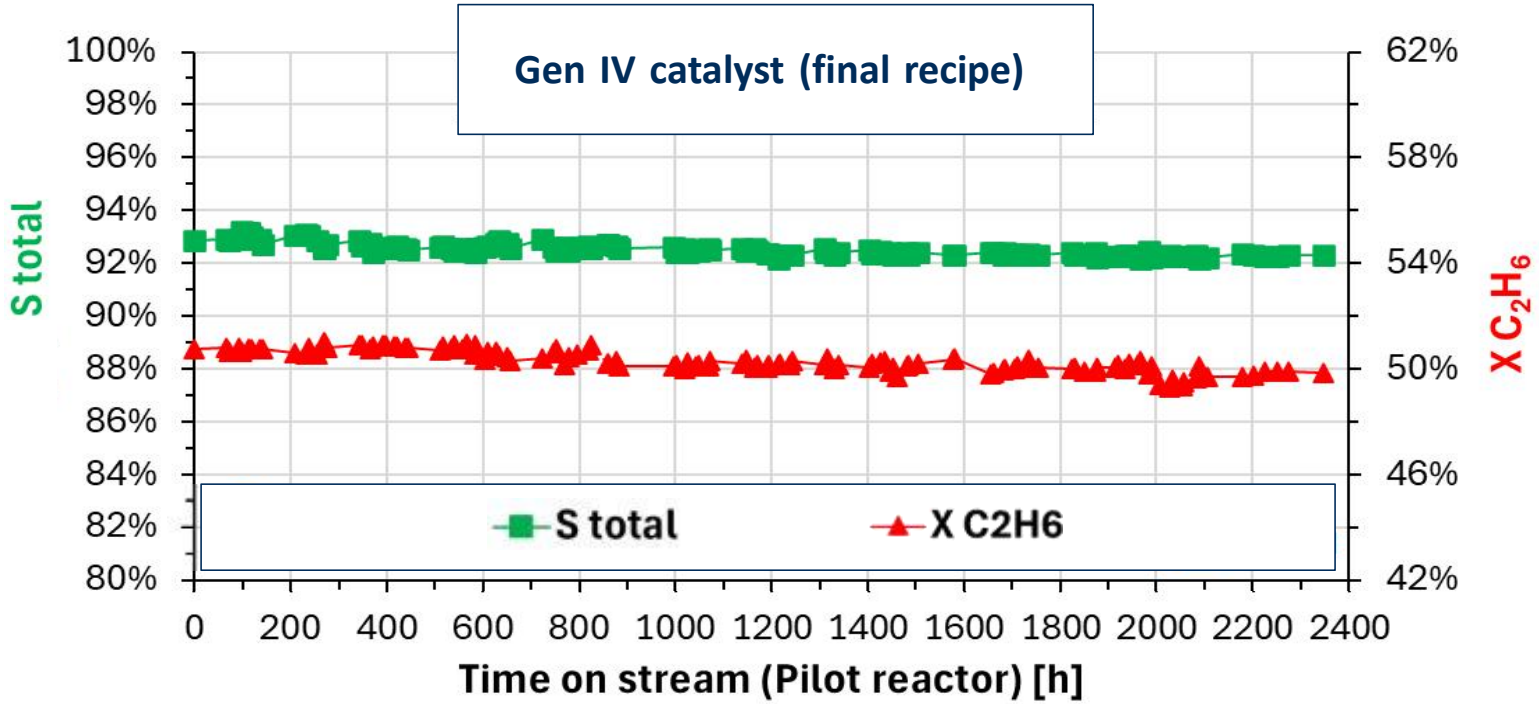
Overall, 9 reactor fillings with 7 catalyst versions of 3 different catalyst generations tested in 13 campaigns

总计进行了13轮试验，涵盖9次反应器装填，涉及3个不同催化剂代际下的7种催化剂版。



Pilot Plant Operational Results 中试装置运行结果

Longtime performance test 长期性能测试



* Combined Ethylene + Acetic Acid **selectivity > 92%** (molar basis)
乙烯和醋酸总选择性＞92%（摩尔计）
* Ethane **conversion 50%**
乙烷转化率 50%

Commercial Scale Multi tubular Reactor Design
商业化应用的多管式反应器设计



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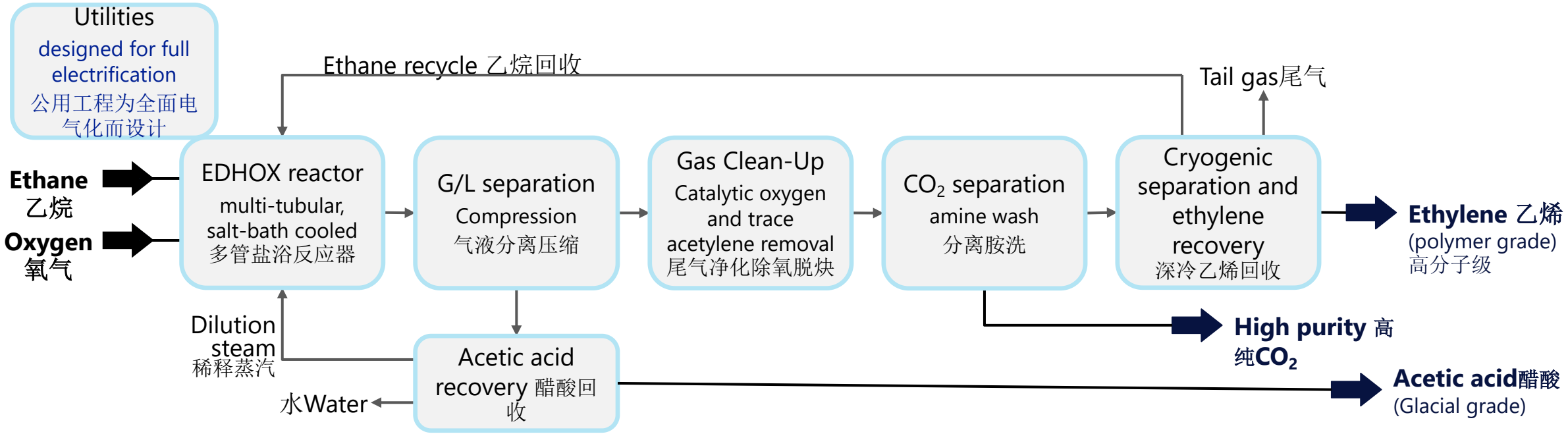
- MAN ES has over 60 years of design and manufacturing experience in the field of salt-operated tubular reactors
  曼能源(DWE) 拥有60多年盐浴管式反应器的设计和制造经验
- Salt-bath regulated temperature **with 10,000-60,000 tubes**
  盐浴温度受控可调，**10,000-60,000 根管子**

EDHOX™ process flow scheme 工艺流程



Higher carbon efficiency than steam cracking due to catalytic conversion
得益于催化转化，**碳效率高于蒸汽裂解**；

Safe operation at mild condition, **no heating** required
在温和条件下**安全运行**，无需加热；

Up to **250 kta ethylene capacity** per reactor
单台反应器乙烯产能最高可达 **25 万吨/年**

Recovery of acetic acid in glacial quality冰醋酸级的回收

Sub-licensed well-referenced technology from KMPS for extractive distillation and purification downstream of gas-liquid-separation
采用经充分验证的、KMPS技术许可，在气液分离工段后进行精馏与提纯

Catalytic **highly selective full conversion of oxygen**
氧气的高选择性催化完全转化

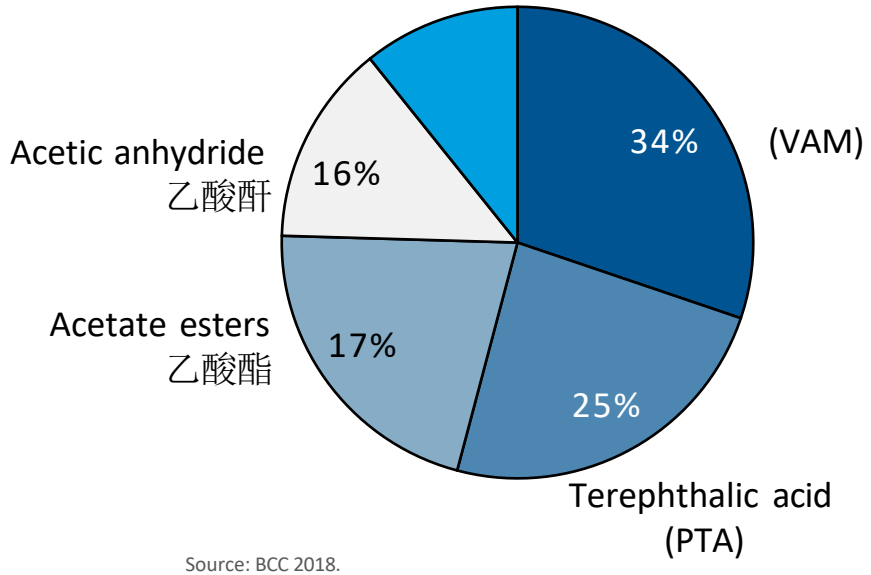
CO_2 separation through established amine wash technology
通过成熟的胺洗技术实现二氧化碳分离

Cryogenic separation using established technologies 利用成熟技术进行深冷分离

Use, release, or store high purity CO_2 depending on site characteristics
根据现场条件，**使用、释放或储存高纯度二氧化碳**

Usage or storage of CO_2 further improves PCF
二氧化碳的使用或储存可进一步改善产品碳足迹（PCF）

Downstream Applications – Ethylene + Acetic Acid Consumers
下游应用 –乙烯+醋酸用户



Source: BCC 2018.

Product 产品	Acetic acid consumption 醋酸消耗量 (t/t product)	Ratio ethylene/acetic acid 乙烯/醋酸比(t/t)
VAM(VAOH)	≈ 0.70	≈ 0.5 (1.4*)
PTA**	**≈ 0.04**	**≈ 3.6**
Ethyl acetate 乙酸乙酯	≈ 0.68	≈ 0.5
EVA	**≈ 0.03-0.42**	**≈ 1-34**

*Acetic Acid recovery through PVA hydrolysis (1.36 mt AA recovered : 1 mt PVAOH, resulting in 1/3 mol/mol of AA/Ethylene)
** For PET production via PTA

VAM: Vinyl Acetate Monomer
VAOH: Vinyl Alcohol derivate (via PVA)
PTA: Purified Terephthalic Acid
EVA: Ethyl Vinyl Acetate
PVA: Polyvinyl Acetate
PVAOH: Polyvinyl Alcohol
PET: Polyethylene Terephthalate

- ¾ of the acetic acid demand requires additional ethylene ¾ 的醋酸用途需求额外的乙烯
- EDHOX™ technology typically produces ethylene/acetic acid at a ratio of around 3 $t_{ethylene}/t_{acetic\ acid}$

  采用EDHOX™ 技术一般以约3吨乙烯/吨乙酸的比率生产乙烯和醋酸

Benefits of EDHOX™ with OxyMax™ E catalyst
经济性和价值创造

A transformative technology addressing sustainability, efficiency, and economic challenges simultaneously that enables a more sustainable production of materials for consumer goods such as sports gear, textiles packaging, construction, and many more
一项变革性技术，能够同时应对可持续性、效率及经济方面的挑战，助力实现更具可持续性的材料生产，所产材料可广泛应用于体育装备、纺织品、包装、建筑等各类消费品领域。

Winner of the 2025 Gulf Energy award as Best Petrochemical Technology
荣获2025年海湾能源奖最佳石化技术奖



www.clariant.com/en/Business-Units/Catalysts/Petrochemical-and-Refining-Catalysts/ODH-Ethylene-Catalysts

Reduced Scope 1 CO_2 emissions by at least 60% up to full net zero with potential for zero Scope 2 emissions when using green electricity; process fully electrified by design
范围1二氧化碳排放量至少减少60%，直至实现完全净零排放；使用绿色电力时可实现范围2零排放；工艺设计实现全面电气化。

Up to 70% lower energy consumption
compared to conventional ethylene production
与传统乙烯生产工艺相比，**能耗可降低70%**。

Mild operating conditions
operates below 400°C vs. >1000°C for steam cracking, improving process safety and reducing equipment stress
温和的操作条件， 低于 400°C，而蒸汽裂解则高于 1000°C，有助于提高工艺安全性并降低设备应力。

Superior economics per ton of ethylene with **5-20% lower CAPEX** requirements
每吨乙烯的经济效益更优，成本降低 5-20%

Improved carbon efficiency by up to 5%
generating more high-value products from the same ethane feedstock stream than conventional processes
碳效率提升最高可达 5%；与传统工艺相比，在乙烷原料输入量相同的情况下，能够产出更多高价值产品。

Commercially ready technology
and applicable for greenfield projects, retrofits, and downstream integration, especially VAM, PTA, EVA
技术成熟，适用于新建项目、改造项目和下游集成，尤其适用于VAM、PTA 和 EVA

Oxidative Dehydrogenation of Ethane Video
乙烷氧化脱氢制乙烯 视频动画



Contact us! 联系我们



王 勇
York Wang

手机：**159 2153 0433**
邮箱：**york.wang@clariant.com**

科莱恩化工科技（上海）有限公司
Clariant Chemicals Technology (Shanghai) Ltd.