MTO AND DMTO PROCESS

OBJECTIVES OF PROJECT

Objective 1

How to convert methanol to olefin effectively.

Objective 2

Study how to make the process eco-friendly and sustainable.

Objective 3

Comparing MTO and DMTO and finding which one is more efficient.

MTO

The **extraction of unconventional gas** has significantly increased the availability of natural gas over the past decade, driven by advancements in horizontal drilling and hydraulic fracturing. This innovation has unlocked vast quantities of shale gas, primarily composed of methane but often containing impurities like nitrogen, carbon dioxide, and light hydrocarbons, which require specialized treatment for effective processing.

MTO

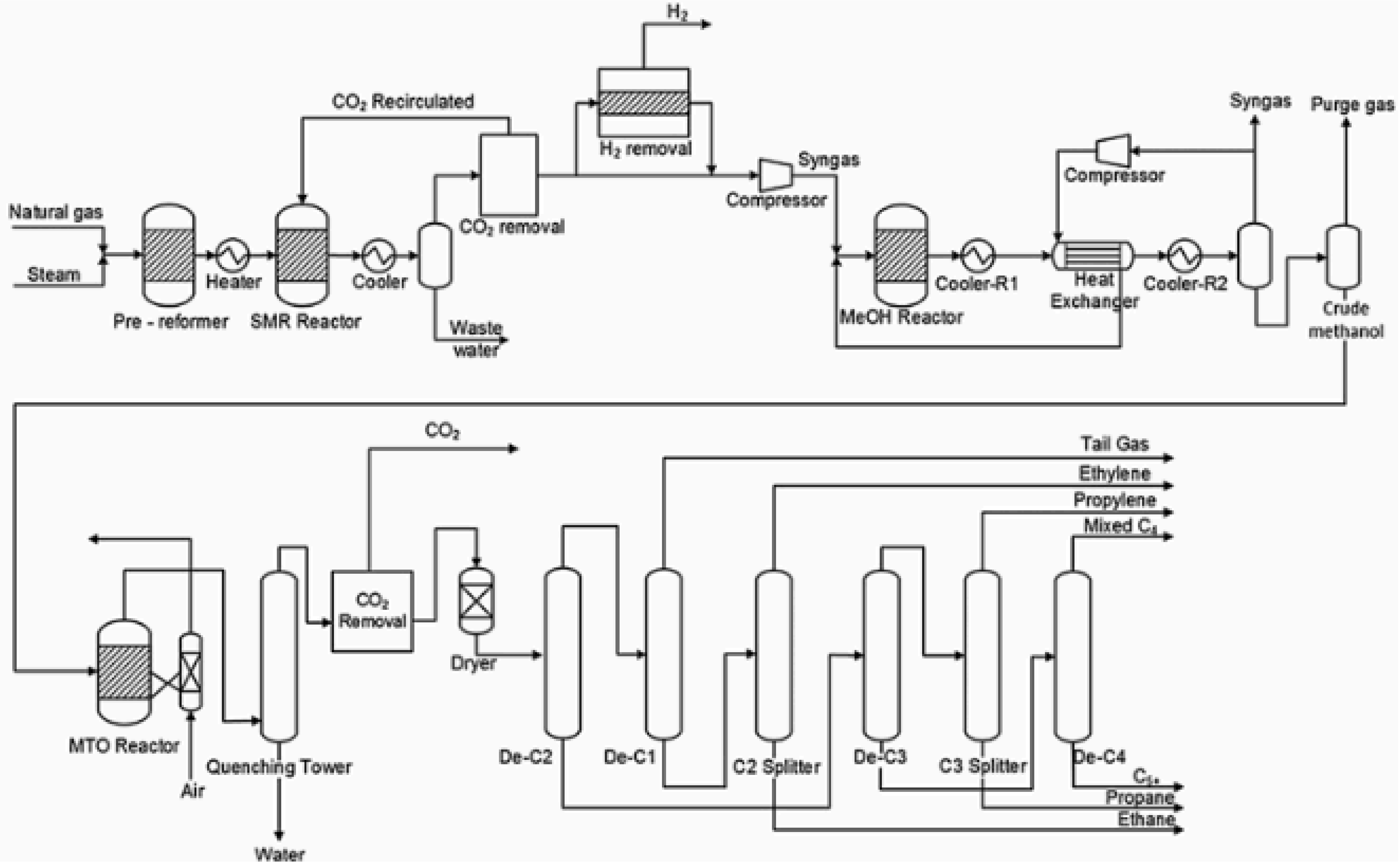
Traditional way : Thermal cracking of naphtha or natural gas liquids (NGL).

Modern methods :

OCM(Oxidative Coupling of Methane)

MTO : In the MTO process, natural gas is first reformed into synthesis gas, a mix of CO and H_2, then converted into methanol. Finally, methanol undergoes a catalytic reaction to produce ethylene along with other low-weight olefins.

MTO FLOWSHEET



CHEMICALS REQUIRED

- **Purified Shale Gas :** Consists primarily of methane, which is reformed to produce synthesis gas (syngas).
- **Steam :** It is used in the steam methane reforming (SMR) process to convert methane into syngas.
- **Hydrogen :** It is required to maintain the appropriate H2 ratio during the syngas production stage.
- **Methanol :** produced from syngas, which is later converted into light olefins (ethylene and propylene) through the MTO reactor.

CHEMICAL EQUATIONS

Methanol Dehydration to Ethylene:

$2CH_3OH \rightarrow C_2H_4 + 2H_2O_2$

(This reaction releases approximately −2.8 kcal/mol at 700K.)

Methanol Dehydration to Propylene:

$3CH_3OH \rightarrow C_3H_6 + 3H_2O$

(This reaction releases approximately −7.4 kcal/mol at 700K.)

Challenges faced during Simulation

They were many challnges faced during the simulation process

- No catalyst can be used so adjusted the reaction accoridngly .
- There were no Packed Bed Reactor so we used a conversion reactor and calculated the conversion rate .
- De ethanizer and seperator were interchanged by gas liquid separator .

ADVANTAGES OF MTO PROCESS

- **Economic Viability:** Strong ROI, especially with low shale gas prices, making it more competitive than alternatives like OCM.
- **Energy Integration:** Efficient heat reuse reduces operating costs, supports cogeneration, and lowers cooling utility needs.
- **Selective Catalysis:** SAPO-34 catalyst enhances selectivity for ethylene and propylene, maximizing product yield.
- **Environmental Adjustments:** Modifications like increased syngas recycling reduce carbon footprint, improving environmental performance.
- **Byproducts Management:** Effective separation units allow efficient handling and purification of byproducts, boosting process efficiency.

RESULTS OF MTO PROCESS SIMULATION

These are the results achieved after simulating the MTO process. The table shows the mass flow balances of all the input and output compounds.

Input/Output material balance for a MTO process				
	Input		**Output**	
	Flow Rate (kg/s)		Yield (%w)	Flow Rate (kg/s)
C2H4			55.7	0.0071
C3H6			39.3	0.005
Total Olefins				**0.0121**
MeOH	0.05		0	0
CH4			0	0
C2H6			3	0.00038
C3H8			2	0.00025
Total hydrocarbon			**100**	**0.01273**
Water				0.0351
Impurities				0.0015
Total (kg/h)	**0.05**			**0.05**

DMTO

The Dimethyl Ether-to-Olefins (DMTO) process is a cutting-edge technology developed to efficiently produce light olefins such as ethylene and propylene, which are vital in the production of plastics, synthetic fibres, and other petrochemical derivatives. The DMTO process utilizes dimethyl ether (DME) as the primary feedstock, offering numerous advantages over traditional methods of olefin production.

DMTO

Why use the DMTO Process?

- **Abundant Feedstock Sources:**DME can be produced from natural gas, coal, or biomass, making it accessible in regions with limited crude oil reserves which enables diversification of raw material sources, reducing dependency on oil markets.DME is derived from methanol, which in turn is produced from syngas (CO and H_2), a by-product of natural gas or coal gasification.The availability of DME ensures scalability and consistent feedstock supply for the DMTO process.
- **Improved Efficiency and Selectivity:**The DMTO process directly converts DME into olefins with high selectivity, minimizing undesired by products.
- **Sustainability:** Cleaner feedstocks and efficient catalytic processes significantly lower the environmental impact compared to traditional naphtha cracking.

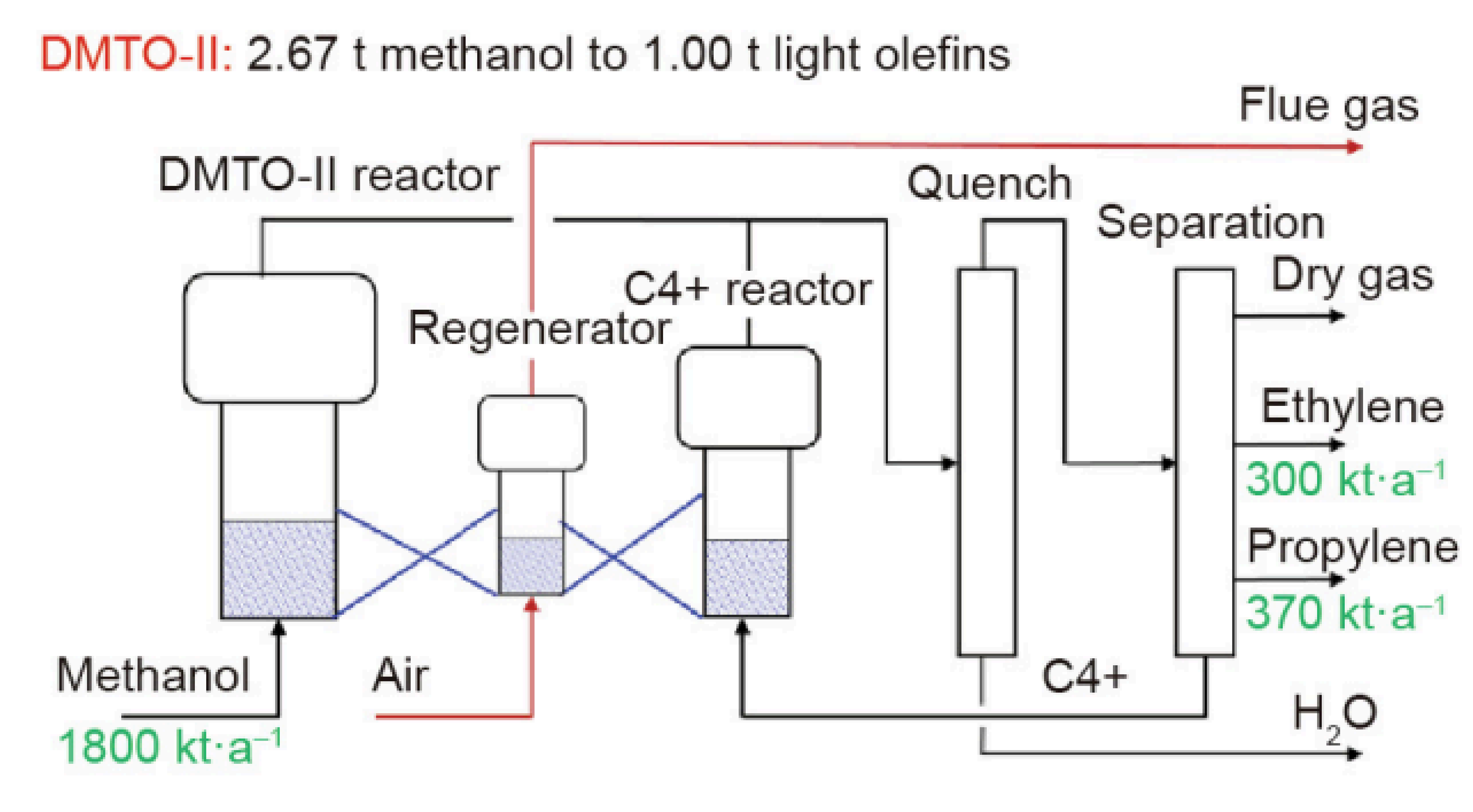
ENVIRONMENTAL EFFECTS OF THE DMTO PROCESS

Reduction in Carbon Footprint:
The DMTO process primarily utilizes dimethyl ether (DME), derived from methanol. Methanol production
from natural gas or biomass emits fewer greenhouse gases compared to crude oil refining and naphtha
cracking.

Lower Energy Consumption:
Advanced catalytic processes and heat integration minimize energy usage, decreasing overall emissions.

Emission of By-products:
Although limited, the process can produce by-products like CO_2 and trace hydrocarbons that need to be
managed effectively.

DMTO FLOWSHEET



CHEMICALS REQUIRED

- **Methanol**: Initially used to produce DME via dehydration. Methanol is often sourced from coal, natural gas, or biomass.
- **Dimethyl Ether (DME)** : The primary feedstock, derived from methanol. DME is converted into light olefins in the process.
- **Zeolite Catalyst:** A specialized catalyst, typically based on SAPO-34 (Silicoaluminophosphate), which facilitates the conversion of DME to olefins like ethylene and propylene.
- **Olefins (Ethylene and Propylene):** : The primary products of the process, separated and purified after the catalytic reaction.

CHEMICAL EQUATIONS

Methanol to Dimethyl Ether:

$2CH_3OH \rightarrow CH_3OCH_3 + H_2O$

(This reaction doesn’t release any heat at 481K.)

DME to Olefins:

$CH_3OCH_3 \rightarrow C_2H_4 + H_2O$

$3CH_3OCH_3 \rightarrow 2C_3H_6 + 3H_2O$

(This reaction release 53.22 kcal/mol heat at 481K.)

ADVANTAGES OF DMTO PROCESS

- **Feedstock Flexibility:** The DMTO process can use methanol from coal, natural gas, or biomass, making it a versatile option for producing olefins in regions rich in non-oil resources, such as coal-rich China, reducing reliance on crude oil.
- **High selectivity and efficiency:** The process is highly selective for ethylene and propylene production, essential for plastics, using SAPO-34 catalysts to efficiently convert DME to olefins with minimal byproducts.
- **Lower Carbon Footprint with Cleaner Feedstocks:** The process emits CO_2 when coal-derived methanol is used but has a lower carbon footprint with natural gas or biomass. Advances are also reducing waste and emissions.
- **Reduced Dependency on Steam Cracking:** Unlike energy-intensive steam cracking of naphtha, the DMTO process offers a lower-energy alternative, reducing reliance on oil-derived feedstocks.

RESULTS OF DMTO PROCESS SIMULATION

These are the results achieved after simulating the DMTO process. The table shows the mass flow balances of all the input and output compounds.

Input/Output material balance for a DMTO process				
	Input		**Output**	
	Flow Rate (kg/s)		Yield (%w)	Flow Rate (kg/s)
C2H4			29.7	0.28537
C3H6			36.6	0.35204
Total Olefins				**0.63741**
MeOH	1.80235		28	0.26963
C2H6O			5.7	0.05509
Total hydrocarbon			**100**	**0.96213**
Water				0.84022
Total (kg/h)	**1.80235**			**1.80235**

CONCLUSION

Both MTO and DMTO processes provide effective routes for the production of light olefins such as ethylene and propylene. The DMTO process, in particular, demonstrates higher yield efficiency, especially when using DME as a feedstock derived from methanol. This higher yield, combined with feedstock flexibility and lower dependency on oil-based resources, positions the DMTO process as a highly effective option in olefin production, particularly in coal and gas-rich regions where alternatives to petroleum are advantageous.

THANK YOU

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