Regulating the crude oil–to–chemical process in a multizone fluidized bed reactor

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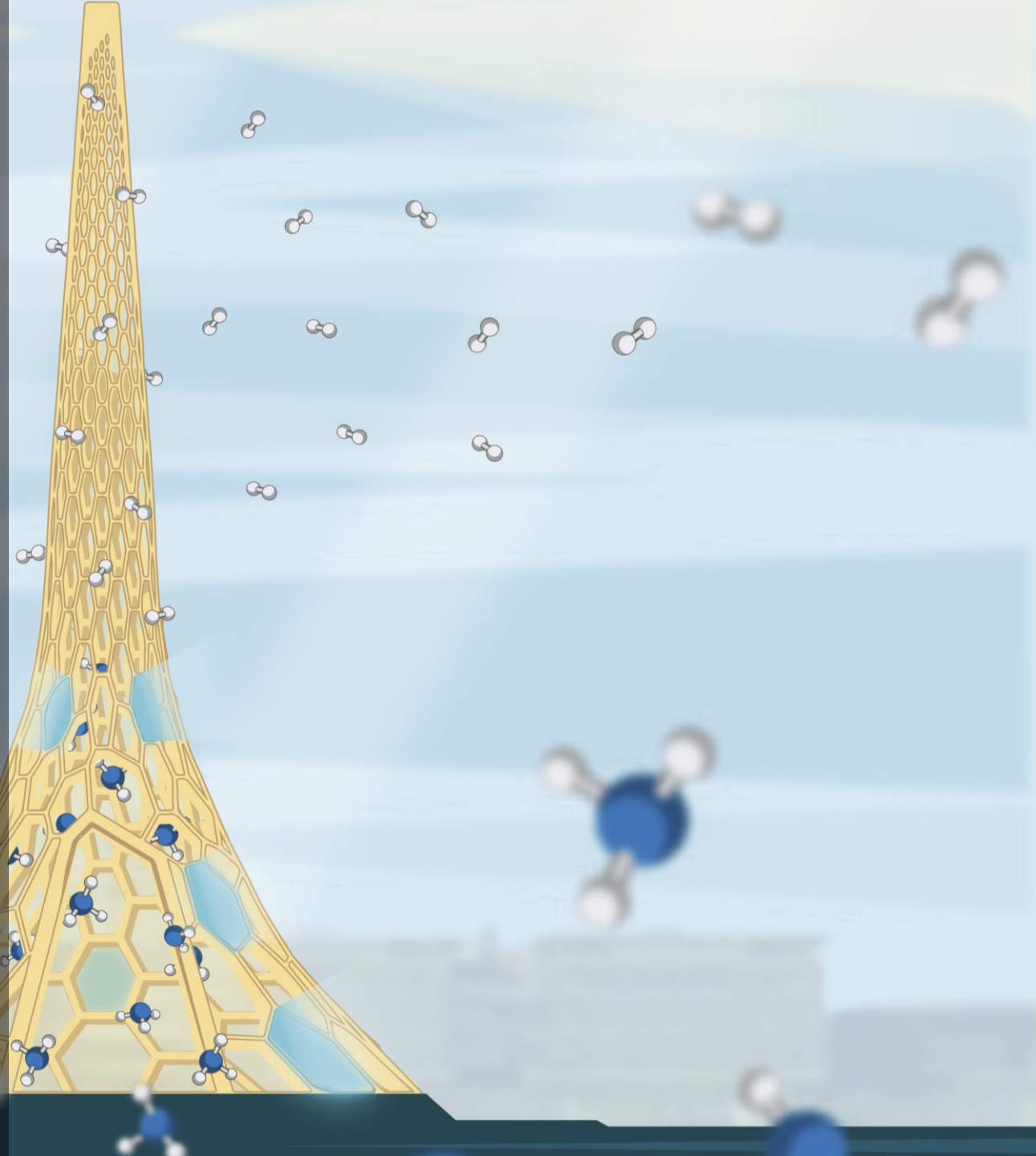
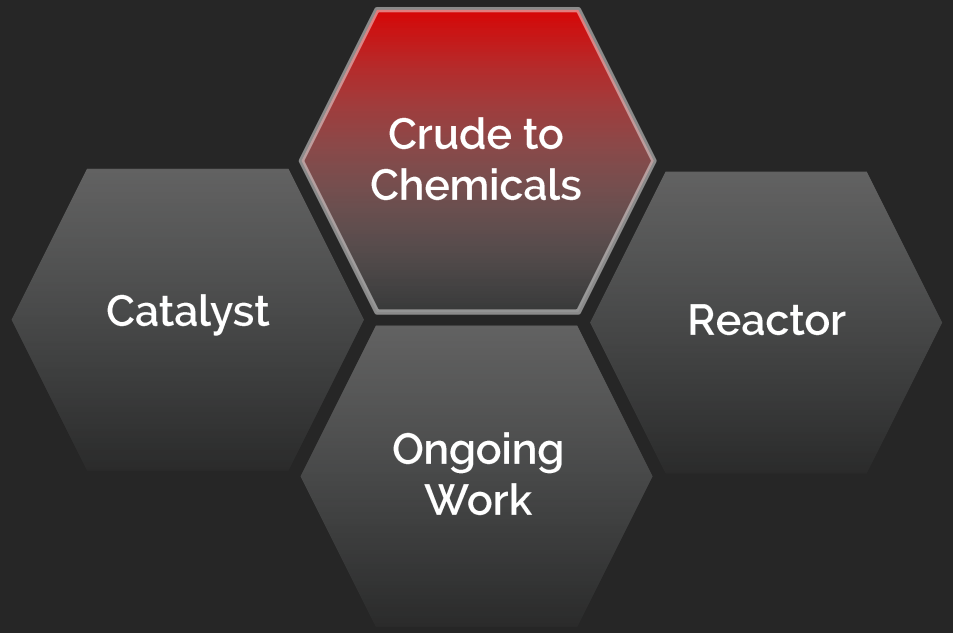


Outlines



Why?

GLOBAL INCREMENT IN LIQUIDS DEMAND 2018-2035

Arabian light crude oil

Controlled deactivation

Spray drying method

Catalyst

Direct Catalytic Cracking

Reactor

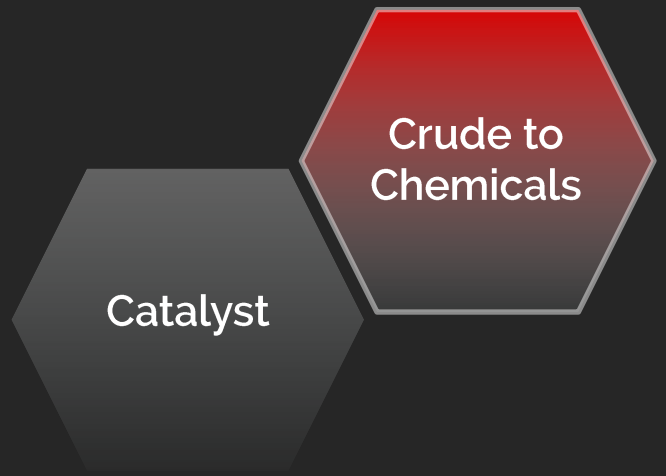
Fluidized bed reactors

High throughput testing

Olefins

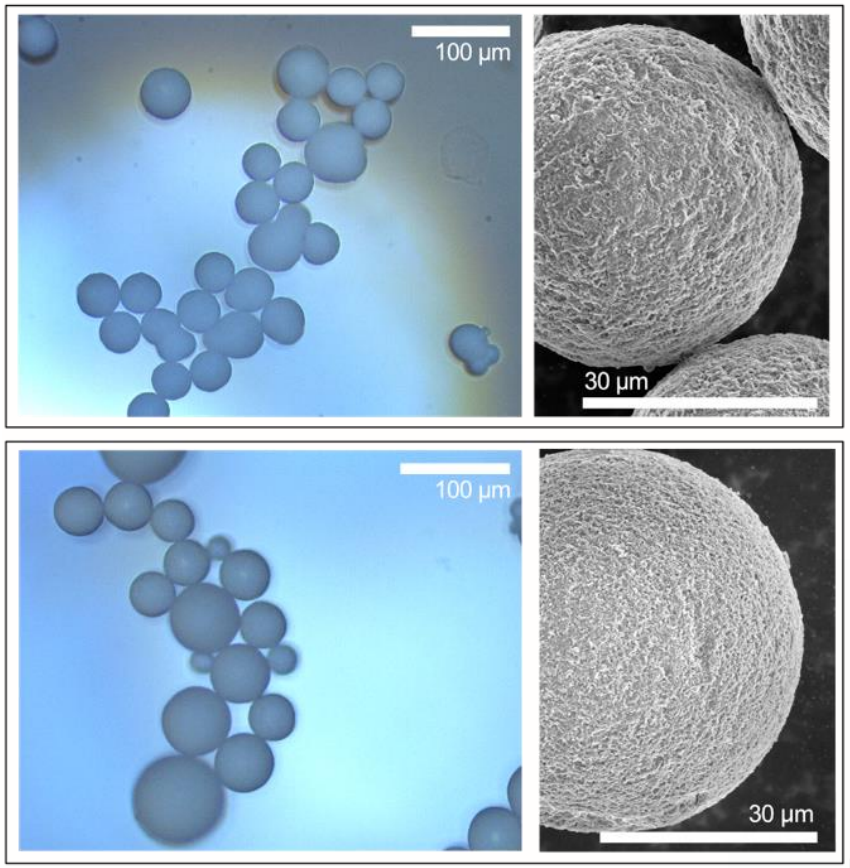
Aromatics

Outlines

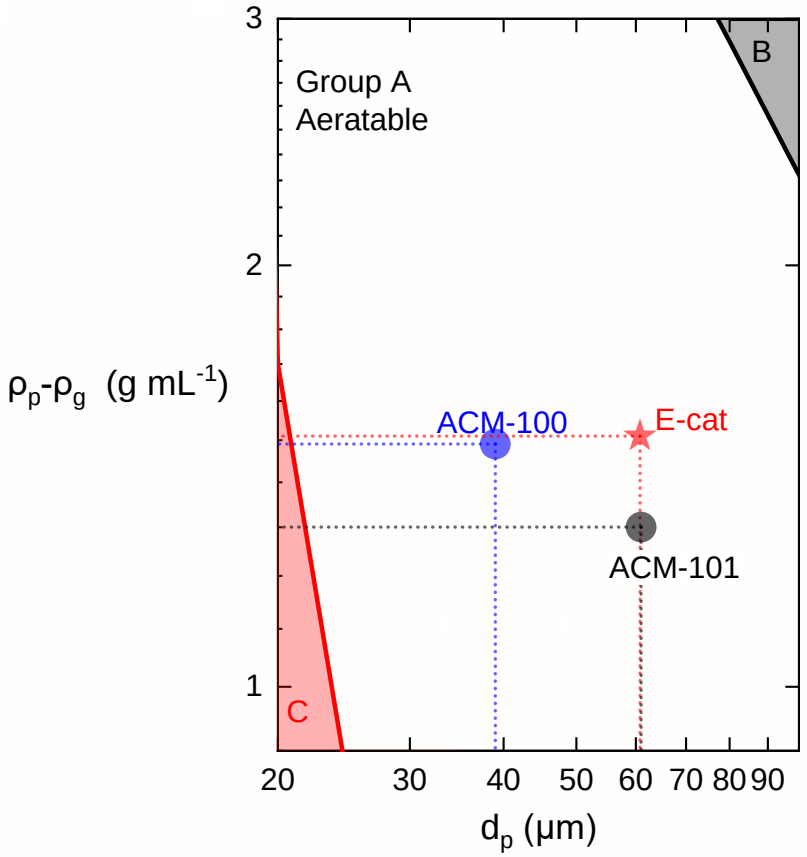


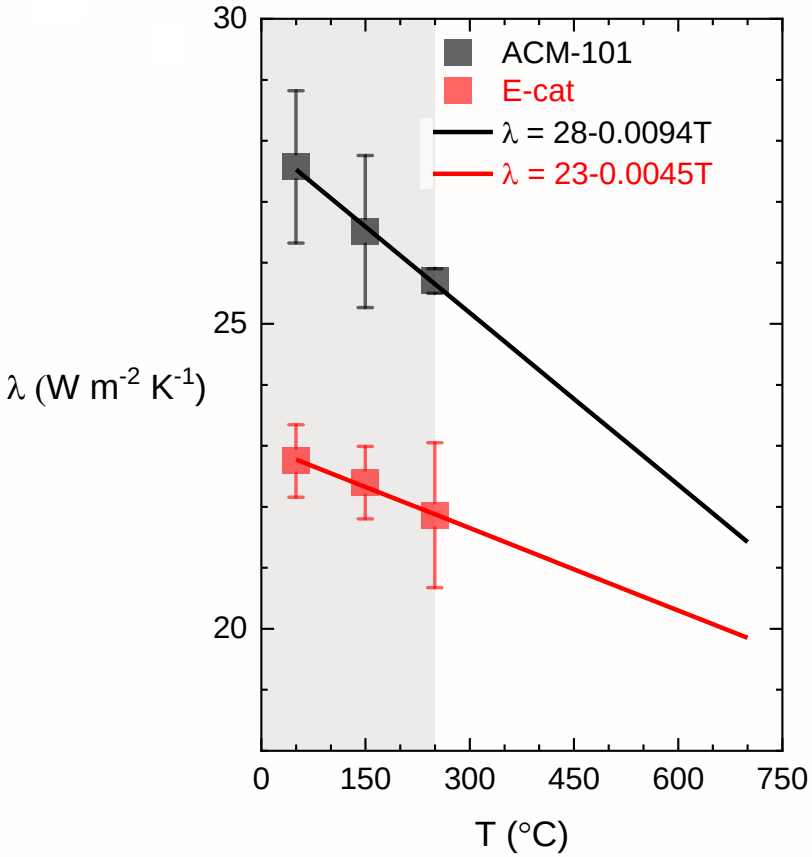
Composition

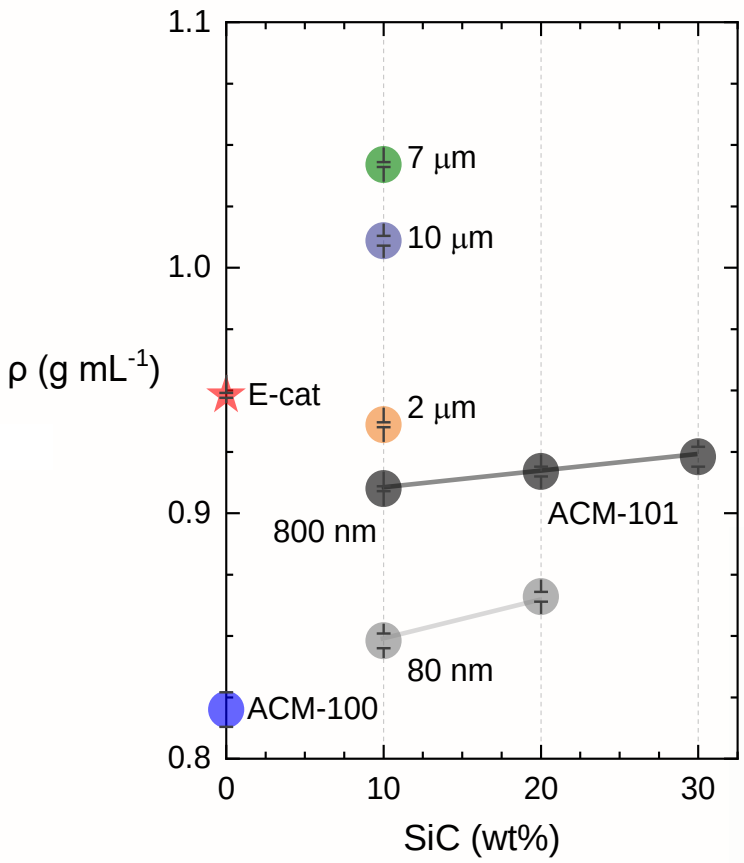
Composition (wt%)	ACM-100	ACM-101
Kaolin clay	40	20
800-nm SiC additive	-	20
FAU (SiO_2/Al_2O_3 = 30)	20	20
P/ZSM-5 (SiO_2/Al_2O_3 = 23, P/Al = 0.4)	20	20
Al_2O_3 binder	20	20



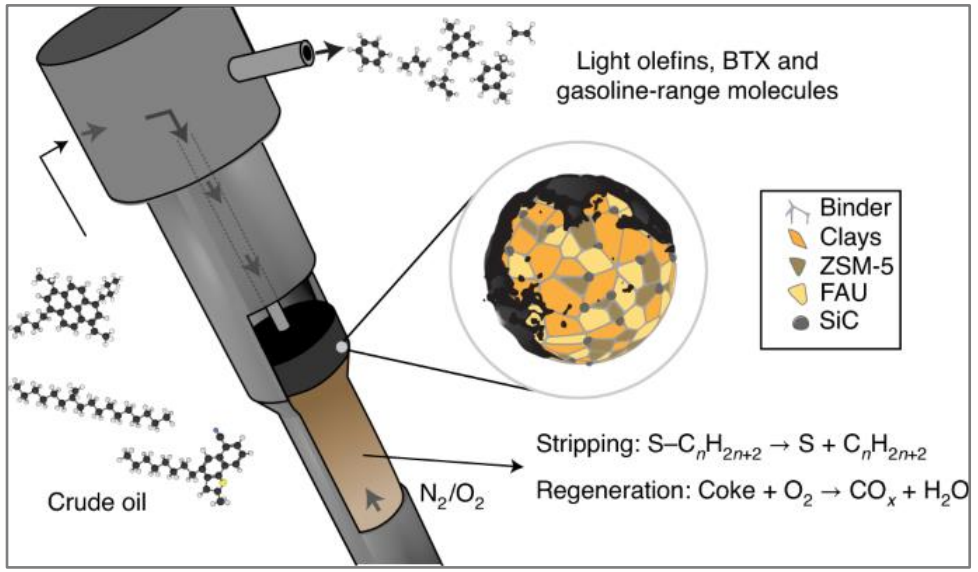
Physical properties







Catalytic cracking



Reaction conditions: T = 570 °C, catalyst mass = 6g, liquid feed flow of 0.1 mL min^{-1} of Arabian light (AL) oil:water (50:50, vol/vol), and an N_2 stream of 100 mL min^{-1} for 2 h

Catalyst	Total gas yield (wt%)	Ethylene yield (wt%)	Propylene yield (wt%)	Coke yield[a] (wt%)
ACM-101	38.5	3.95	13.44	7.45
E-cat	29.3	1.85	8.26	5.7

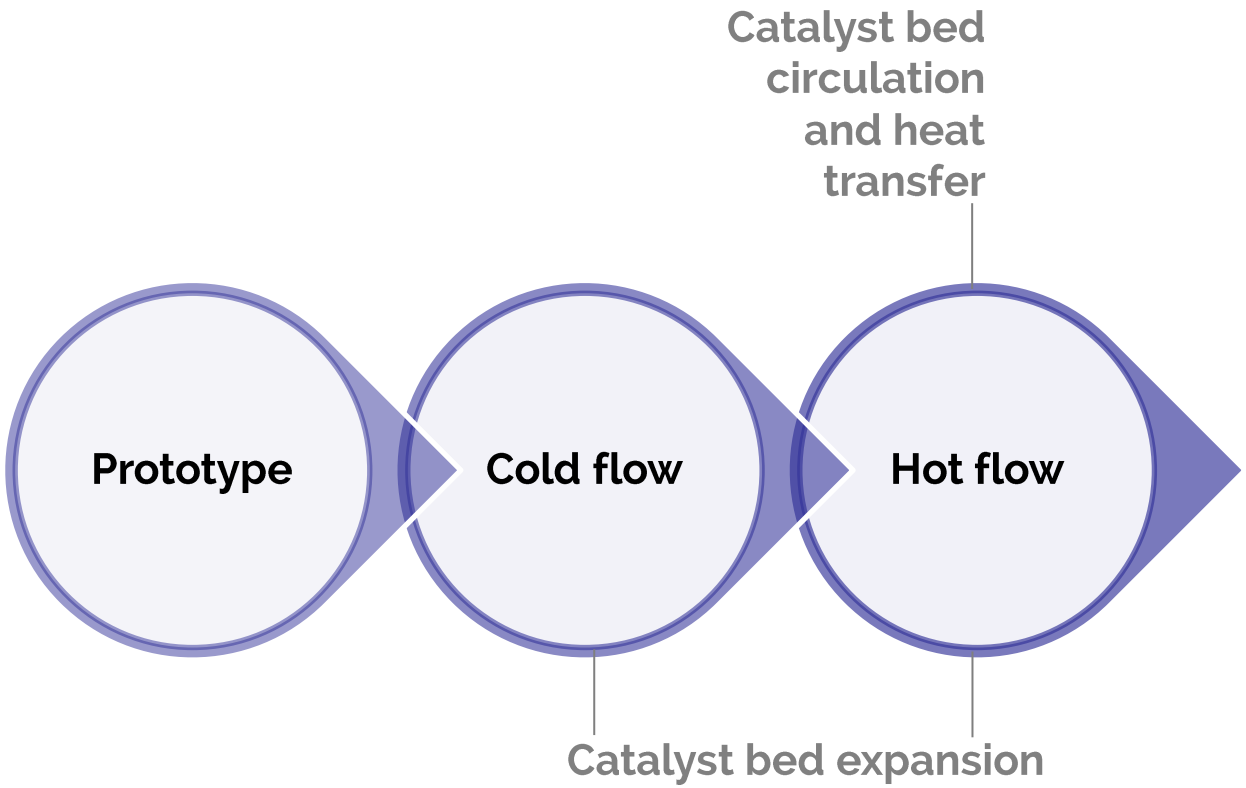
a: of the catalyst

Outlines

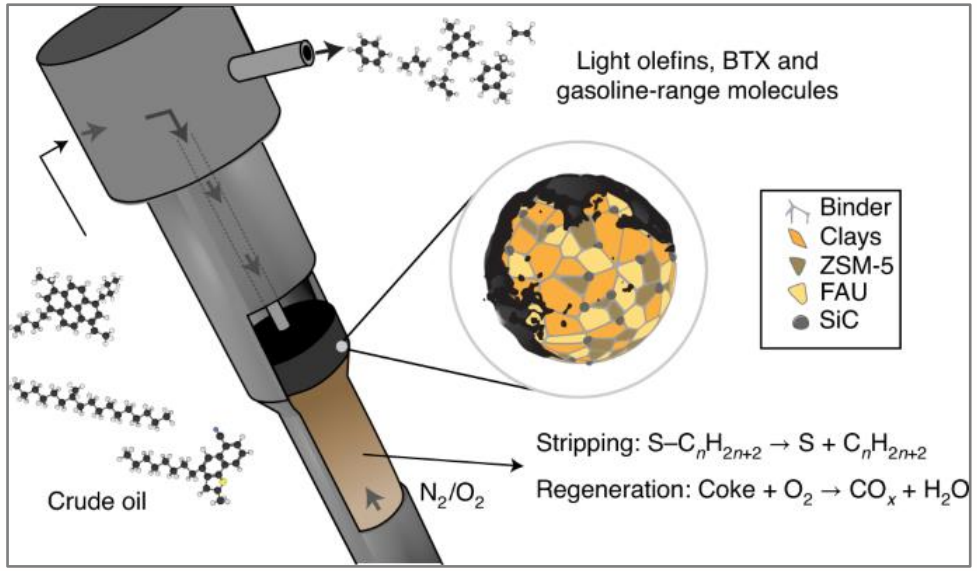
Catalyst

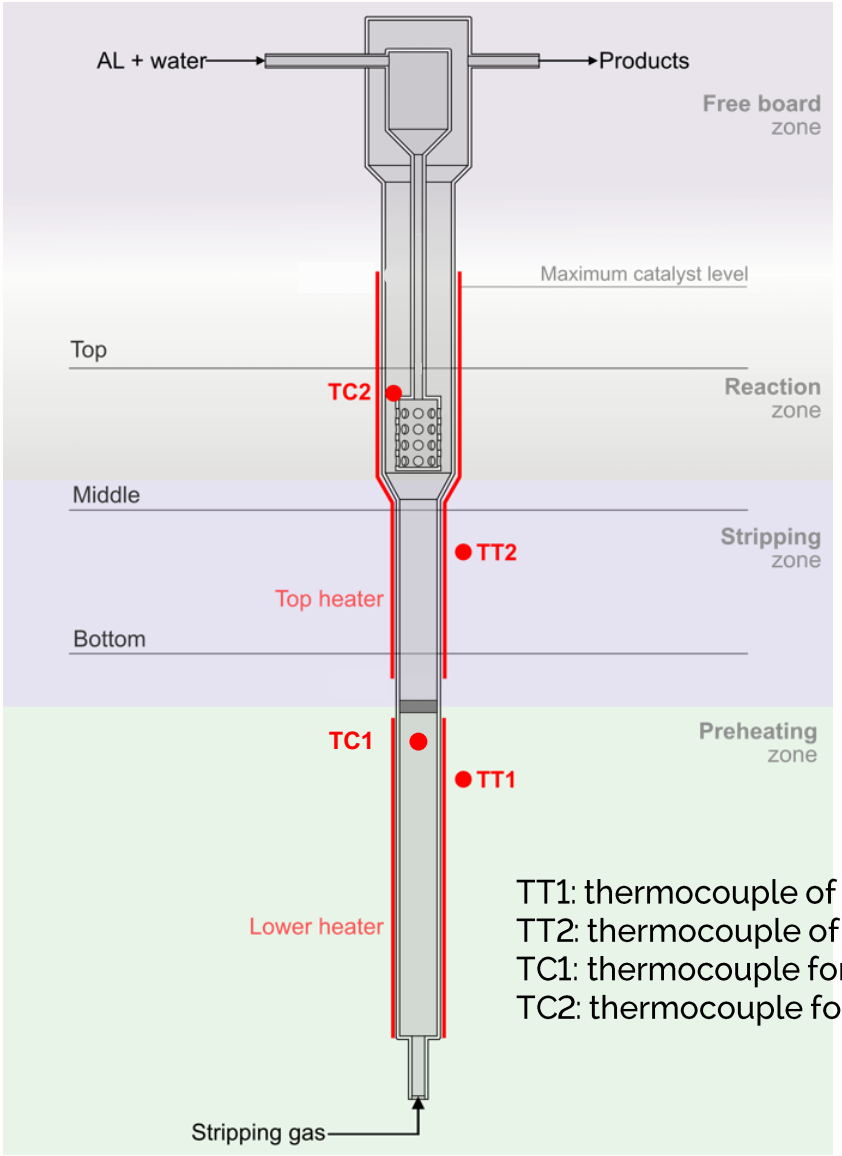
Reactor

Workflow


Catalyst bed circulation and heat transfer
Prototype
Cold flow
Hot flow
Catalyst bed expansion

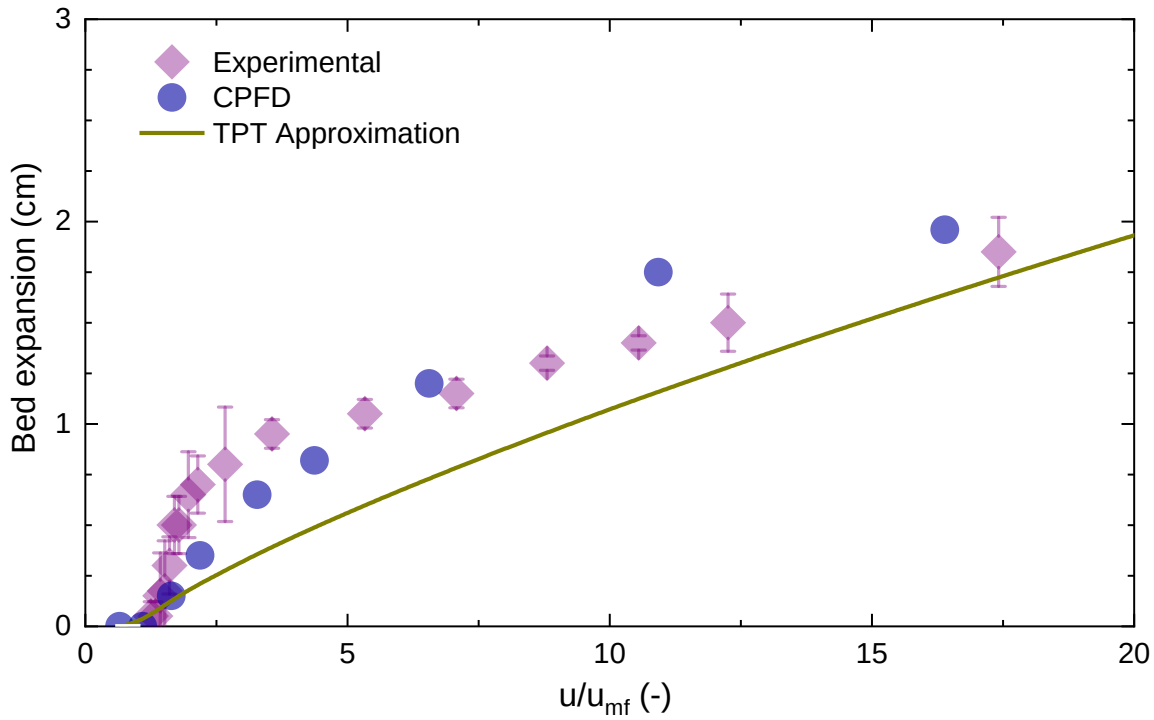
Prototype



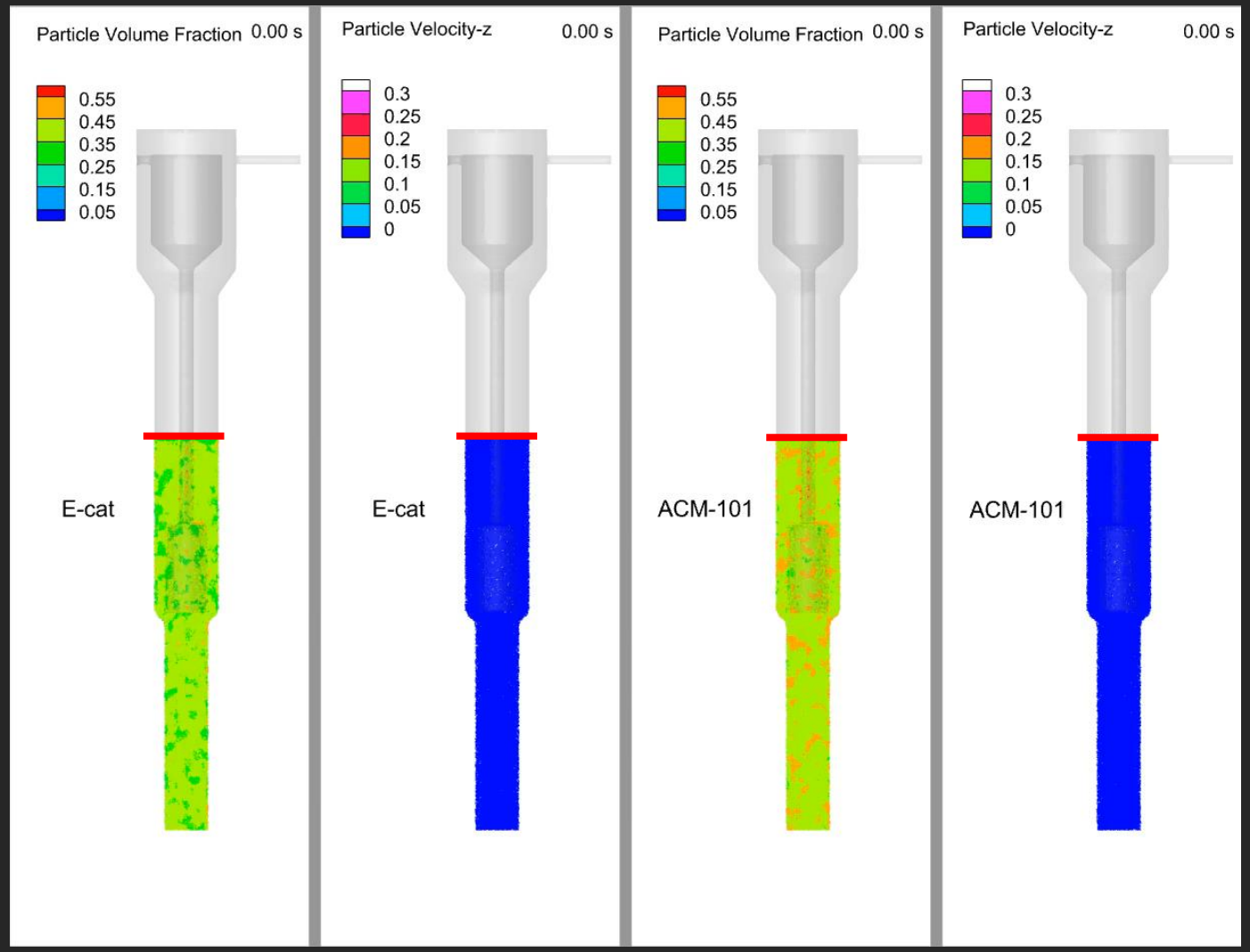


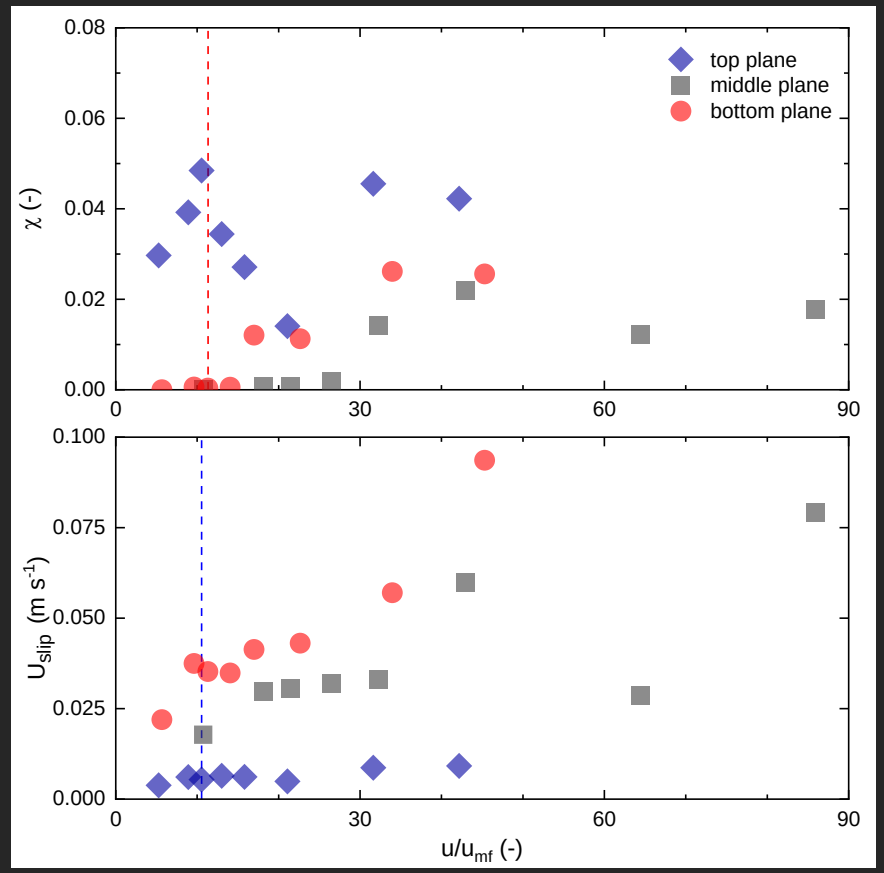
TT1: thermocouple of the bottom heater
TT2: thermocouple of the top heater
TC1: thermocouple for bottom heater temperature control
TC2: thermocouple for top heater temperature control

Cold flow


Experimental
CPFD
TPT Approximation
Bed expansion (cm)
u/u_mf (-)
0
1
2
3
0
5
10
15
20

Hot flow: hydrodynamics

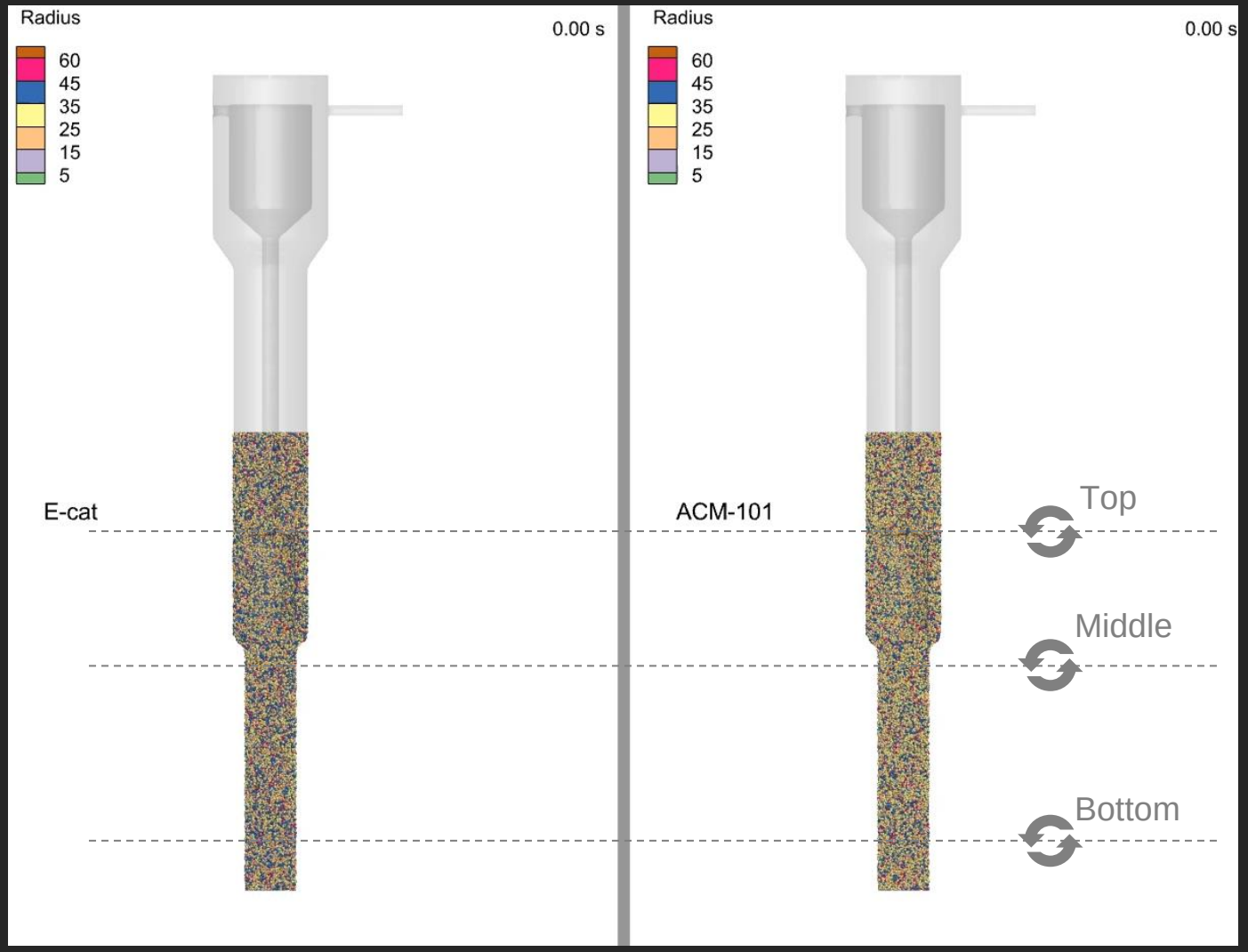


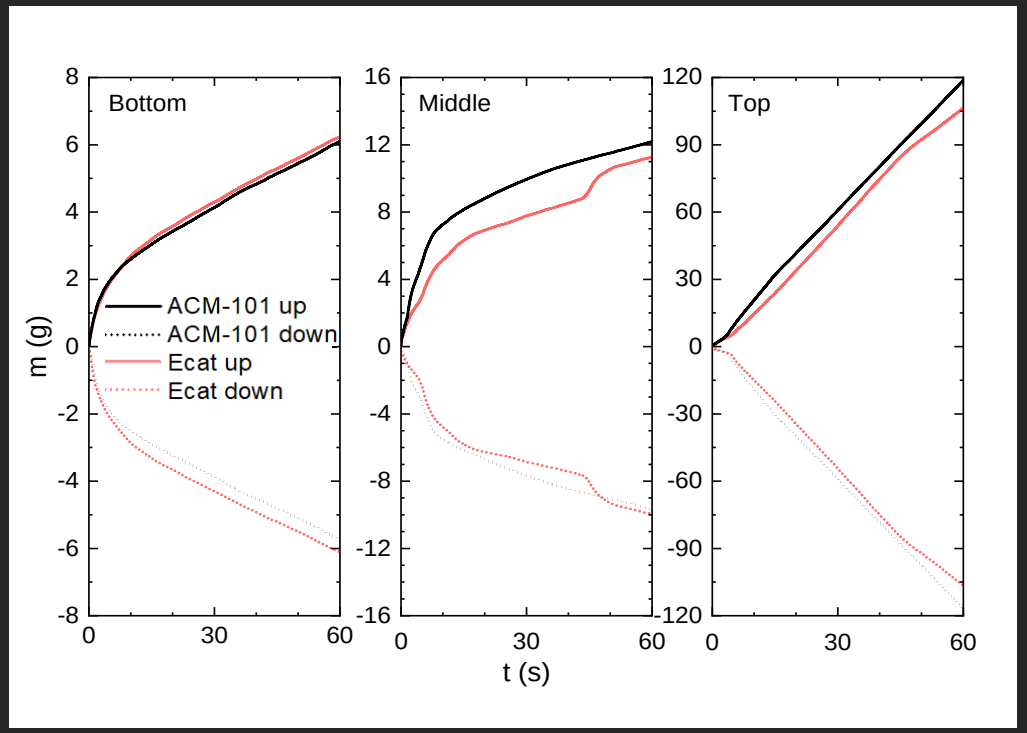


Simulation conditions: reaction temperature = 773 K, stripping N_2 gas flow = 100 mL min^{-1} @ STP, reaction zone: U/U_{mf}= 8.92 and stripping zone: U/U_{mf}= 9.09

Mengmeng Cui, et al., Powder Technol., 2024, 119573

Hot flow: particle circulation





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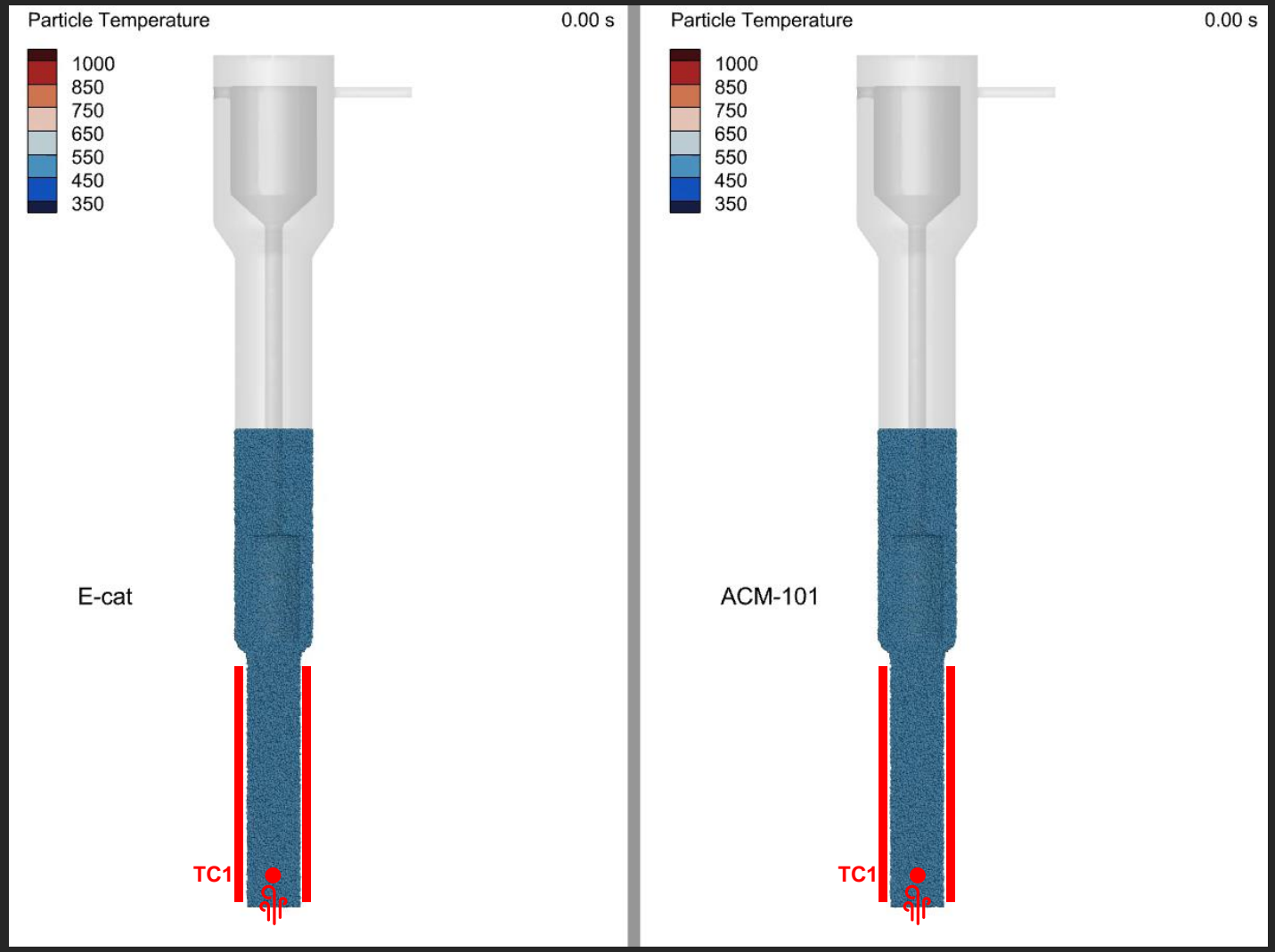
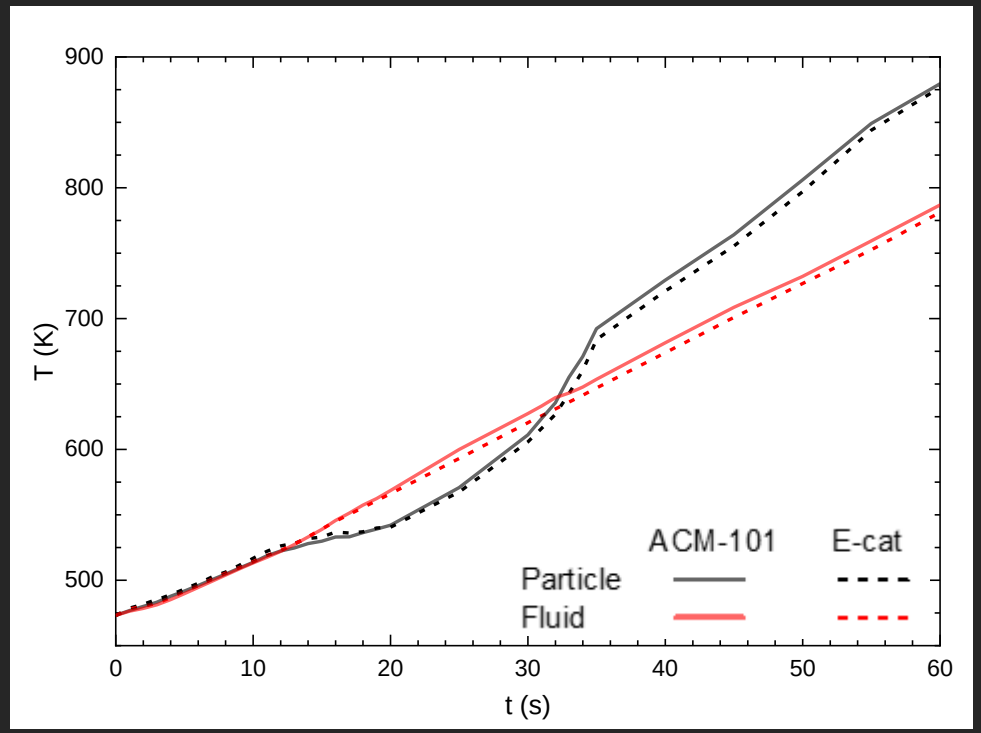
Mengmeng Cui, et al., Powder Technol., 2024, 119573

Hot flow: heat transfer





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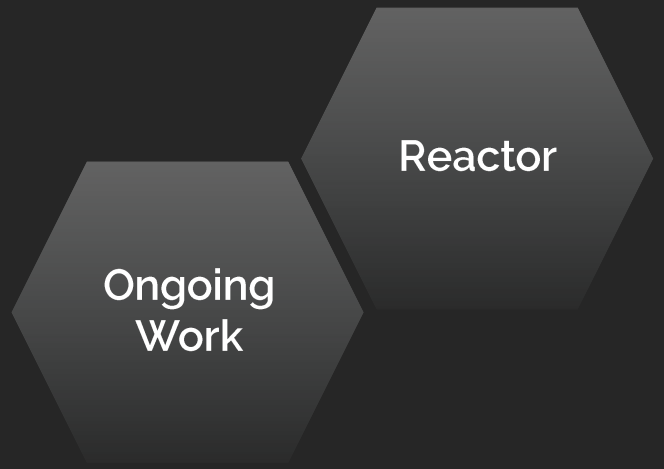
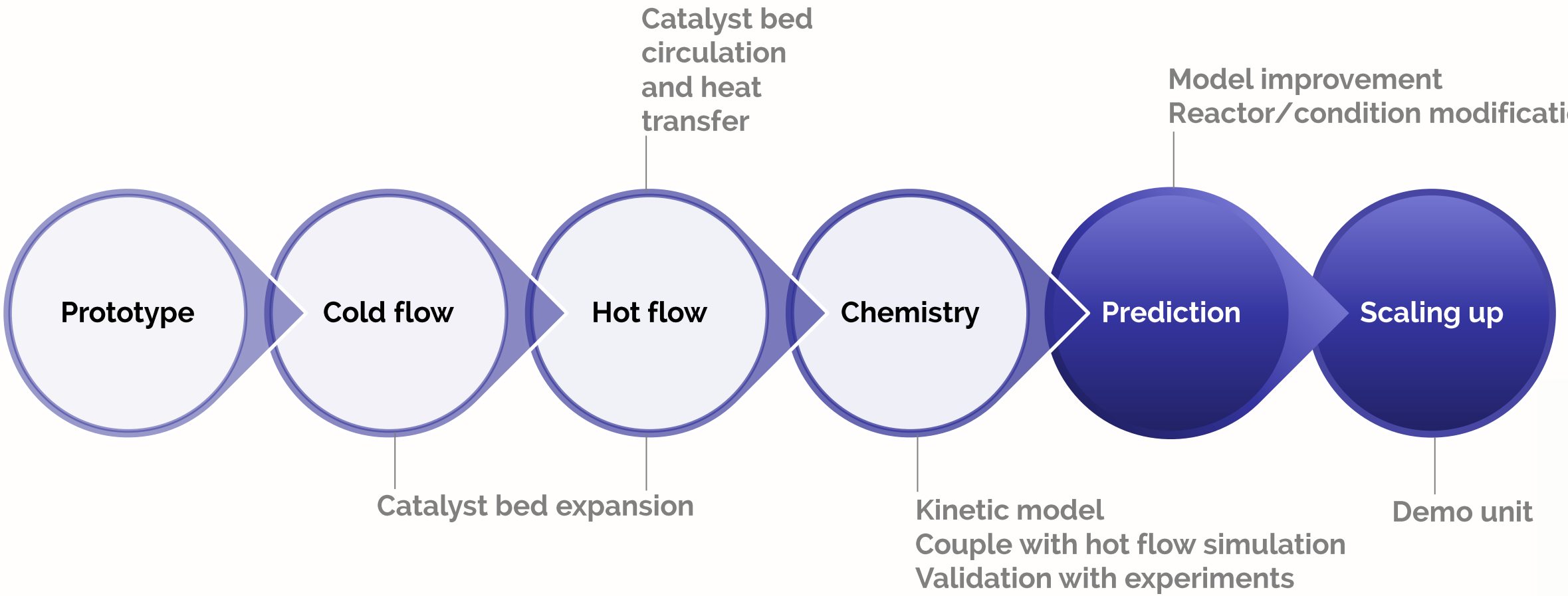
Outlines



Workflow

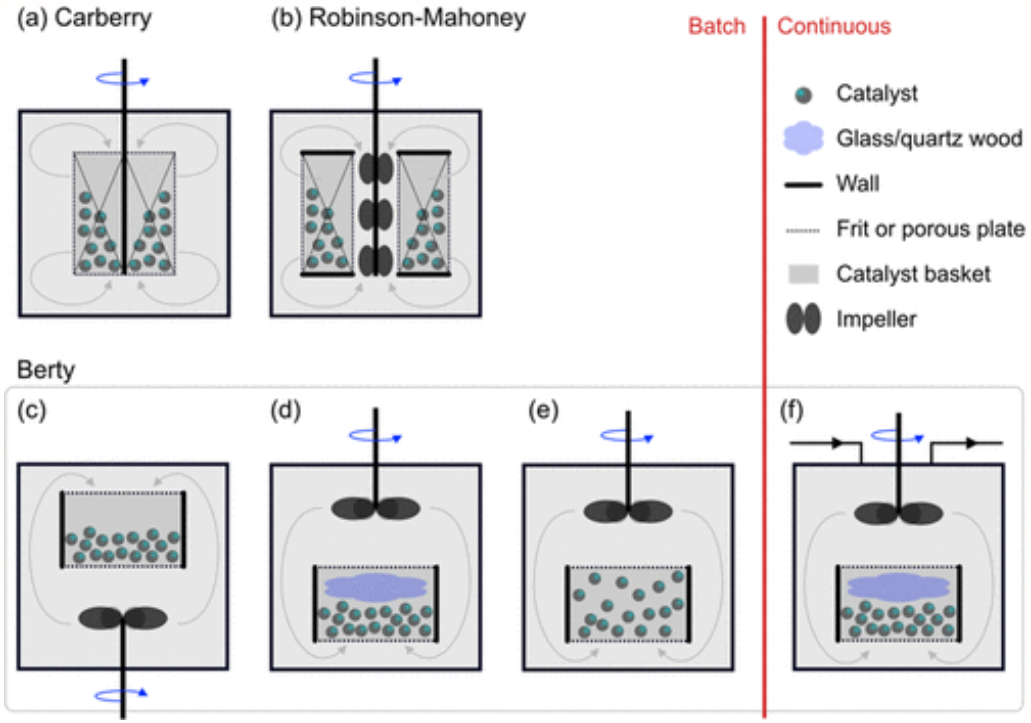

Catalyst bed circulation and heat transfer
Model improvement
Reactor/condition modification
Prototype
Cold flow
Hot flow
Chemistry
Prediction
Scaling up
Catalyst bed expansion
Kinetic model
Couple with hot flow simulation
Validation with experiments
Demo unit

Micro-activity testing

- Gas and solid residence times are different
- Good mass balance for heavy feed
- In-situ coke measurement
- Multiple experiments per day

Berty reactor

- Same gas and solid residence time



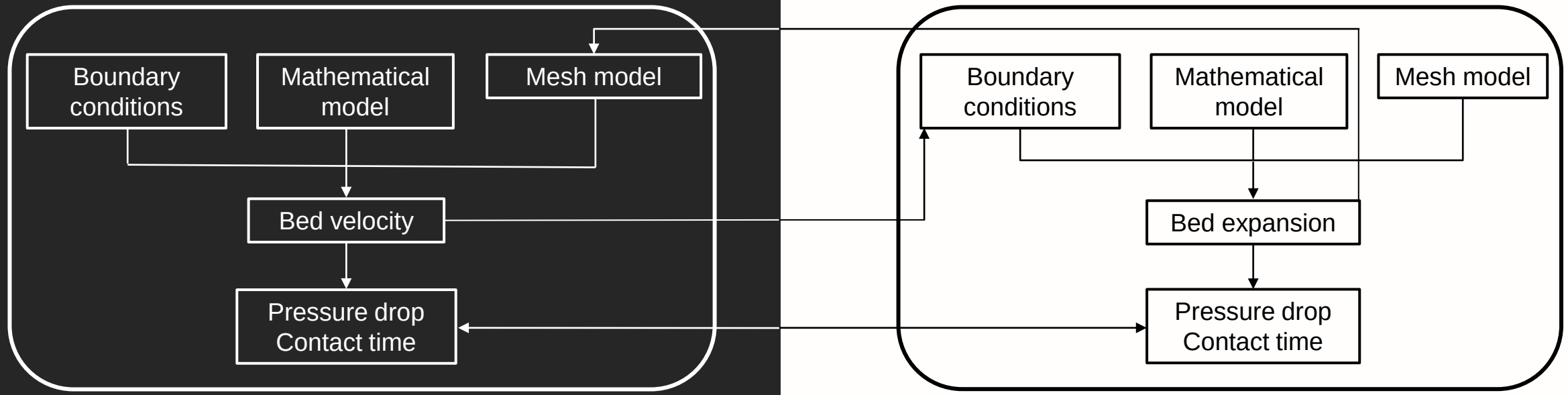
Mengmeng Cui, et al., ACS Eng. Au (2022), 2, 103-117

Computational fluid dynamics

- Slice model to represent the whole reactor
- Uniform particles assumption by porous media settings
- Rotation by multiple reference frame
- ANSYS Fluent

Computational particle fluid dynamics

- Gas-particle interaction
- CPFD Barracuda VR



Mengmeng Cui, et al., React. Chem. Eng., 2024, Advance Article

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