

# PROCESS INTENSIFICATION USING PROTON CONDUCTING MEMBRANES

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**COORSTEK.**  
MEMBRANE SCIENCES



CoorsTek Membrane Sciences (CTMS) is a technology leader in ion-conducting ceramic membranes used in direct gas-to-chemicals (GTCh) and gas-to-liquids (GTL) conversion applications. CTMS combines the hydrogen transport membrane (HTM) and oxygen transport membrane (OTM) technologies to offer commercial-scale solutions to energy and chemical producers

- Subsidiary of CoorsTek Inc. – The worlds largest manufacturer of advanced ceramics
- Central role in EU and national coordinated projects
- 25 employees: ceramic manufacturing, electrochemistry and catalysis



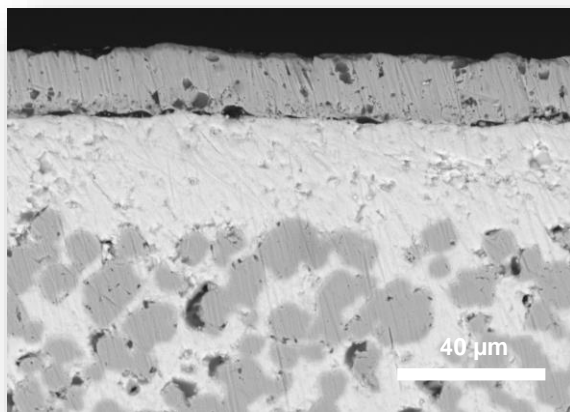


# NOVEL MEMBRANE INTEGRATED PROCESS SCHEMES

## Dehydrogenation

In-situ extraction of hydrogen allowing to explore thermodynamically unfavorable reactions

E.g. methane dehydroaromatization

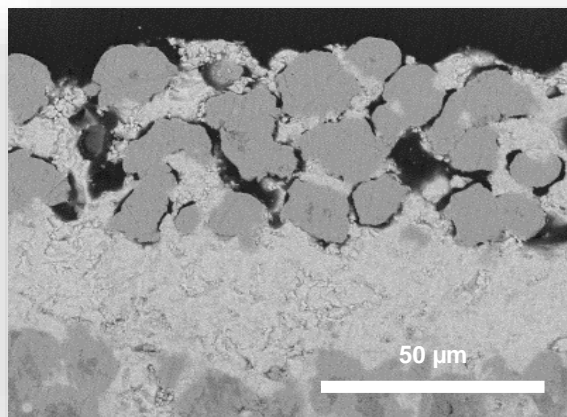


Cu | BZCY72 | Ni/BZCY72

## Reforming and compression

Dual chambers allows for synergetic effects

E.g. steam methane reforming and hydrogen compression

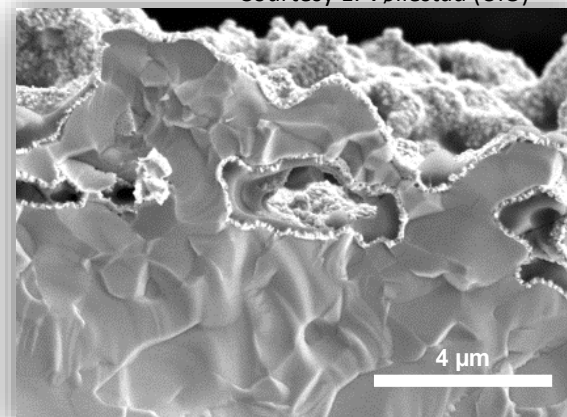


Ni/BZCY72 | BZCY72 | Ni/BZCY72

## Hydrogen production and power generation

Highly efficient and flexible electrolyzers and fuel cells

\* Courtesy E. Vøllestad (UiO)

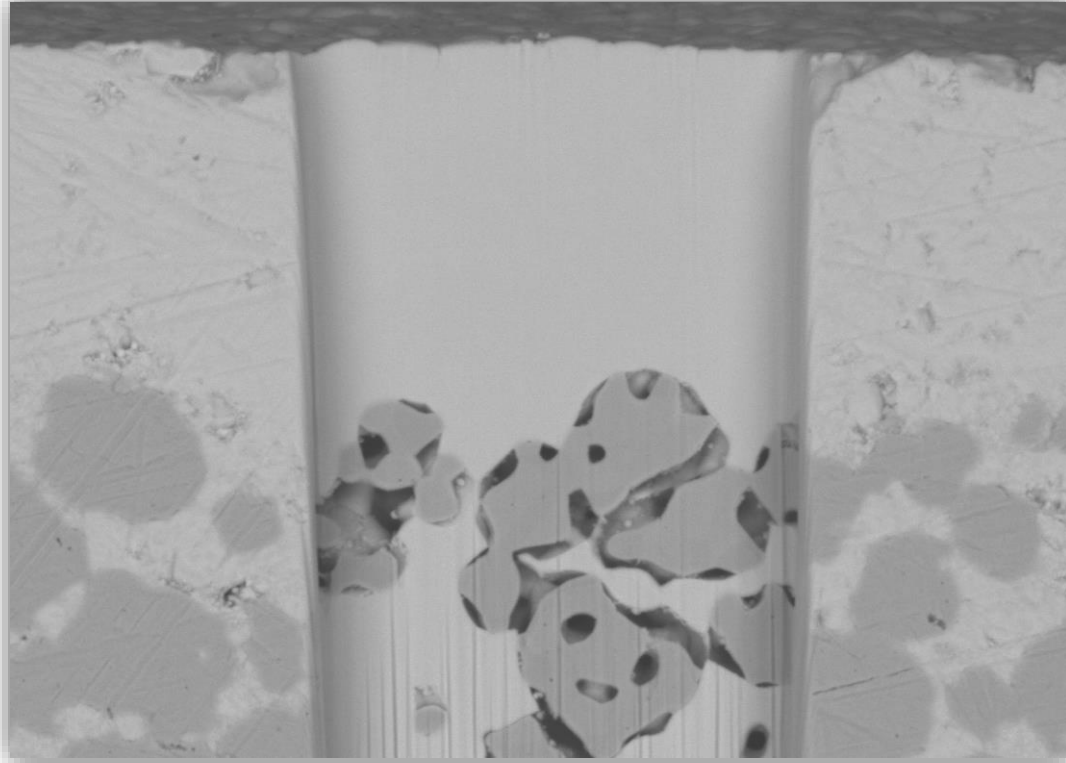


Ag/BZCY727 | BZCY72 | Ni/BZCY72



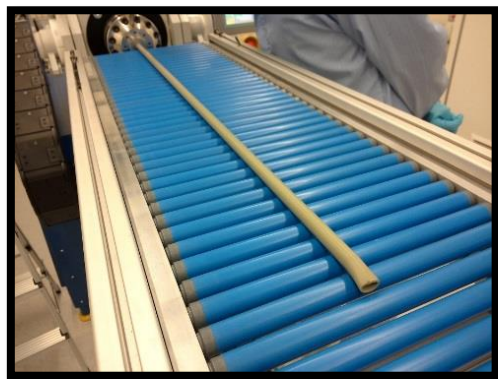
# BZCY72 | Ni/BZCY72 HALF CELL

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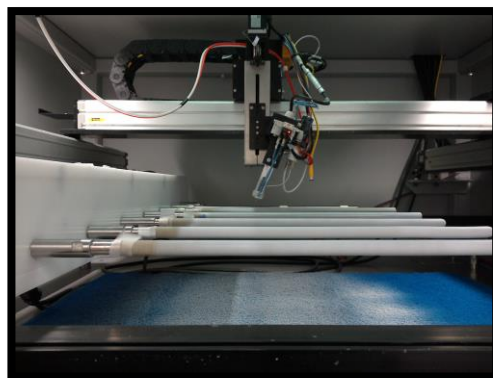


# FABRICATION

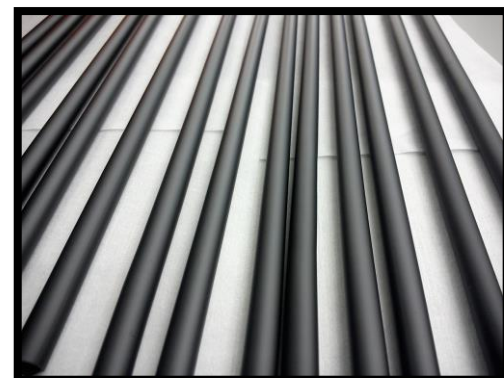
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Green tubes are fabricated either via extrusion or slip casting (for COE tube)



The green tubes are then coated with a barium zirconate-based electrolyte composition



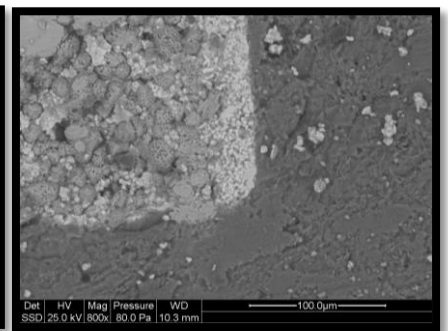
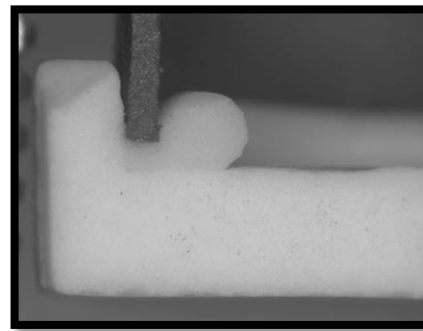
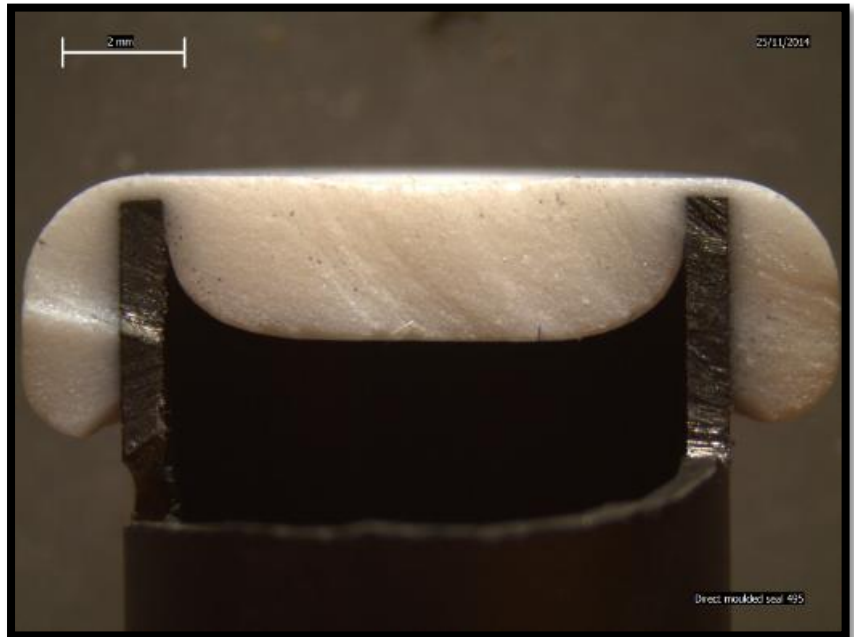
Hang fire sintering produces a dense membrane with a nominal thickness of 15 to 20  $\mu\text{m}$



# SEALING

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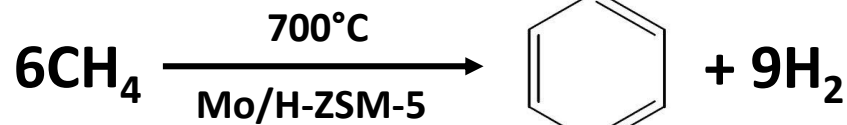
- High temperature glass ceramic sealing has been developed through careful CTE measurements
- Sealing preforms facilitates simple setup and high reproducibility
- The glass ceramic material is robust and chemically inactive in its crystalline form







# METHANE DEHYDROAROMATIZATION



**CH<sub>4</sub> into alkyl-aromatics**

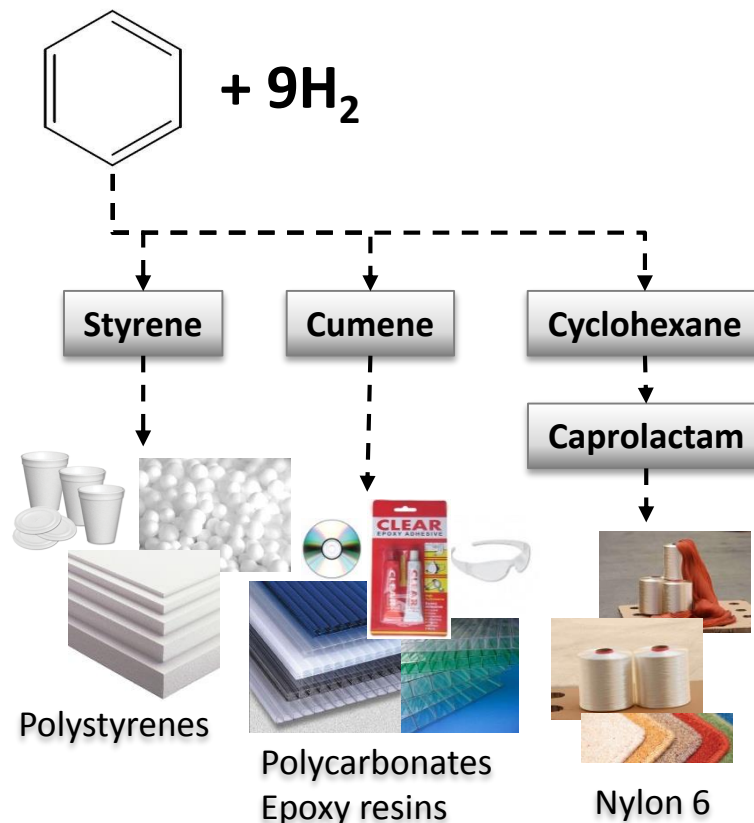


**Benzene important intermediate for the manufacture of diverse products**

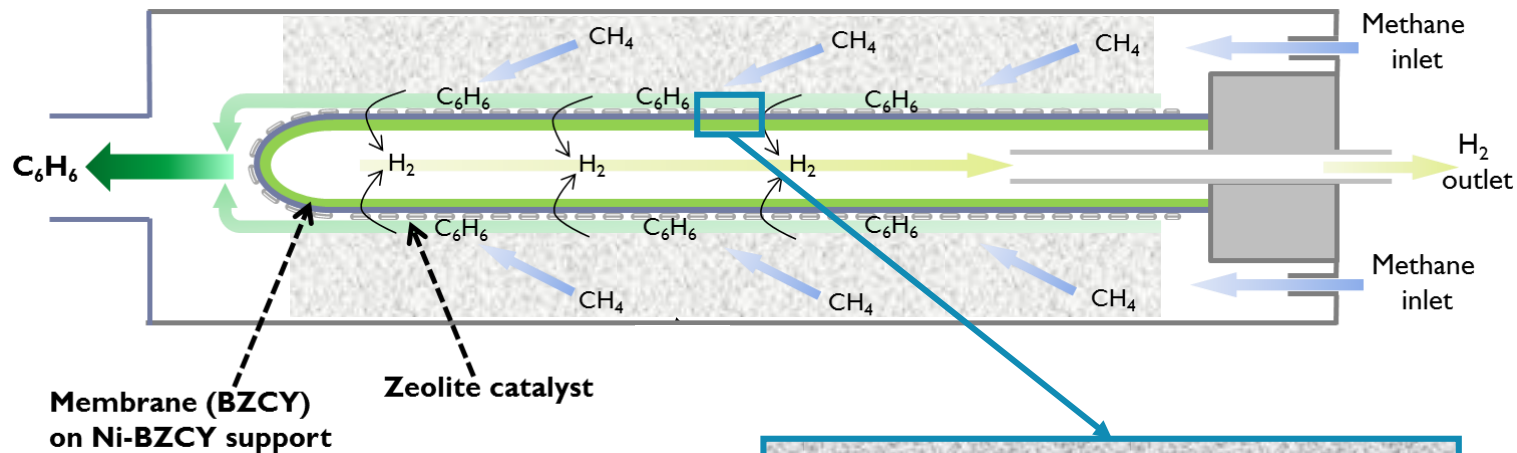
**H<sub>2</sub> as valuable by-product**

**Thermodynamically limited**

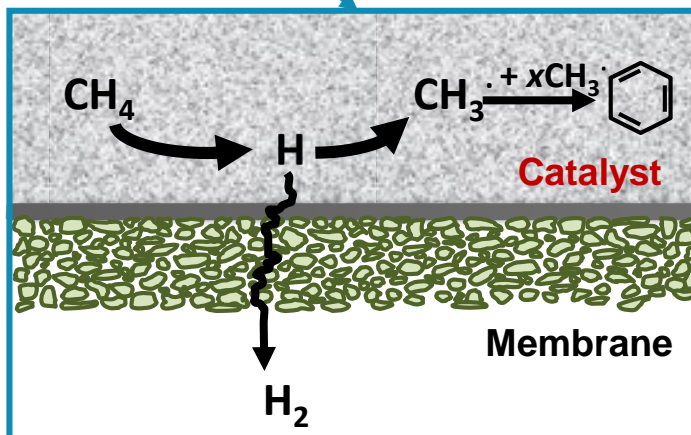
**Maximum conversion 12 % at 700°C**



# METHANE DEHYDROAROMATIZATION



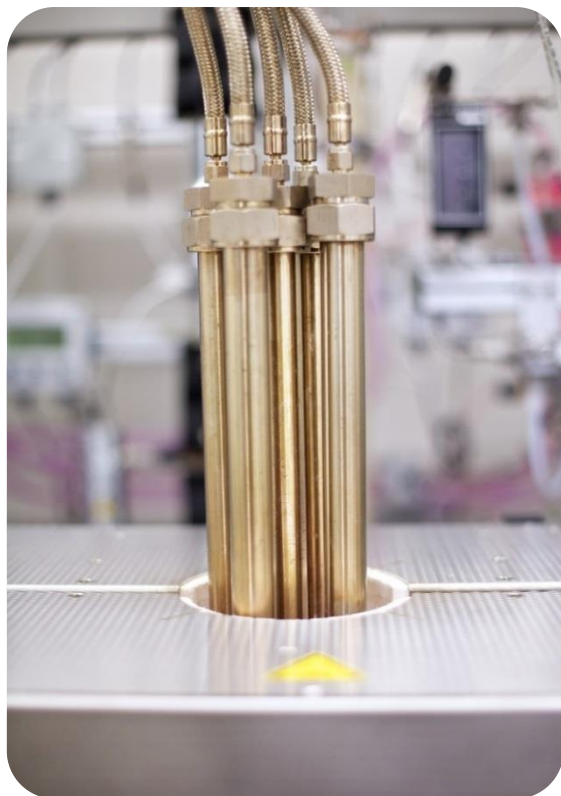
Continuous  $H_2$  removal during MDA reaction could improve the catalytic results



# METHANE DEHYDROAROMATIZATION

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- Include recycle to obtain high carbon efficiency
- Current demonstration on the L/day scale



# PARTNERS AND ACKNOWLEDGEMENT

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QUÍMICA



Colorado School  
of Mines



UNIVERSITY  
OF OSLO



UiO : Universitetet i Oslo



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