

Methanol synthesis over modified MOFs

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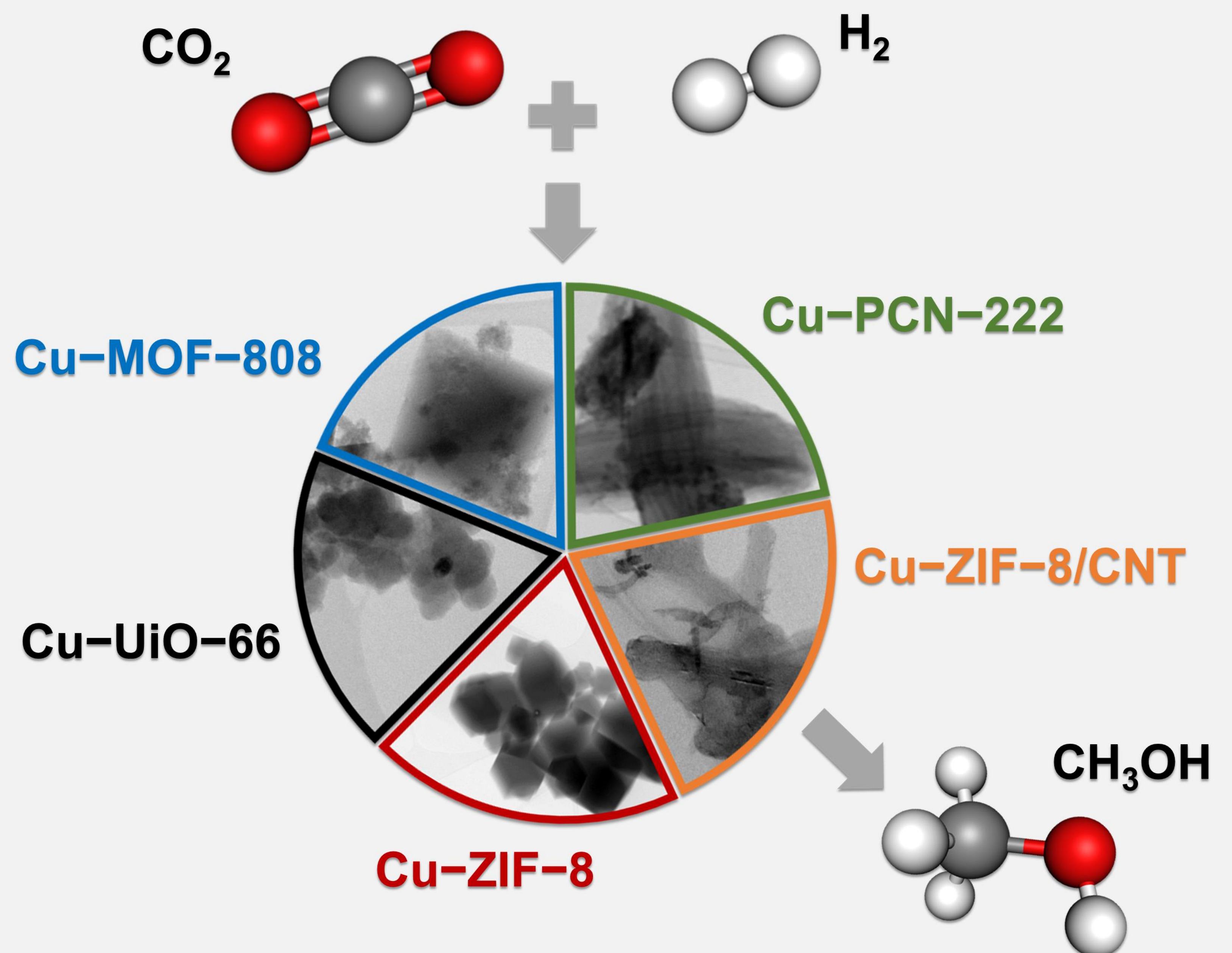
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INTRODUCTION:

As the urgency to mitigate climate change grows, there's a pressing need to convert CO₂ emissions into valuable chemicals such as methanol, offering a sustainable approach to reducing greenhouse gas levels. However, to conduct that process effectively, new promising catalytic systems have to be developed. In this research, we present five MOF-based materials, which contained zirconium clusters (UiO-66, MOF-808, PCN-222) or zinc ions (ZIF-8) and were additionally enriched with copper to facilitate methanol synthesis.

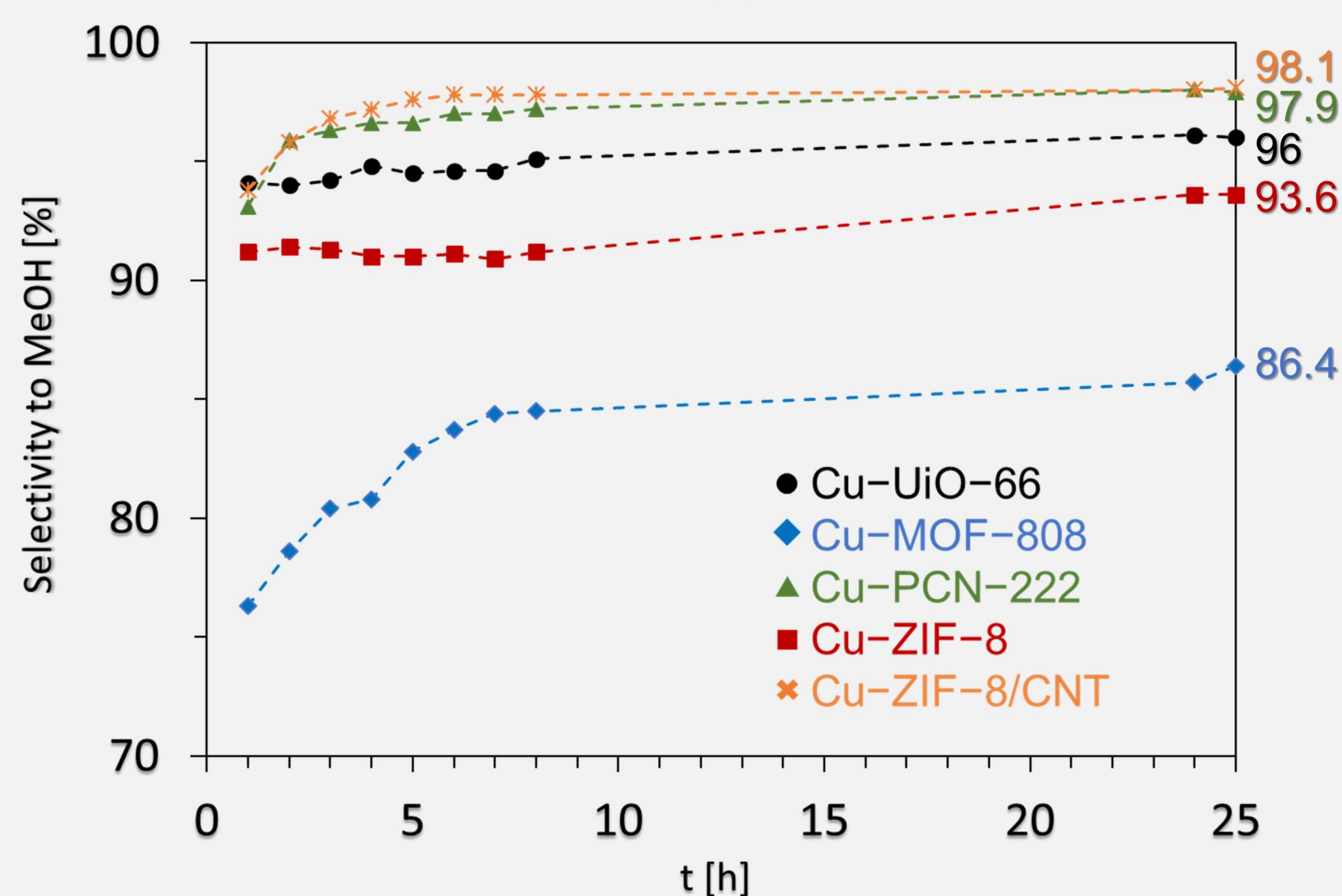
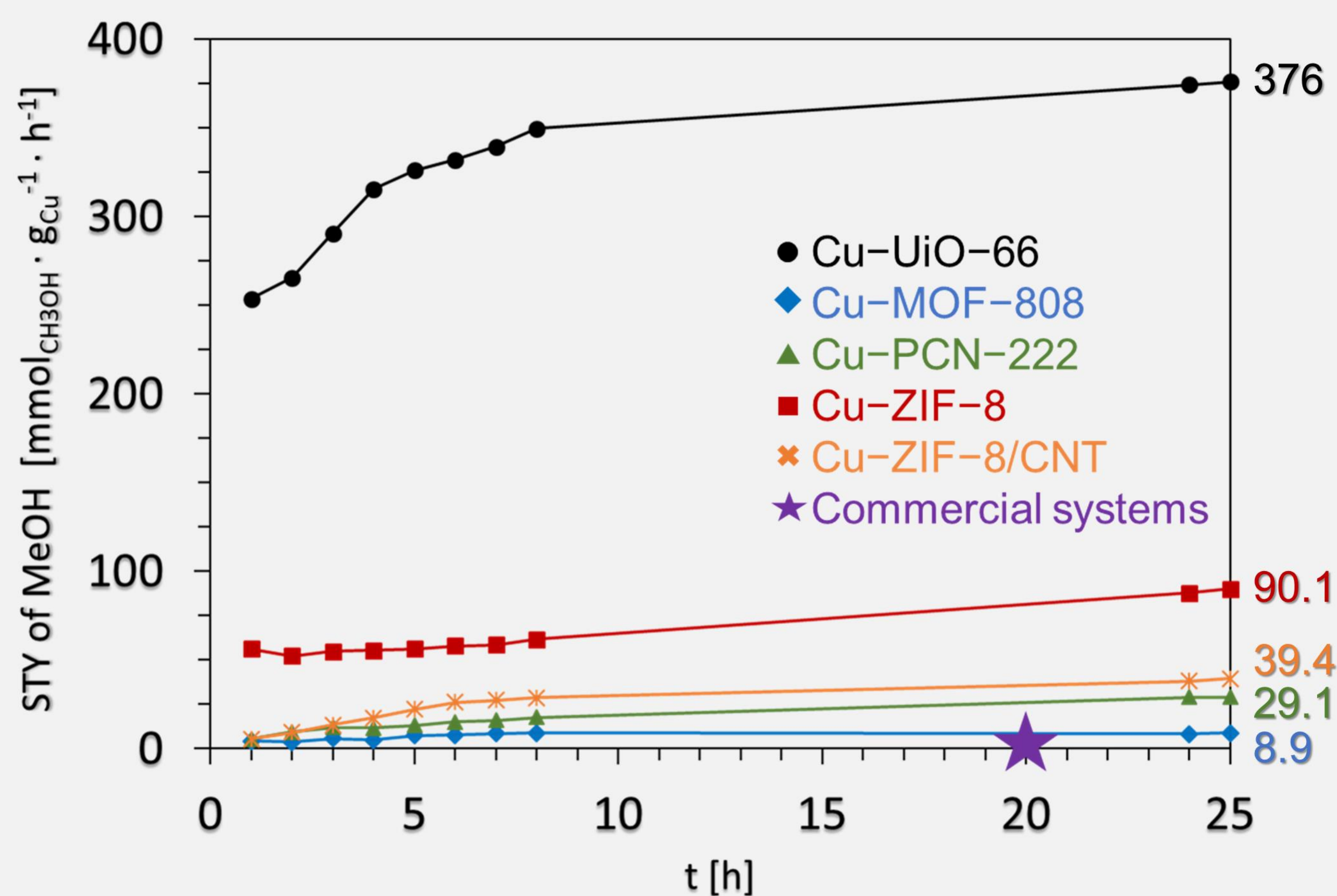
AIM OF THE RESEARCH:

Obtaining a novel, highly active catalyst for the reaction of direct hydrogenation of CO₂ to methanol.



METHANOL SYNTHESIS:

Test conditions: H₂/CO₂ = 3:1, 18 bar, 200 °C, 25 h



Sources:

- [1] Levalant et al., J. Catal. 324 (2015) 41
[2] Xiao et al., Appl. Surf. Sci. 338 (2015) 146
[3] Cai et al., Catal. Today 242 (2015) 193

★ Commercial systems:

Catalyst	STY of MeOH [mmol _{MeOH} · g _{Cu} ⁻¹ · h ⁻¹]	Selectivity to MeOH [%]	Test conditions
Cu/ZnO/Al ₂ O ₃ [1]	3.1	47	250 °C, 30 bar
Cu/ZnO/ZrO ₂ [2]	3.8	41	240 °C, 30 bar
CuZnGa [3]	5.8	38	250 °C, 30 bar

N₂ SORPTION (77 K):

Catalyst	S _{BET} [m ² /g]	V _{pores} [cm ³ /g]	D _{pores} [nm]
Cu-UiO-66	1328	0.69	2.1
Cu-MOF-808	776	0.53	2.8
Cu-PCN-222	1654	1.36	3.3
Cu-ZIF-8	1510	0.77	2.0
Cu-ZIF-8/CNT	889	0.16	1.4

ICP-AES:

Catalyst	Zr [wt. %]	Zn [wt. %]	Cu [wt. %]
Cu-UiO-66	24.3	-	0.2
Cu-MOF-808	19.1	-	1.4
Cu-PCN-222	17.4	-	4.7
Cu-ZIF-8	-	30.0	0.3
Cu-ZIF-8/CNT	-	25.4	4.2

CONCLUSIONS:

- ❖ All prepared materials exhibited satisfactory catalytic properties in the reaction of CO₂ hydrogenation to MeOH, greatly exceeding those reported for **commercial catalysts**^[1-3].
- ❖ Best STY of methanol (**376 mmol_{MeOH} · g⁻¹ · h⁻¹**) was observed for **Cu-UiO-66**.
- ❖ Best selectivity to MeOH of around **98%** was achieved for **Cu-ZIF-8/CNT** and **Cu-PCN-222** catalysts.