Supporting Information

Cu-Mg synergy enhanced synthesis of methyl formate over noble metal-free heterogeneous catalyst system

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Table S1: The surface and bulk composition of elements determined by XPS and ICP-MS analysis

Entry	Catalysts	Surface composition (%) XPS Analysis			Bulk composition (%) ICP-AES Analysis		
		Cu	Mg	Zr	Cu	Mg	Zr
1	Z	-	-	23.94	-	-	35.15
2	20MZ	-	17.76	22.79	-	19.78	33.29
3	5C-20MZ	1.01	15.19	23.55	4.91	19.72	32.68

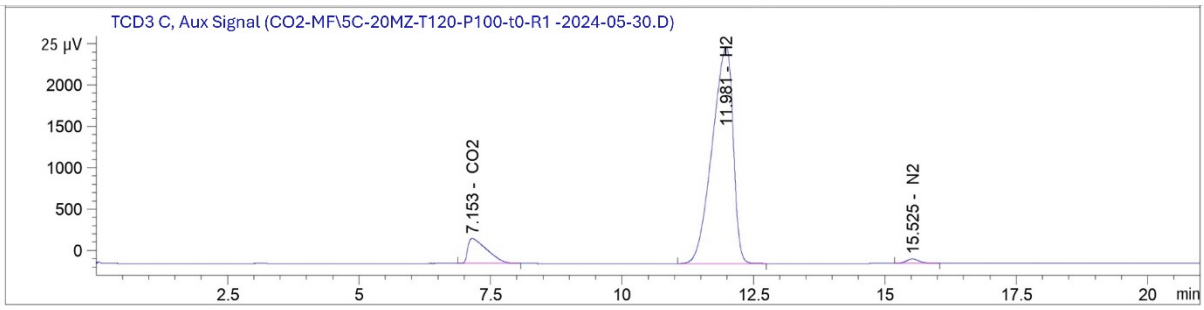
Table S2: CO_2 desorption data of the catalysts obtained from CO_2-TPD and surface properties collected from N_2-physisorption analysis

Entry	Catalysts	CO_2 desorbed (cm^3/g STP)				S_{BET} (m^2/g)	PD (nm)	PV (cm^3/g)
		Weak	Medium	Strong	Total			
1	Z	-	0.7428	-	0.7428	78	11.8	0.3
2	20MZ	0.8057	0.3855		1.1912	66	9.9	0.2
3	5C-20MZ	0.8122	0.6212	0.1165	1.5499	61	9.4	0.2

***S_{BET}: BET Surface area, PD: Pore diameter, PV: Pore volume**

GC Chromatogram

(a) Before reaction



(b) After reaction

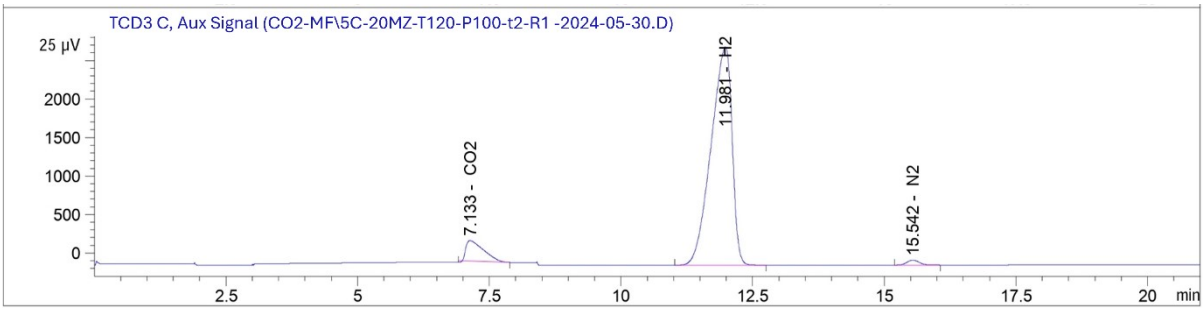


Figure S1: GC chromatogram for 5%Cu-20%MgO-ZrO2 catalyst (a) before reaction (at time: 0h) and (b) after reaction (at time: 2h)

Table S3: Chromatogram data obtained from GC-Thermal conductivity detector (Model: Agilent 7890B) for the catalyst 5%Cu-20%MgO-ZrO_2

Before reaction				**After reaction**			
Retention time [min]	**Compound**	**Area [25 µV*s]**	**Norm %**	**Retention time [min]**	**Compound**	**Area [25 µV*s]**	**Norm %**
7.153	CO_2	7519.4	46.07	7.133	CO_2	6465.9	39.62
11.981	H_2	72225	49.86	11.981	H_2	62113.5	42.88
15.525	N_2	887.33	4.06	15.542	N_2	1051.64	4.81