

1 **Electronic Supplementary Information: Methane Assisted Catalyst**
2 **Synthesis and Catalytic Conversion of Oleic Acid**

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22 *Keywords: Methane Activation, ZSM-5, Oleic Acid, Dry Gel Conversion, imprinting*

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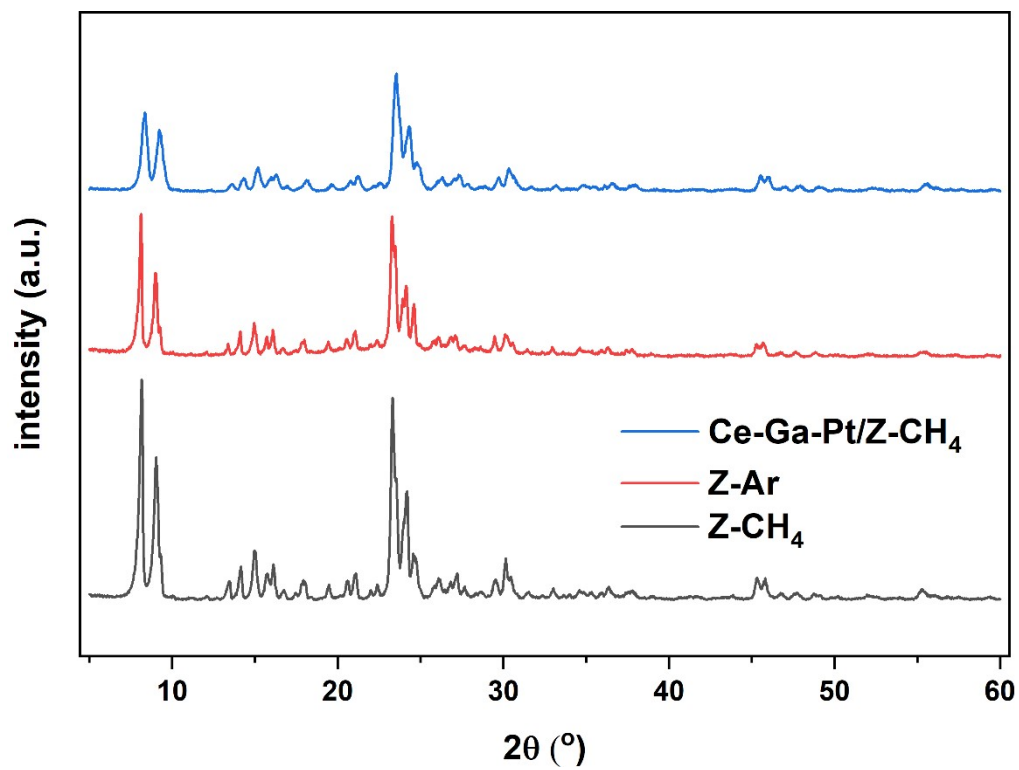
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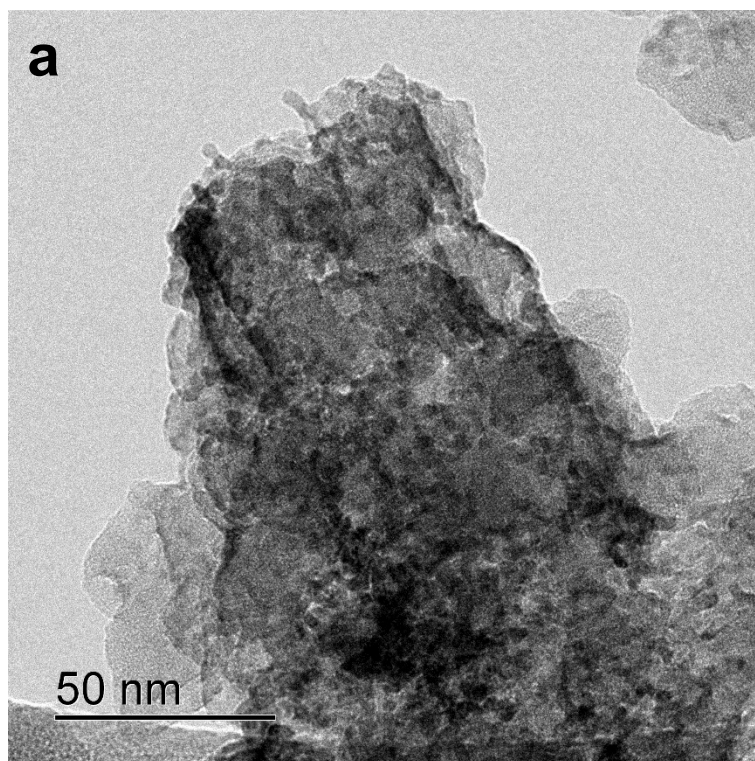
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46 **Figure S1.** XRD patterns of Z-CH₄ (grey), Z-Ar (red), and Ce-Ga-Pt/Z-CH₄ (blue)



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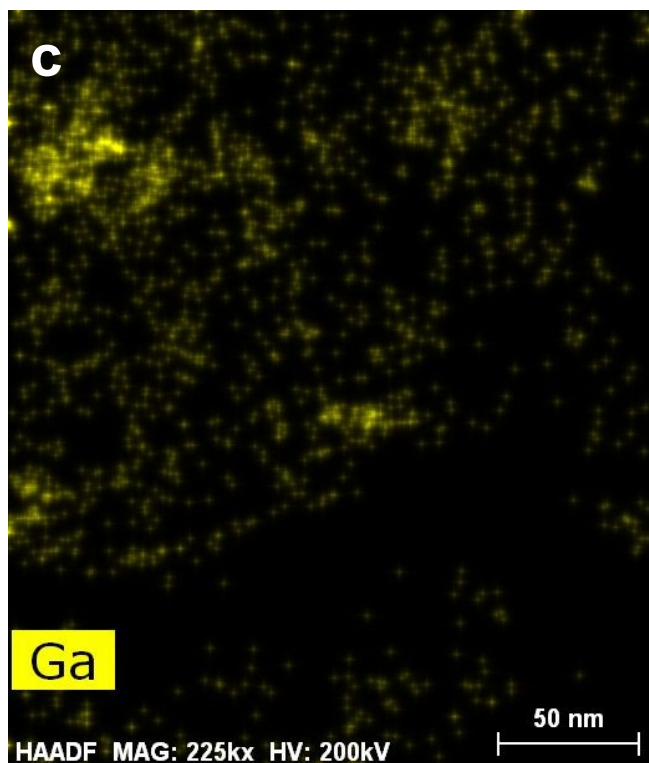
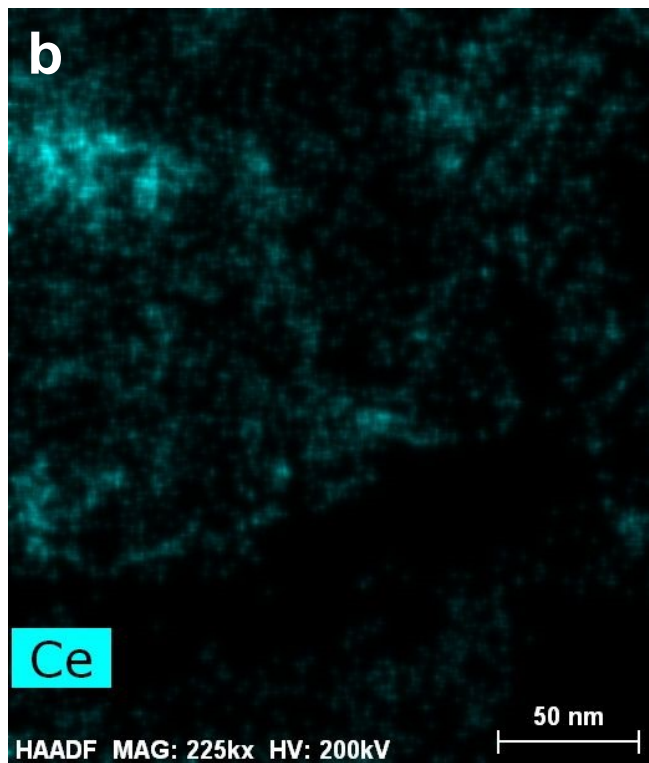
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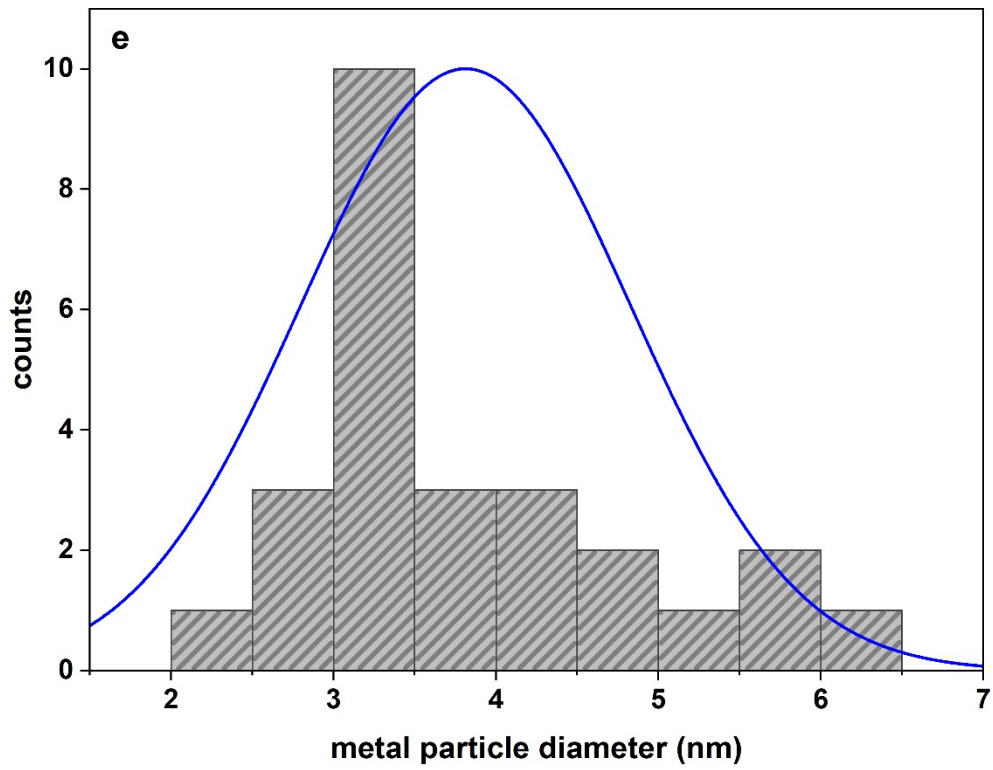
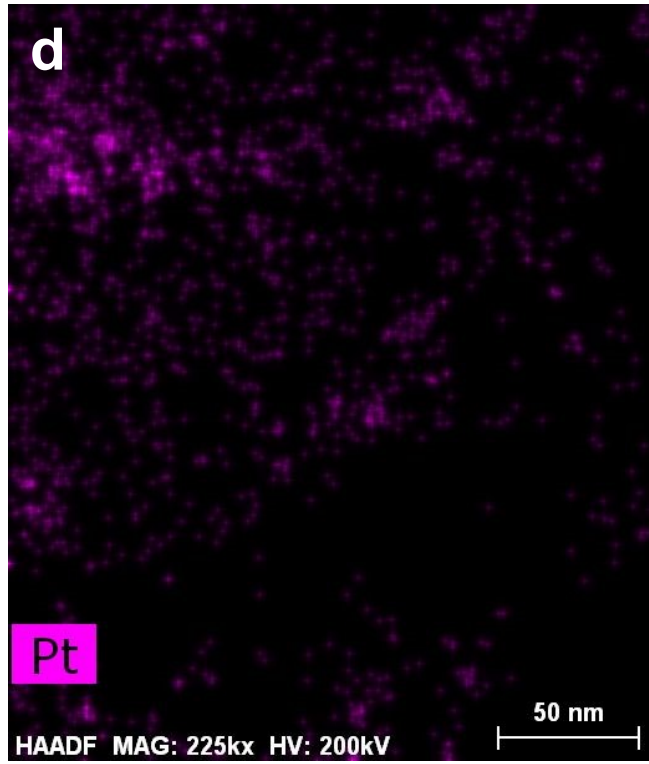
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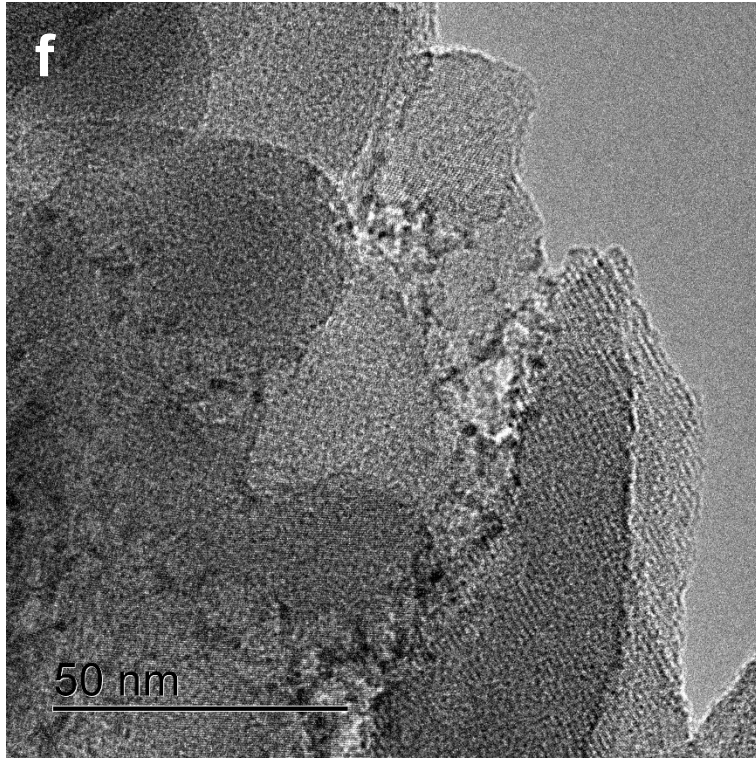
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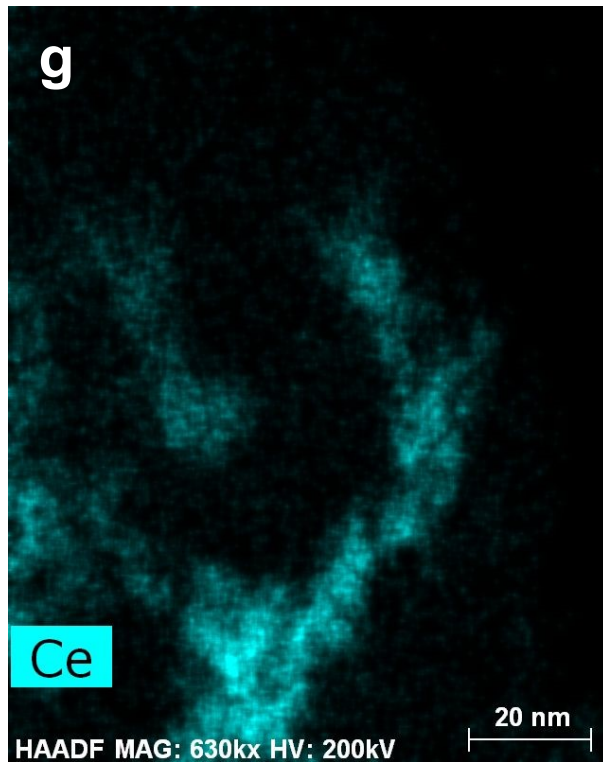
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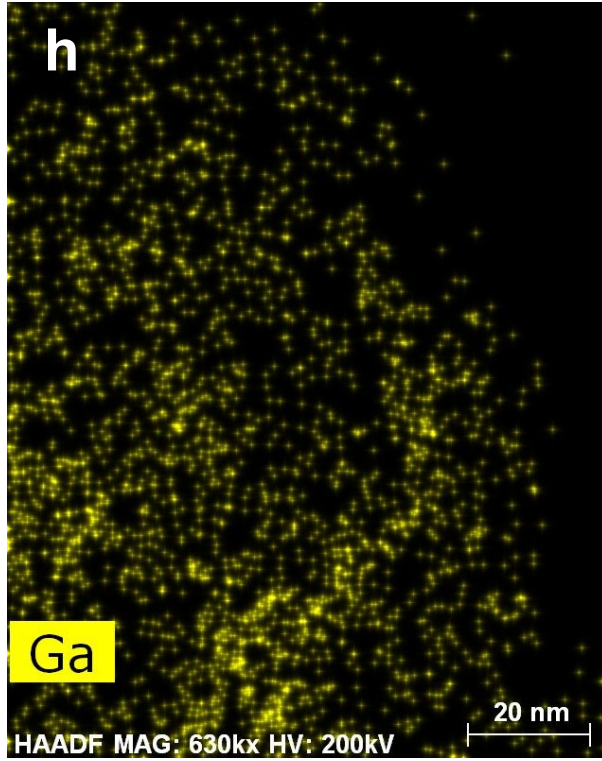
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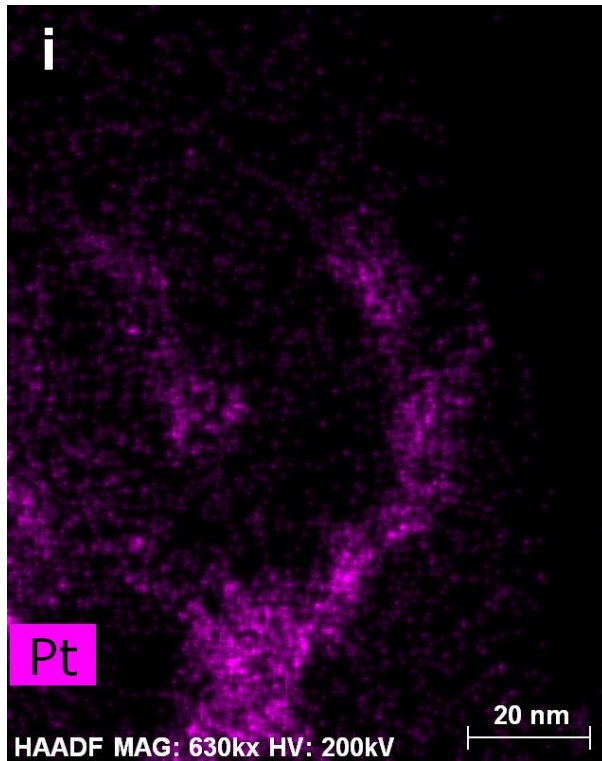
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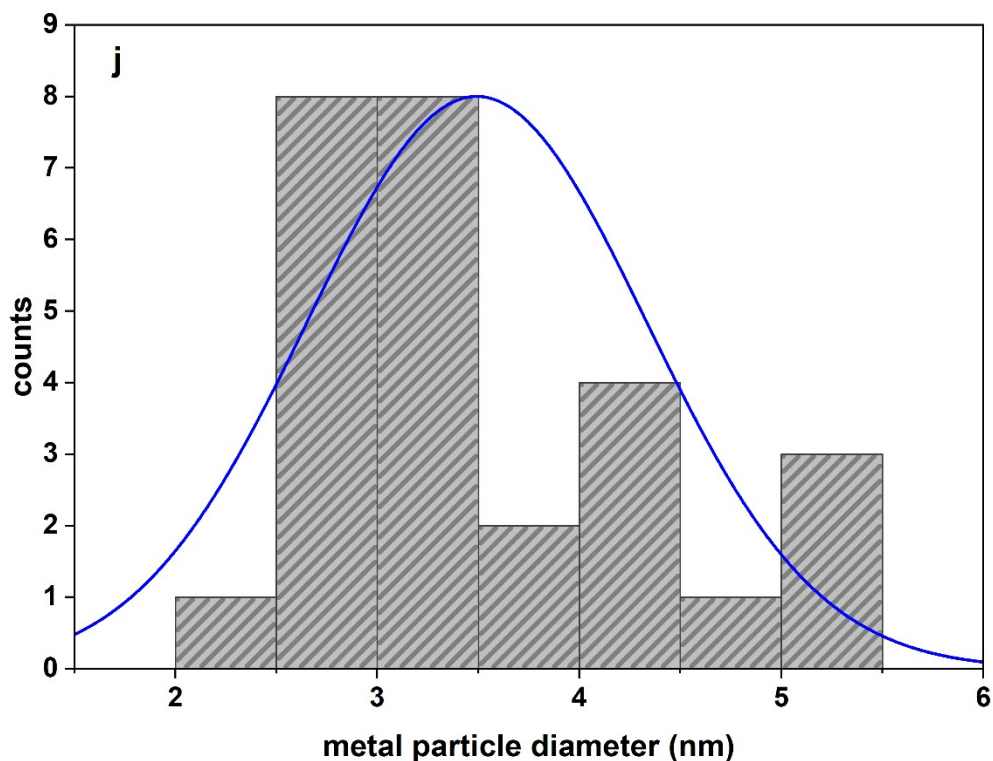
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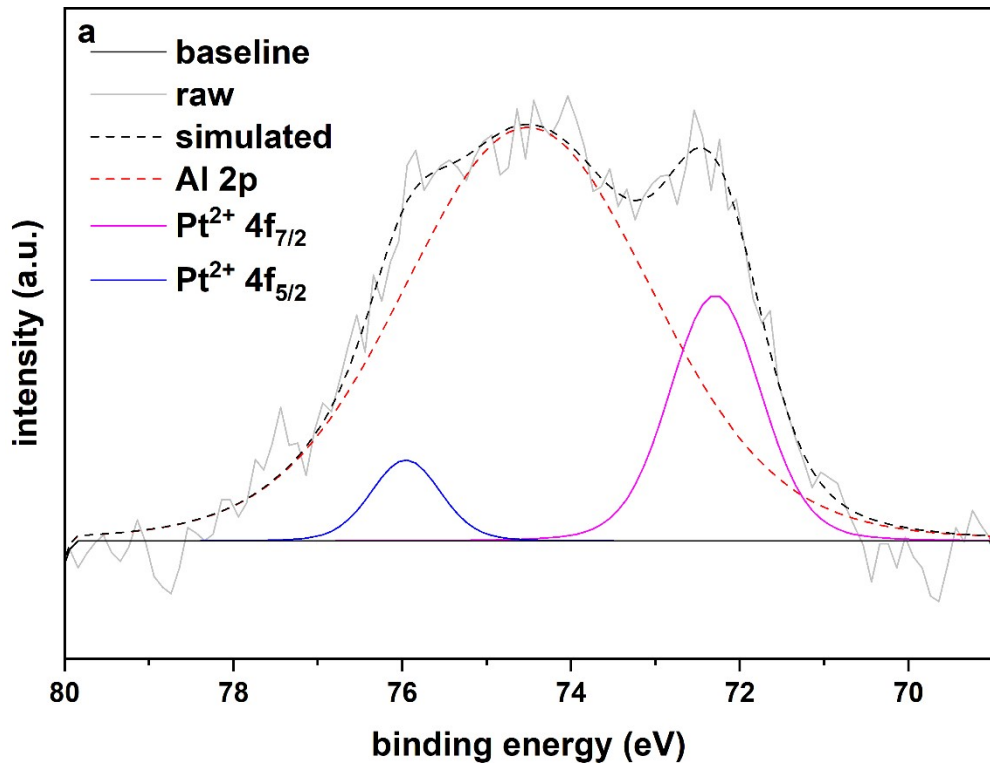
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111 **Figure S2.** (a) High resolution TEM image of 5%Ce-0.5%Ga-0.5%Pt/Z-CH₄ catalyst, (b)
 112 TEM/EDX image of Ce species on 5%Ce-0.5%Ga-0.5%Pt/Z-CH₄ catalyst, (c) TEM/EDX image of
 113 Ga species on 5%Ce-0.5%Ga-0.5%Pt/Z-CH₄ catalyst, (d) TEM/EDX image of Pt species on
 114 5%Ce-0.5%Ga-0.5%Pt/Z-CH₄ catalyst, (e) distribution of metal particles on 5%Ce-0.5%Ga-
 115 0.5%Pt/Z-CH₄ catalyst. (f) High resolution TEM image of 5%Ce-0.5%Ga-0.5%Pt/Z-Ar catalyst, (g)
 116 TEM/EDX image of Ce species on 5%Ce-0.5%Ga-0.5%Pt/Z-Ar catalyst, (h) TEM/EDX image of
 117 Ga species on 5%Ce-0.5%Ga-0.5%Pt/Z-Ar catalys, (i) TEM/EDX image of Pt species on 5%Ce-
 118 0.5%Ga-0.5%Pt/Z-Ar catalyst, (j) distribution of metal particles on 5%Ce-0.5%Ga-0.5%Pt/Z-Ar
 119 catalyst.

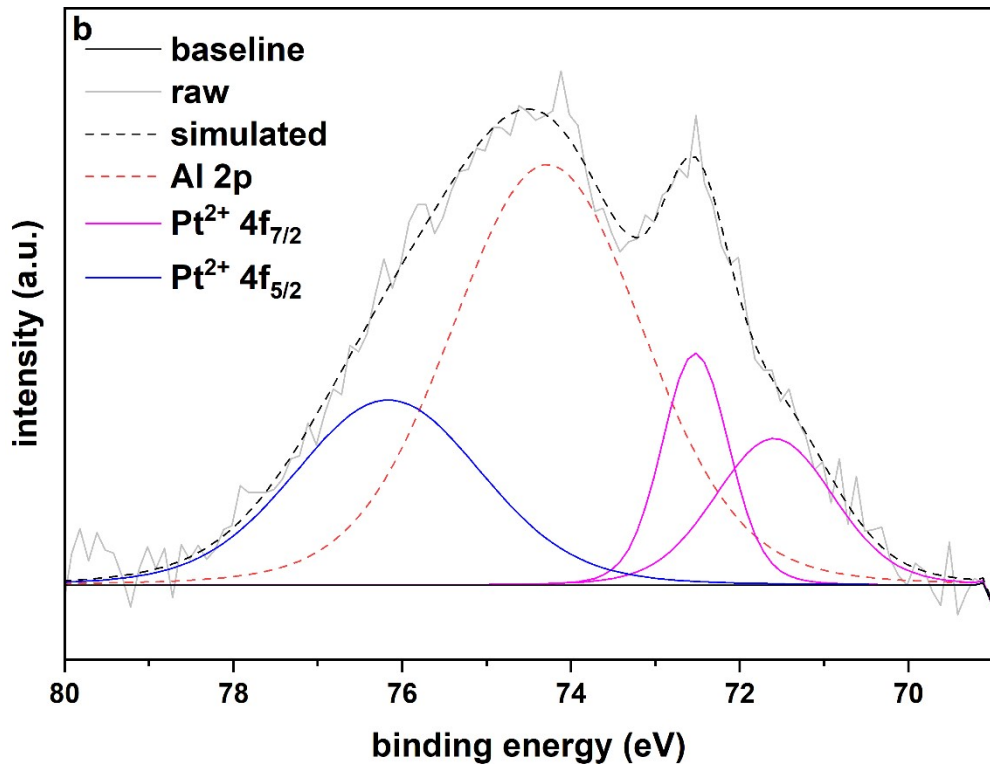
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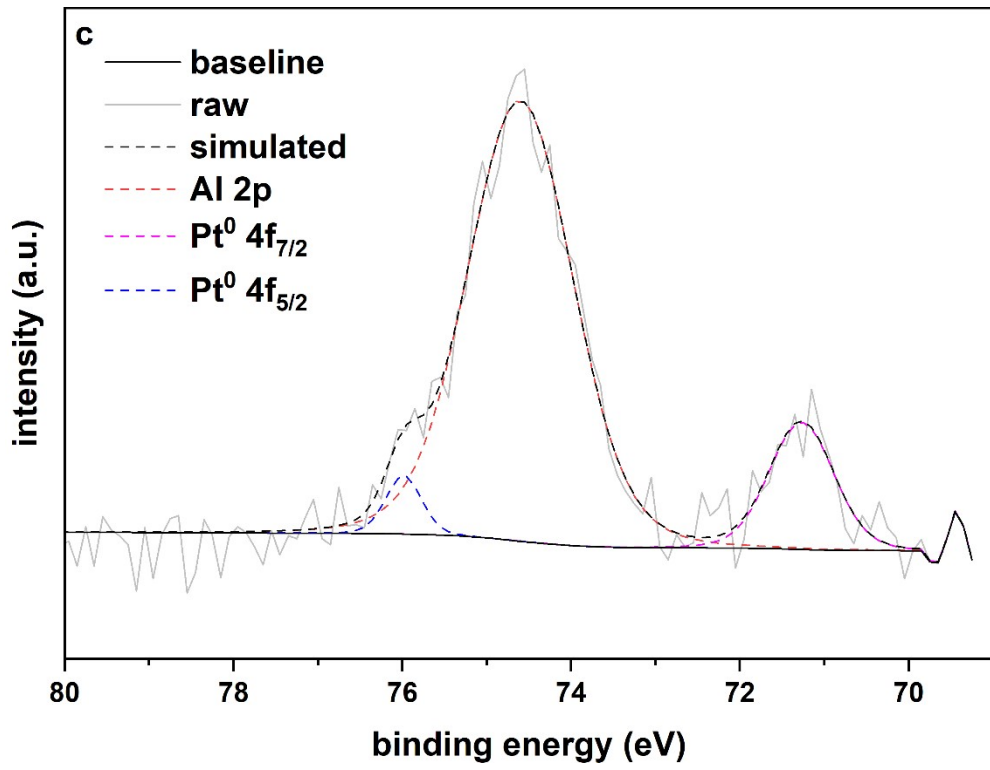


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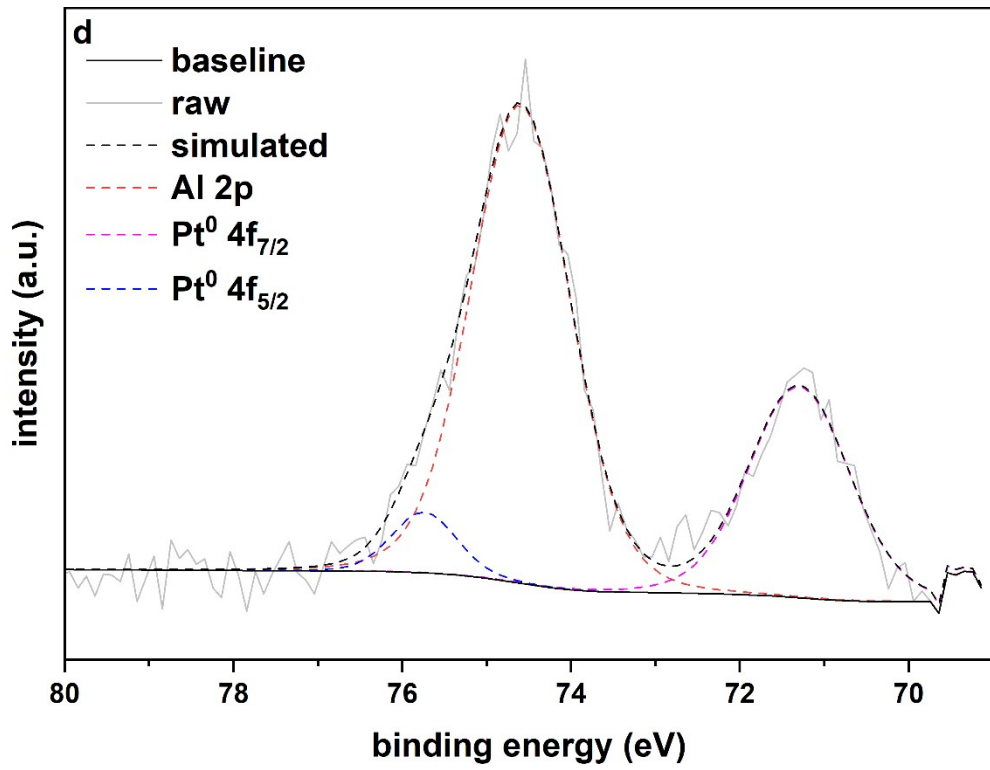


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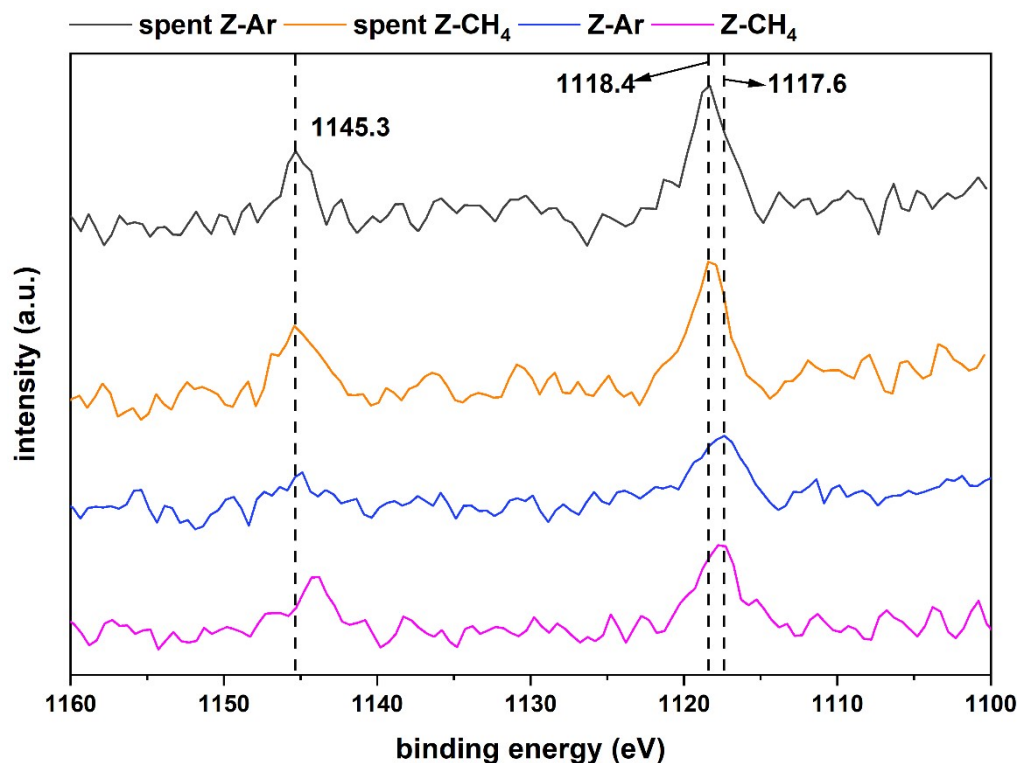
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129 **Figure S3.** (a) XPS spectrum of the Pt4f region of the fresh 5%Ce-0.5%Ga-0.5%Pt/Z-CH₄
130 catalyst, (b) the fresh 5%Ce-0.5%Ga-0.5%Pt/Z-Ar catalyst, (c) the spent 5%Ce-0.5%Ga-
131 0.5%Pt/Z-CH₄ catalyst, (d) the spent5%Ce-0.5%Ga-0.5%Pt/Z-Ar catalyst.



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133 **Figure S4.** XPS spectrum of the Ga2p region of the fresh 5%Ce-0.5%Ga-0.5%Pt/Z-CH₄ catalyst
134 (magenta), the fresh 5%Ce-0.5%Ga-0.5%Pt/Z-Ar catalyst (blue), the spent 5%Ce-0.5%Ga-
135 0.5%Pt/Z-CH₄ catalyst (orange), and the spent 5%Ce-0.5%Ga-0.5%Pt/Z-Ar catalyst (grey).

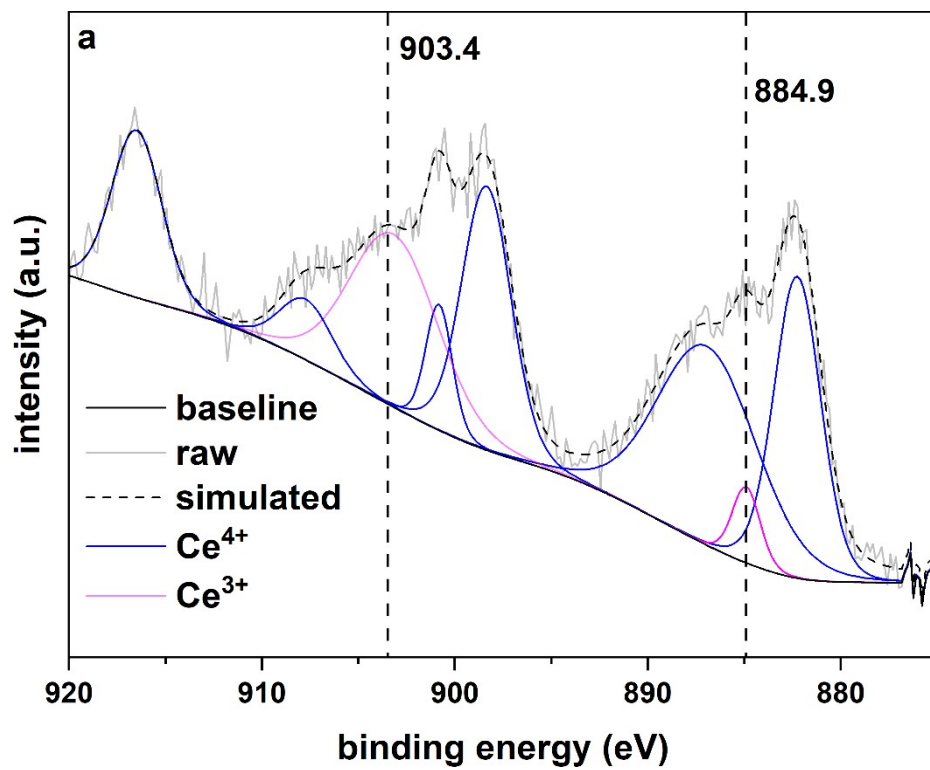
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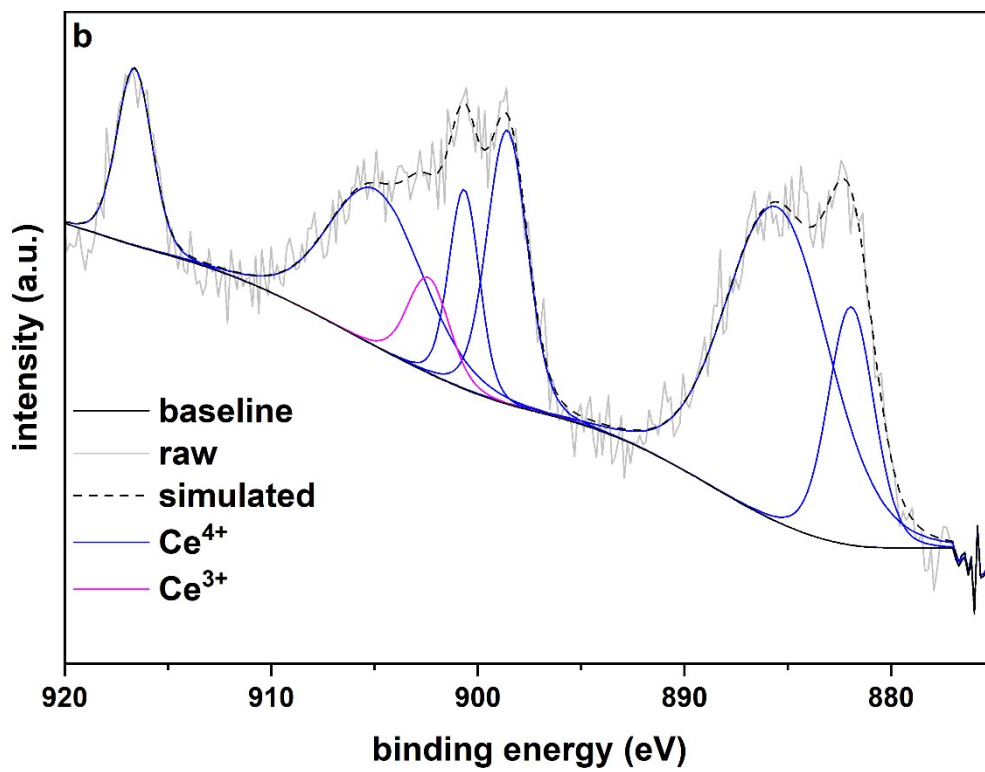
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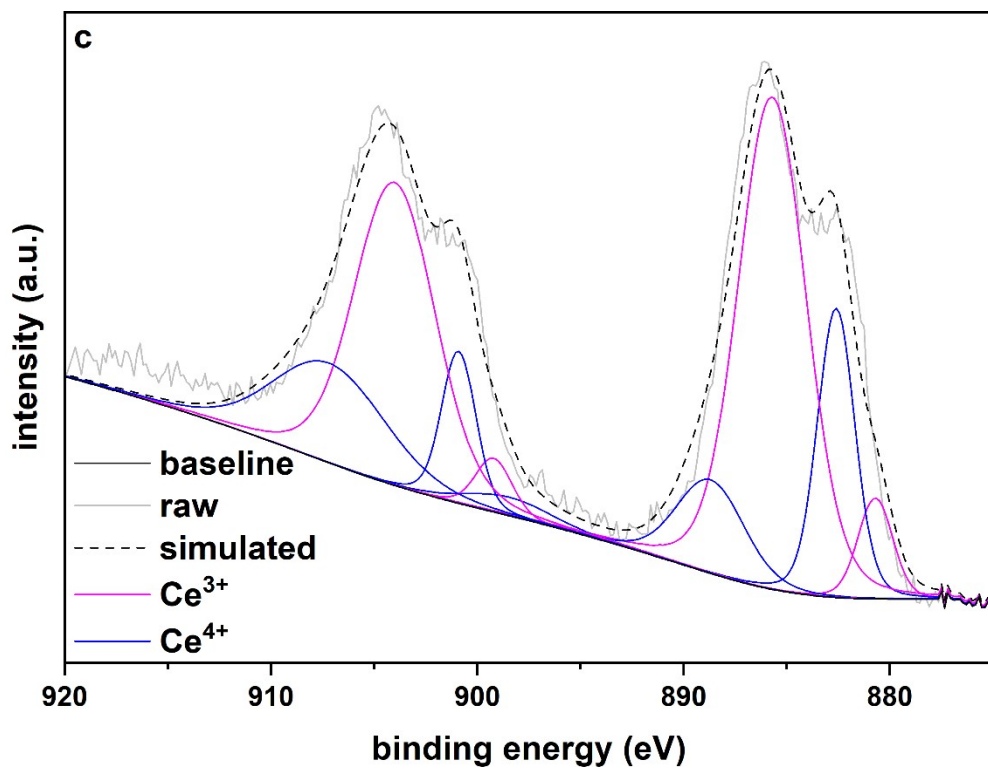
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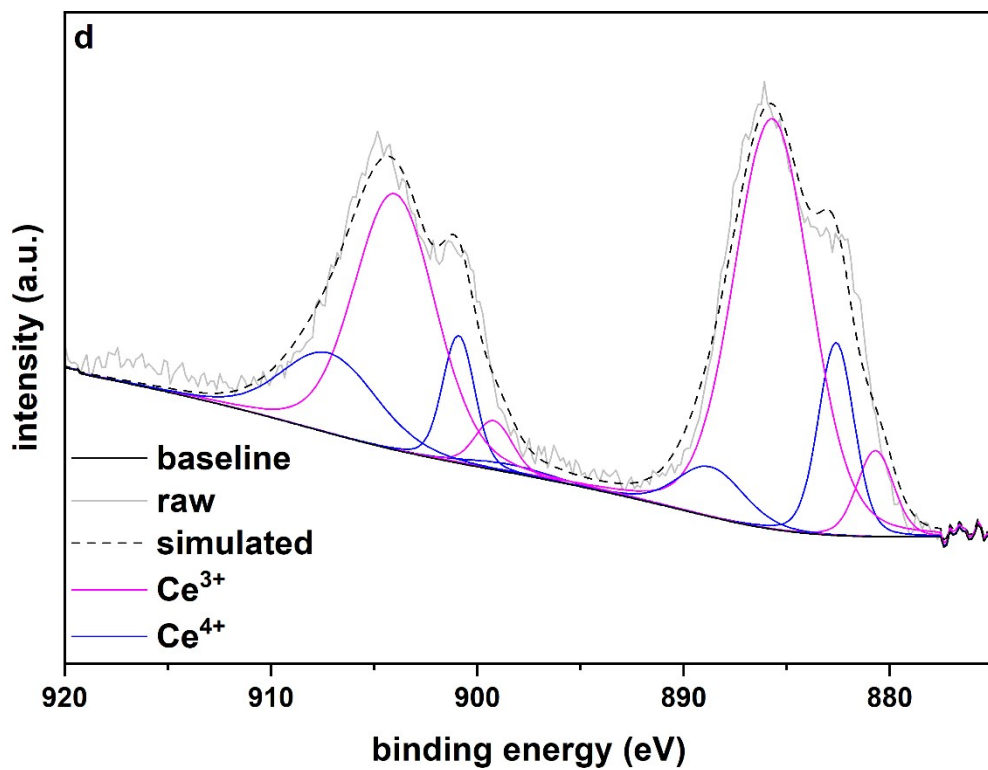
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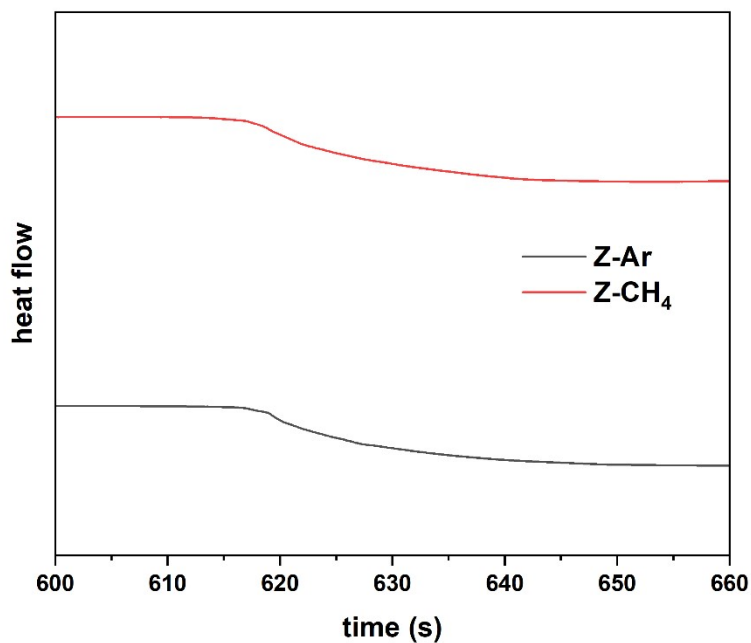
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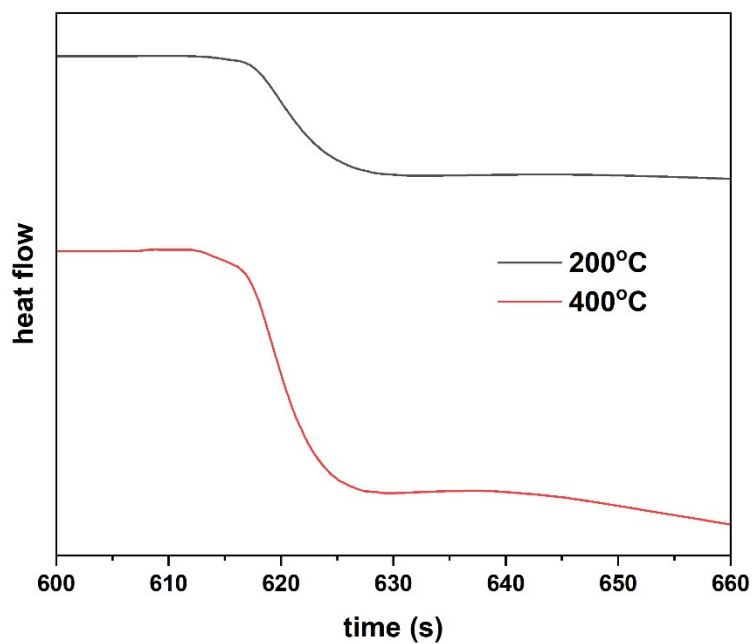
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146 **Figure S5.** (a) XPS spectrum of the Ce3d region of the fresh 5%Ce-0.5%Ga-0.5%Pt/Z-CH₄
147 catalyst, (b) the fresh 5%Ce-0.5%Ga-0.5%Pt/Z-Ar catalyst, (c) the spent 5%Ce-0.5%Ga-
148 0.5%Pt/Z-CH₄ catalyst, (d) the spent5%Ce-0.5%Ga-0.5%Pt/Z-Ar catalyst.



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150 **Figure S6.** TGA-DSC methane probe of 5%Ce-0.5%Ga-0.5%Pt/Z-Ar and 5%Ce-0.5%Ga-
151 0.5%Pt/Z-CH₄ catalysts at 25°C.



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153 **Figure S7.** TGA-DSC methane probe of empty (no catalyst) pan at 200°C (black) and 400°C
 154 (red).

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158 **Table S1.** N₂ physisorption data for catalysts.

<i>Catalyst</i>	<i>BET surface area</i> (m ² /g)	<i>External surface</i> <i>area</i> (m ² /g)	<i>Micropore area</i> (m ² /g)	<i>Micropore</i> <i>volume</i> (cm ³ /g)	<i>Total pore</i> <i>volume</i> (cm ³ /g)	<i>Average pore</i> <i>diameter</i> (nm)
Z-CH₄	403.52	136.94	266.58	0.14	0.45	4.48
Z-Ar	369.55	115.59	253.95	0.13	0.27	2.88
Ce-Ga-Pt/Z-CH₄	312.78	156.80	155.98	0.08	0.45	5.73

Ce-Ga-Pt/Z-Ar	371.15	129.09	242.06	0.13	0.31	3.35
Ce-Ga-Pt/Z-CH₄ (CH ₄)	204.50	107.14	97.35	0.06	0.32	6.31
Ce-Ga-Pt/Z-Ar (CH ₄)	263.26	94.60	168.66	0.10	0.24	3.58

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160 **Table S2.** ICP-OES data for metal loading of the two supports

Catalyst	Ce loading (wt%)	Pt loading (wt%)	Ga loading (wt%)
Ce-Ga-Pt/Z-CH₄	4.98	0.54	0.56
Ce-Ga-Pt/Z-Ar	4.91	0.53	0.56

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168 **Table S3.** Product distribution data for all reactions

	Ce-Ga- Pt/Z-CH₄	Ce-Ga- Pt/Z-Ar	Ce-Pt/Z- CH₄	Ce-Ga/Z- CH₄	Ga-Pt/Z- CH₄	Ce-Ga-Pt/Z- CH₄ (N₂)	Ce-Ga-Pt/Z- Ar (N₂)
gas yield (wt%)	40.9	40.5	40	41.6	39.3	36.5	37.1

<i>liquid yield</i> (wt%)	57.03	57.03	57.87	57	58.73	56.6	57.5
<i>solid yield</i> (wt%)	2.8	3.2	2.6	2.3	3.2	6.1	4.7
<i>CH₄ conversion</i> (wt%)	3.2	2.1	1.6	3	2.8		
<i>mass balance</i>	100.7	100.7	100.5	100.9	101.3	99.2	99.3
<i>H₂</i>	0.3	0.2	0.2	0.1	0.2	0.1	0.1
<i>=(C₂-C₅)=</i>	6.6	10.9	9.1	5.4	10.5	12.6	12.5
<i>-(C₂-C₅)-</i>	19.1	17.4	16.5	20.1	16.4	8	10
<i>CO</i>	2.2	2.9	2	4.2	1.9	6.5	6
<i>CO₂</i>	12.6	9.2	12.2	11.9	10.4	8.0	7.3
<i>CH₄</i>						1.2	1.2
<i>paraffins</i>	2.4	3.6	5.1	6.1	6.4	2.9	2.1
<i>PAH</i>	1.1	2.6	1.6	1.5	2	5	5.6
<i>aromatics</i>	50.8	44.6	46.9	43.5	45.2	40	39.6
<i>olefins</i>	0.9	2.4	1.2	0.6	0.9	4.9	5
<i>naphthenes</i>	0.9	0.6	1.8	3.7	2.9	1.7	1.9
<i>water</i>	0.7	2.7	1.2	1.2	1.1	1.5	2.3
<i>oxygenates</i>	0.3	0.5	0.2	0.4	0.2	0.7	0.9
<i>benzene</i>	3.4	4.4	5.5	4.1	4.6	4	2.7
<i>toluene</i>	40.1	26.8	36.8	40.7	41.2	38.9	28.7
<i>EB</i>	7.8	5.8	5.5	5.6	7.9	6.7	9

<i>xylene</i> s	16.8	22.6	18.3	17.1	20.2	19.1	24
<i>C</i> ₉ aromatics	21.2	24.8	22.4	15.9	16.9	19	28
<i>C</i> ₁₀ aromatics	10.7	15.6	11.5	16.5	9.2	12.4	7.5
<i>CO</i> ₂ (mmol)	5.2	4.2	5.2	4.8	4.3	3.3	3
<i>CO</i> (mmol)	0.7	0.9	0.5	1.3	0.6	2.1	1.9
<i>other</i> (mmol)	0.5	1.3	0.7	0.2	1.5	1	1.5

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170 *All values are given as total selectivity in wt% unless mmol, yield, mass balance, and CH₄

171 conversion are specified.