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## Supplementary Information

### Low Temperature Selective Oxidation of Methane using Gold-Palladium Colloids

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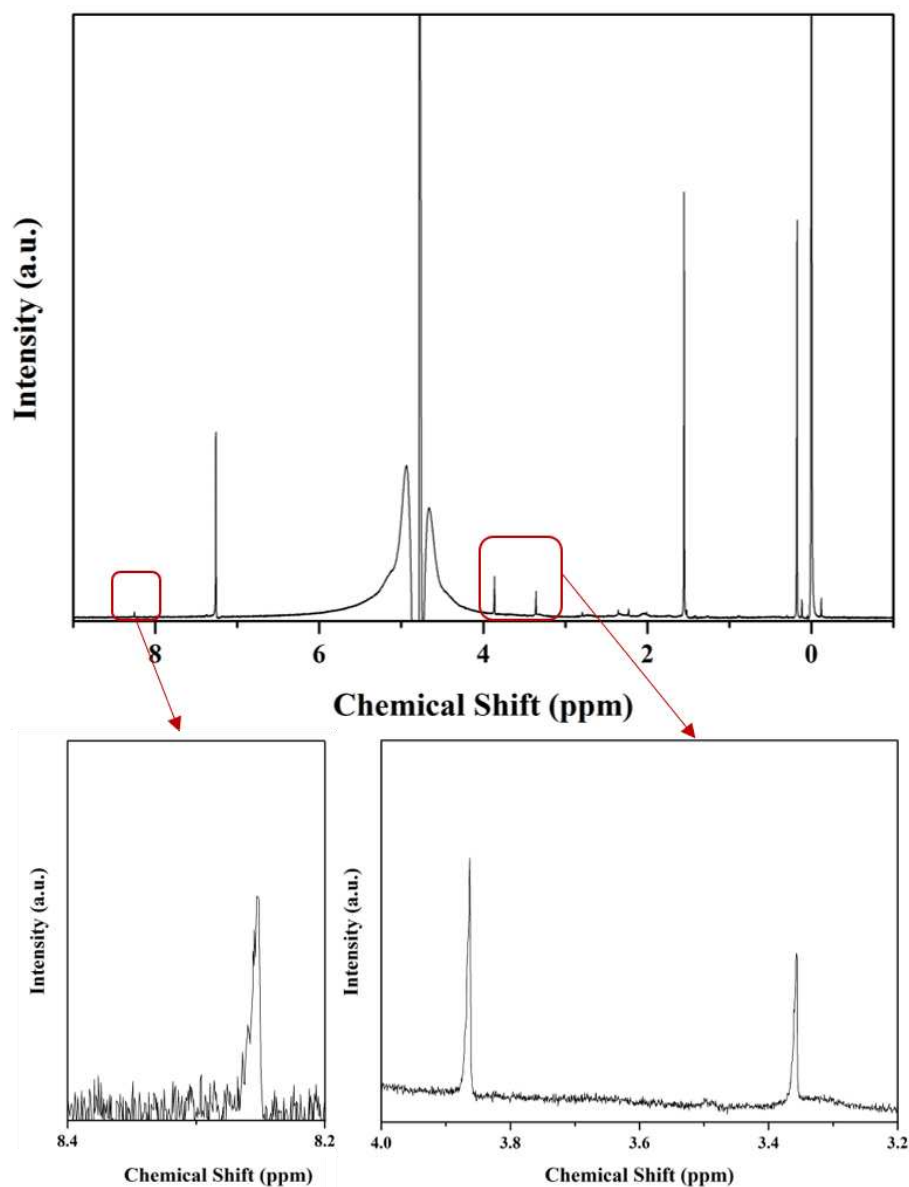
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**Figure S1** –  $^1\text{H}$ -NMR spectrum obtained from a typical reaction mixture.

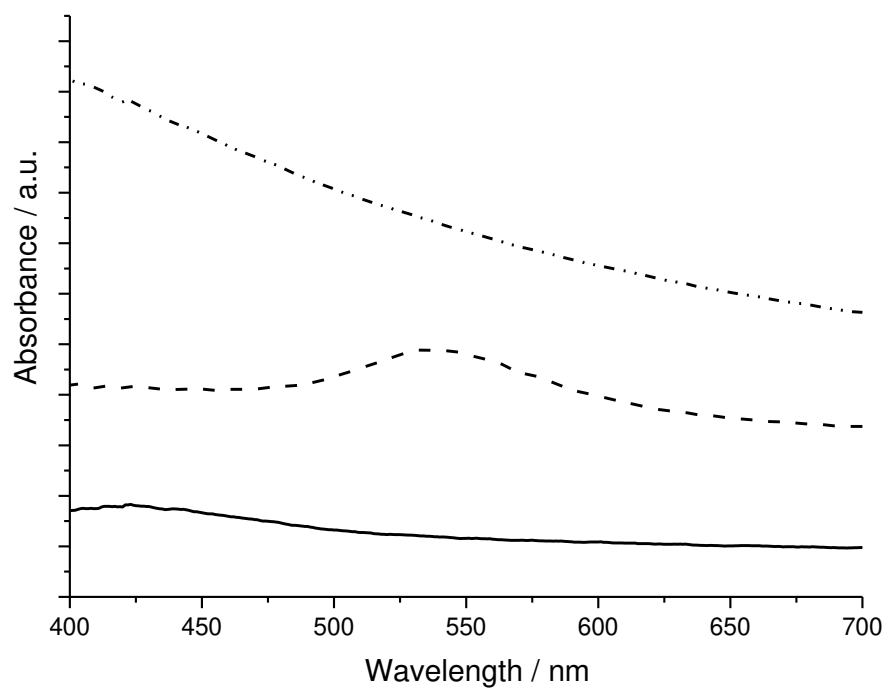


The oxygenated species identified were methylhydroperoxide (s,  $\delta=3.9$ ) and methanol (s,  $\delta=3.4$ ) shown in the zoomed inset along with formic acid (s,  $\delta=8.4$ ). The relative intensities in insets are arbitrarily shown. The other signals present corresponds to tetramethylsilane (s,  $\delta=0$ ),  $\text{CHCl}_3$  (s,  $\delta=7.3$ ),  $\text{H}_2\text{O}$  in  $\text{CDCl}_3$  (s,  $\delta=1.5$ ) and dissolved  $\text{CH}_4$  (s,  $\delta=0.2$ ).

**Table S1** Liquid phase oxygenated products analysed by  $^1\text{H}$ -NMR for methane oxidation.

Species	Abbreviation	$\delta/\text{ppm}$
Methanol	$\text{CH}_3\text{OH}$	3.35, s
Methyl hydroxyperoxide	$\text{CH}_3\text{OOH}$	3.9, s
Formic acid	$\text{HCOOH}$	8.4, s

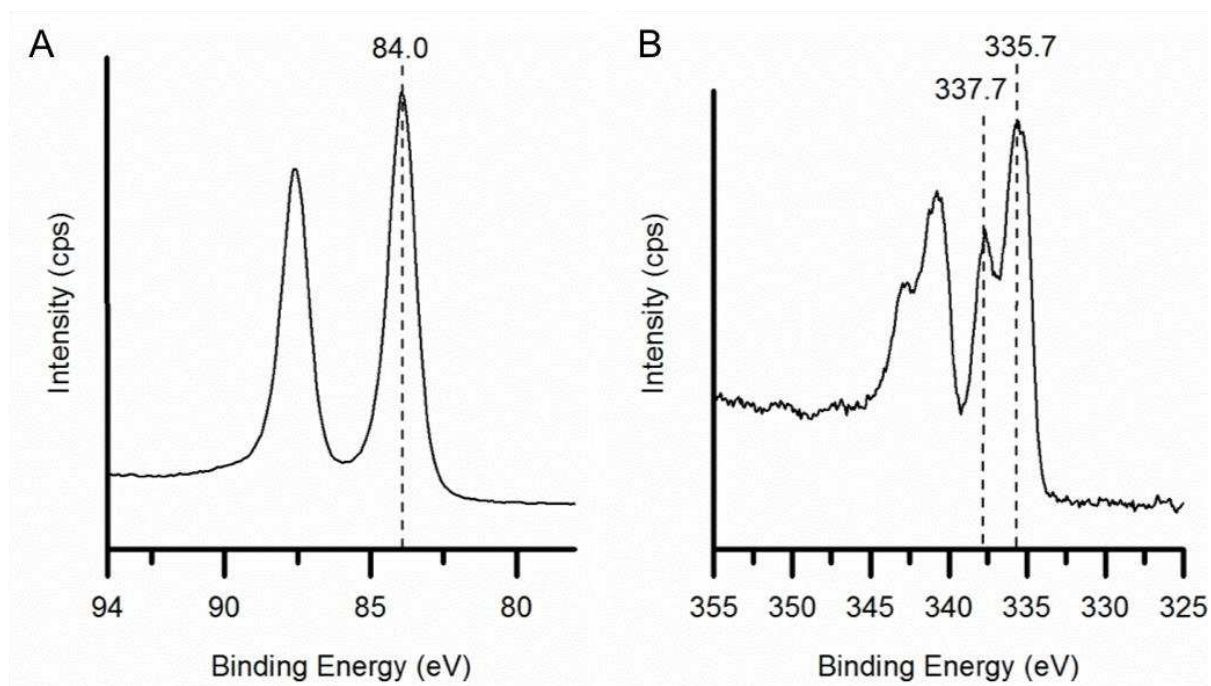
**Figure S2** – UV-vis spectrometry of Au-only, Pd-only and Au-Pd colloids



*Key:* Solid line – palladium-only colloid, dashed line – gold-only colloid, dashed/dotted line – gold/palladium colloid.

*All colloids:* PVP (10kDa) : Metal = 1.2 : 1, Au : Pd = 1:1 molar, [metal] =  $7.57 \times 10^{-4}$  M.

**Figure S3** – XPS spectra of monometallic (A) Au(4f) for Au colloid, (B) Pd(3d) for Pd colloid,



**Table S2** – Re-usability of the Au-Pd -PVP colloid over multiple reaction cycles

Entry	Time	Amount of Product ( $\mu\text{mol}$ )				Oxygenate Selectivity (%)	MeOH Selectivity (%)	Productivity ( $\text{mol kg}^{-1}_{\text{cat}} \text{h}^{-1}$ )	TOF ( $\text{h}^{-1}$ )	$\text{H}_2\text{O}_2$ used/ products generated
		$\text{CH}_3\text{OH}$	$\text{CH}_3\text{OOH}$	$\text{HCOOH}$	$\text{CO}_2$					
1	1 x 10	2.14	4.43	2.14	1.31	87	21.4	52.6	7.8	80
2	2 x 10	2.86	4.00	9.29	3.65	82	14.4	51.9	7.6	100

*Reaction Conditions;* 1000  $\mu\text{mol}$   $\text{H}_2\text{O}_2$ , 50  $^\circ\text{C}$ , total volume 10 ml, 30 bar, 1500 rpm, 7.57  $\mu\text{mol}$  metal per reaction.

*Colloid;* Au: Pd = 1:1 molar,  $[\text{metal}] = 7.57 \times 10^{-4} \text{ M}$ .

**Table S3** – Methane oxidation under optimized conditions with Au-Pd colloids with H<sub>2</sub>O<sub>2</sub>

Entry	Catalyst	Amount of Product (μmol)				Oxygenate Selectivity (%)	MeOH Selectivity (%)	Productivity (mol kg <sup>-1</sup> <sub>cat</sub> h <sup>-1</sup> )	TOF (h <sup>-1</sup> )	H <sub>2</sub> O <sub>2</sub> used/ products generated
		CH <sub>3</sub> OH	CH <sub>3</sub> OOH	HCOOH	CO <sub>2</sub>					
1	Au-Pd colloid – PVP <sup>a</sup>	2.29	10.86	2.57	1.09	94	14	29.4	4.2	40
2	Au-Pd colloid – PVP <sup>b</sup>	11.00	13.86	9.57	8.11	81	26	74.4	11	110
3	Au-Pd colloid – PVP <sup>c</sup>	0.00	0.00	0.00	0.17	-	-	-	0.06	46

<sup>a</sup> *Reaction condition:* 1000 μmol H<sub>2</sub>O<sub>2</sub>, 50 °C, total volume 10 ml, 30 bar, 0.5 h, 1500 rpm, 7.57 μmol metal per reaction.

<sup>b</sup> *Optimum Condition:* 5000 μmol H<sub>2</sub>O<sub>2</sub>, 60 °C, total volume 10 ml, 40 bar, 0.5 h, 1000 rpm, 7.57 μmol metal per reaction.

<sup>c</sup> *Blank Reaction:* 1000 μmol H<sub>2</sub>O<sub>2</sub>, 50 °C, total volume 10 ml, 30 bar N<sub>2</sub>, 0.5 h, 1500 rpm, 7.57 μmol metal per reaction.

*Colloid; PVP:* metal = 1.2:1, Au: Pd = 1:1 molar, [metal] = 7.57×10<sup>-4</sup> M