Supplementary Information (SI) for RSC Sustainability.

Electronic Supplementary Information

Methane Decomposition by a Ni-Cu-based Hollow-wall-structured Catalyst Prepared by Combined Electroless Plating

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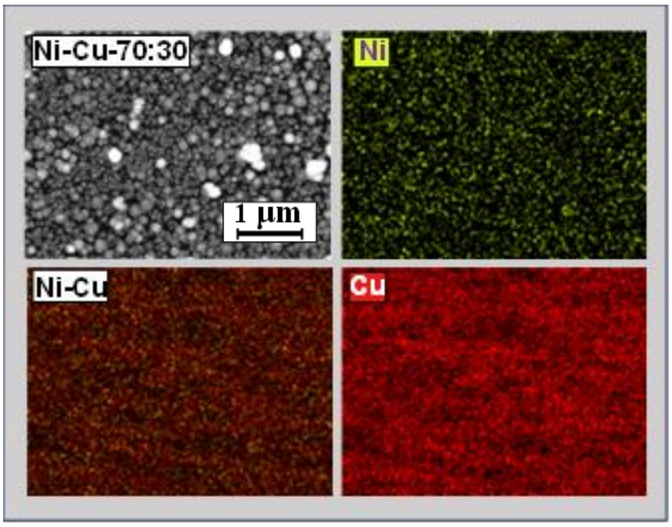

Fig S1: FE-SEM imaging of the Fresh Ni-Cu 70:30 catalyst and Corresponding SEM EDX Elemental mapping of the Ni and Cu along with the Overlap condition of Ni and Cu

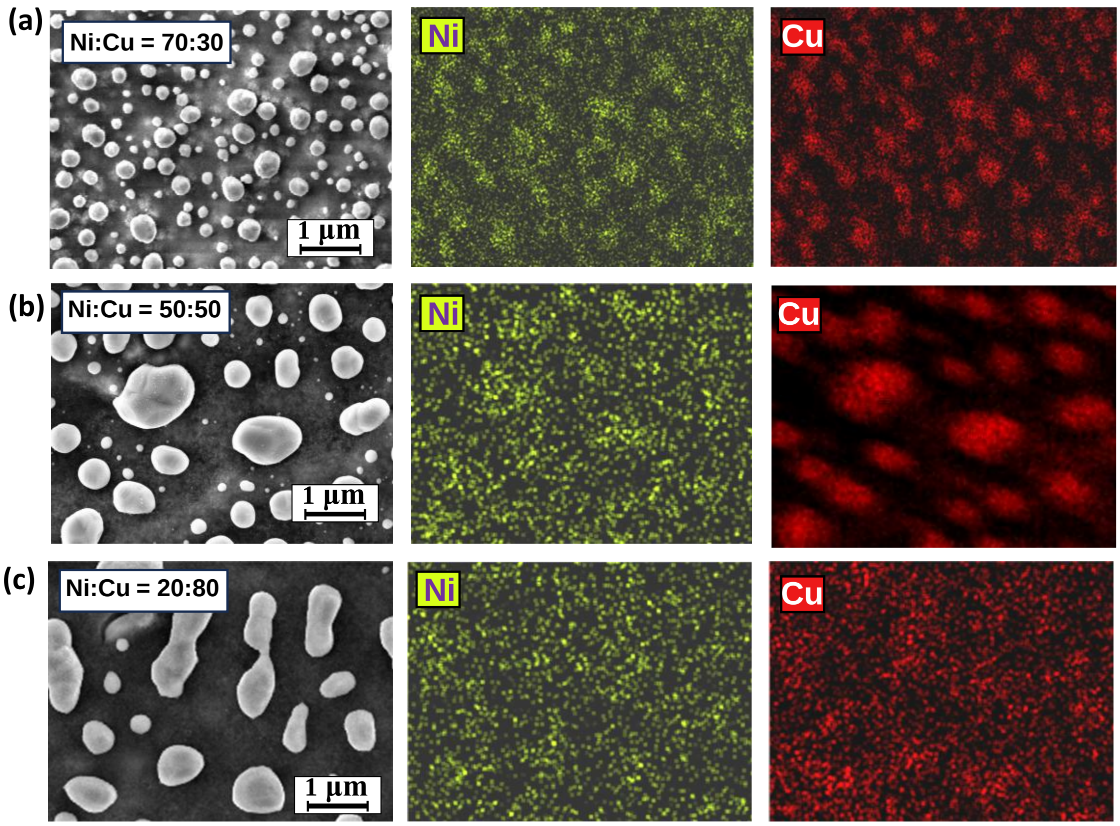

Fig S 2: SEM EDX analysis of the Catalyst Surface as per different Cu plating time.(a) reduced Surface of Ni Cu 70-30 (b) reduced surface of Ni Cu 40-60 (c) Reduecd surface of Ni Cu 20-80

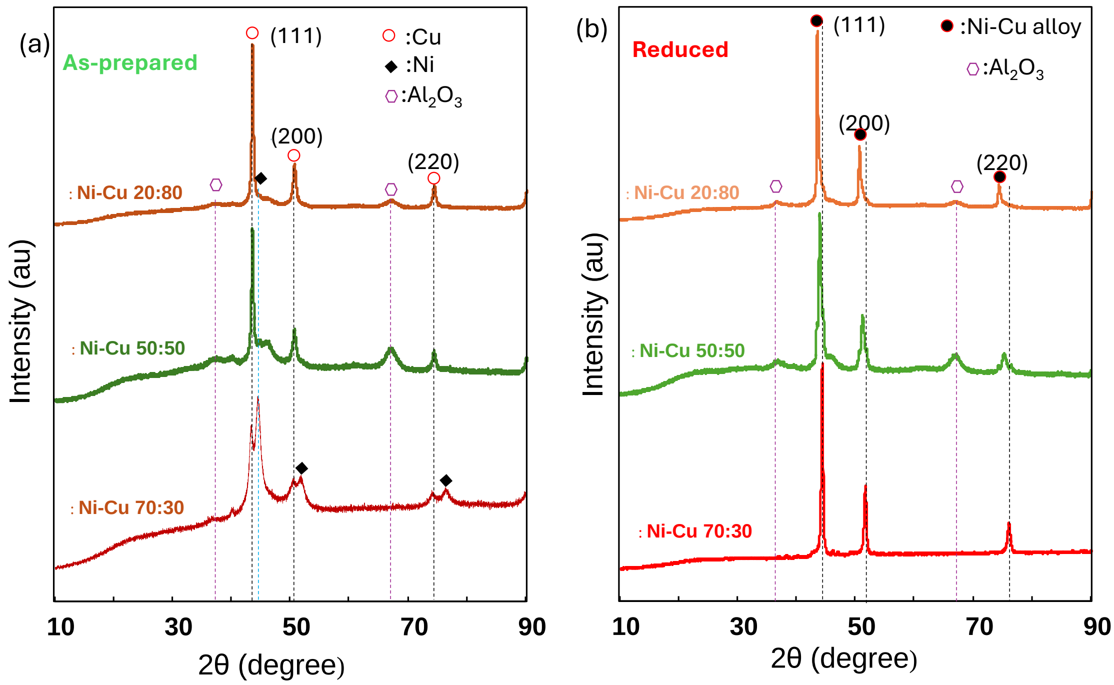

Fig S3: XRD pattern of different composition Ni:Cu catalyst prepared by ELP method (a) resh catalytic surface and surface after the reduction.

The XRD profile of the Ni-Cu ELP-based catalyst reveals significant structural insights. The analysis identified three major peaks—111, 200, and 220—indicative of the hexagonal arrangement, as confirmed through Rietveld refinement. For the 70-30 Ni-Cu composition, distinct peaks for Ni and Cu were observed at all respective positions. However, with increasing Cu content, the intensity of the Ni peaks decreased, signifying a higher presence of Cu in the crystalline planes. Further increases in Cu content resulted in negligible Ni peaks at 111 and their complete absence at 200 and 220, highlighting the dominance of Cu in the structure. Upon reduction, alloying was observed for the 70-30 Ni-Cu composition, with peaks shifting towards the Cu side as the Cu content increased. This shift is attributed to the greater influence of Cu on the crystalline structure in the respective planes. These findings provide crucial insights into the interplay between Ni and Cu, which significantly impacts the catalyst's structural and functional properties.

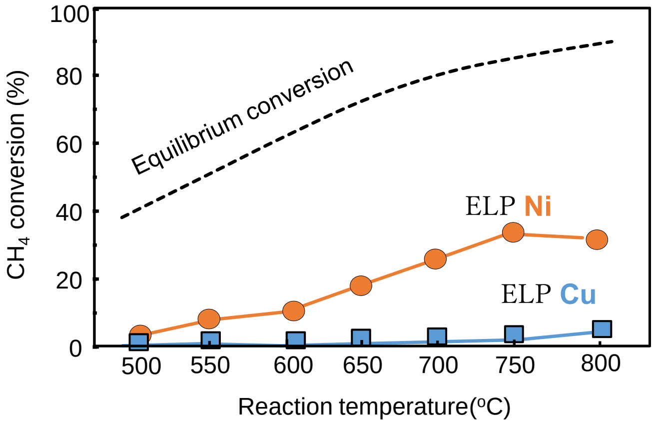

Fig S4: Temperature dependency test of Electroless plating derived metallic nickel and copper from 500–800 °C.

S.N.	ELP Plating time of Ni and Copper	Actual Ni Loading	Actual Copper loading	Used
1	30-7	68	32	70-30
2	30-15	52	48	50-50
3	30-20	47	53	50-50
3	30-45	23<...	77<	20-80

Table 1: XRF analysis of the Actual Ni and cu loading as per the different copper loading time of the Catalyst

The time dependent compositional control was very unreliable in terms of gaining the desired composition. The multiple steps involved in the electroless plating method might be the reason for such behaviour. Both as low as 56% Cu loading has been observed with the 30 min plating sometime as much as 78 %. The pH and Platong bath micro temperature fluctautio n might be some of the phiosio chemical factor that controlling such plating reaction rate is might be due to the uncontrollable initial plating seedlings that initiates the deposition of the different quantity of Cu.

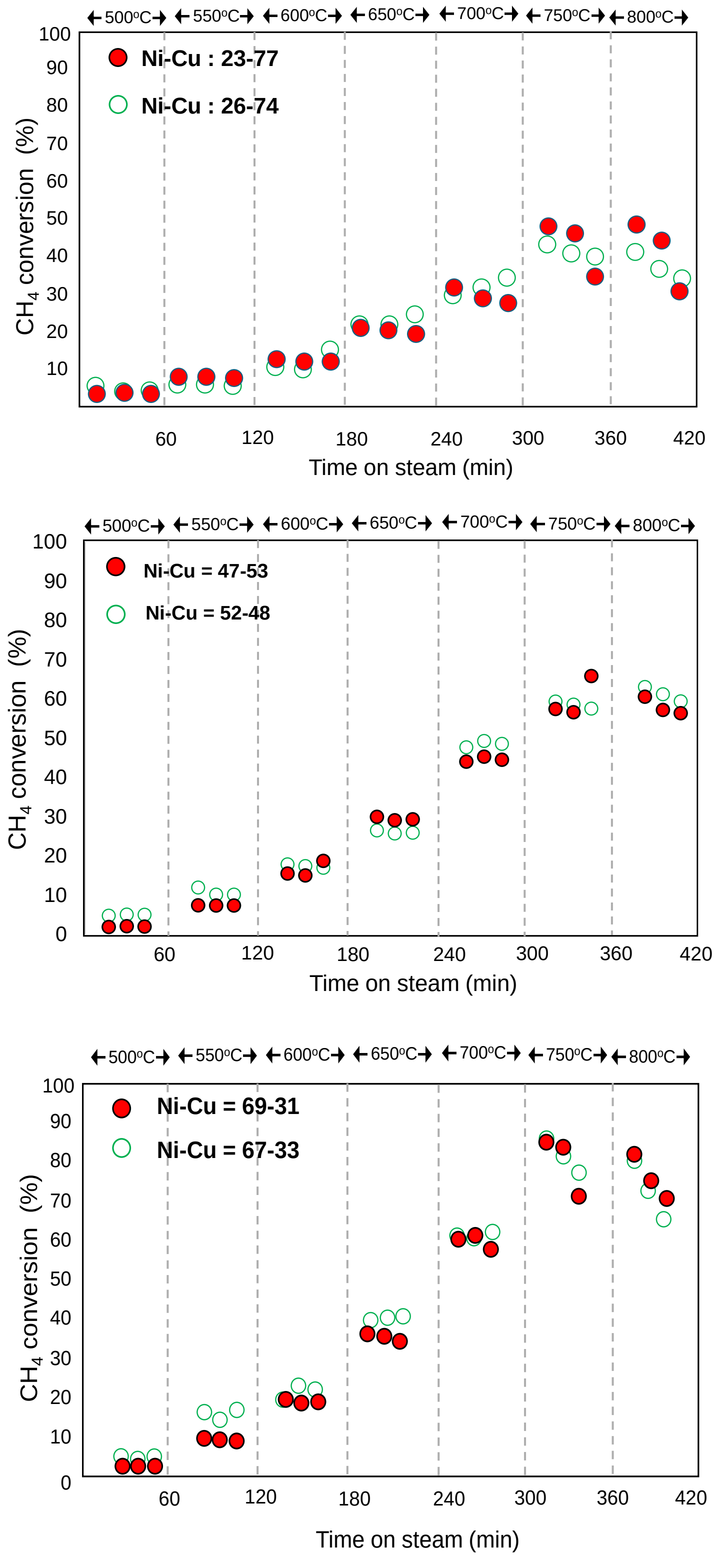

Fig S5: Temperature dependency test performance for the catalyst prepared under similar conditions using the ELP method, with performance evaluated in comparable Cu plating conditions.

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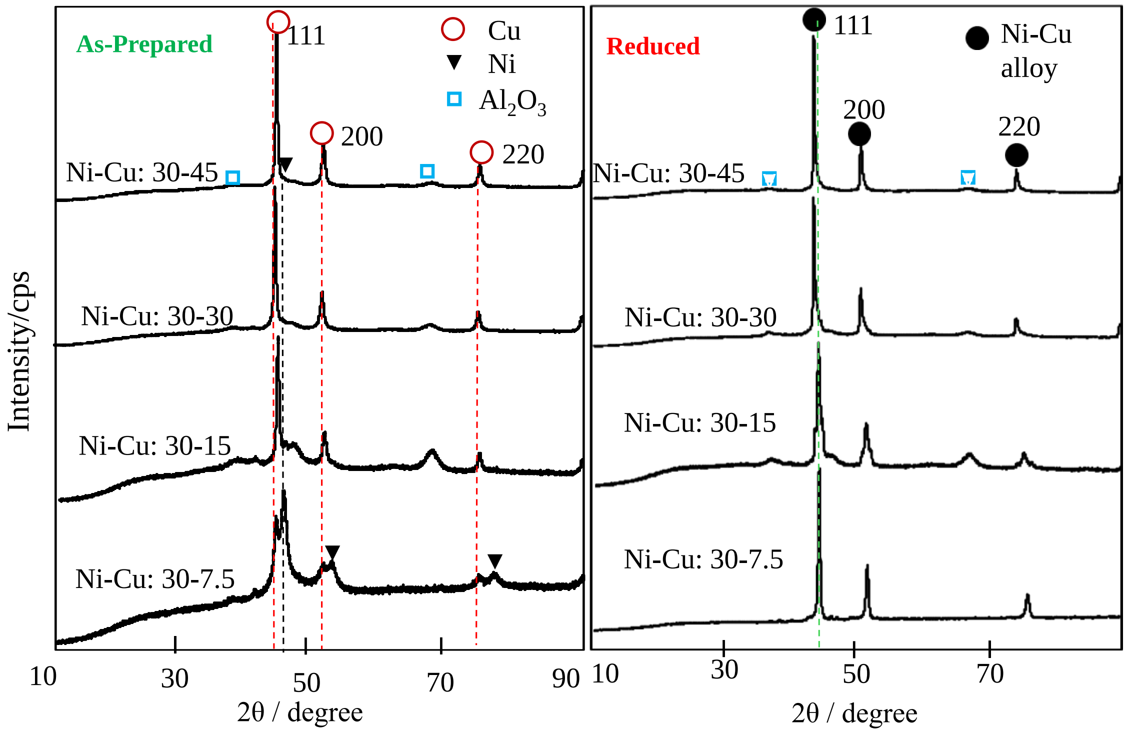

Fig S6 : XRD analysis of the Fresh and Reduced Catalyst at various plating time .

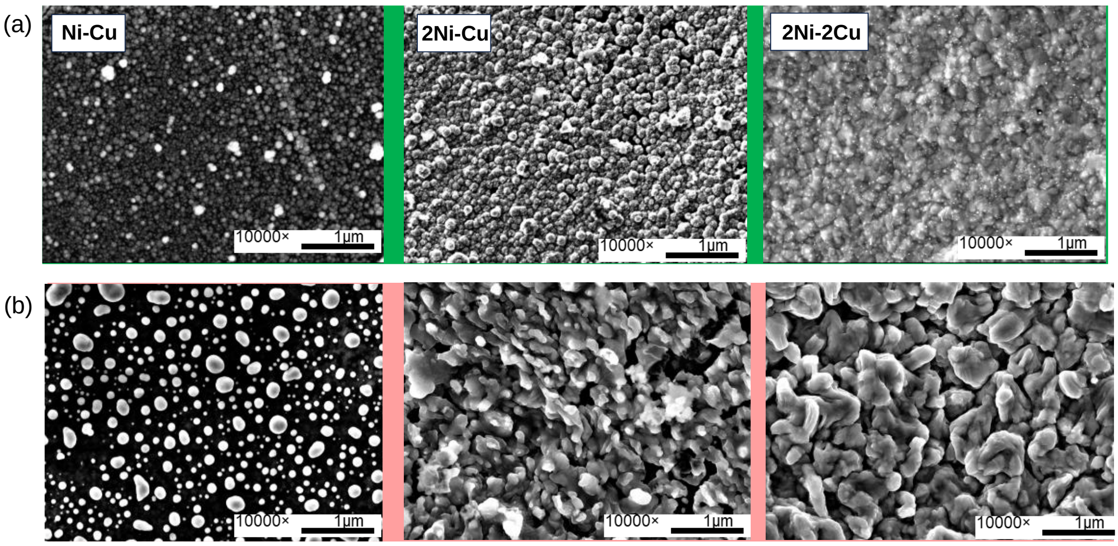

Fig S7: FE-SEM surface morphology upon changing the plating solution concentration (a) As prepared catalyst surface (b) Reduced catalyst surface.

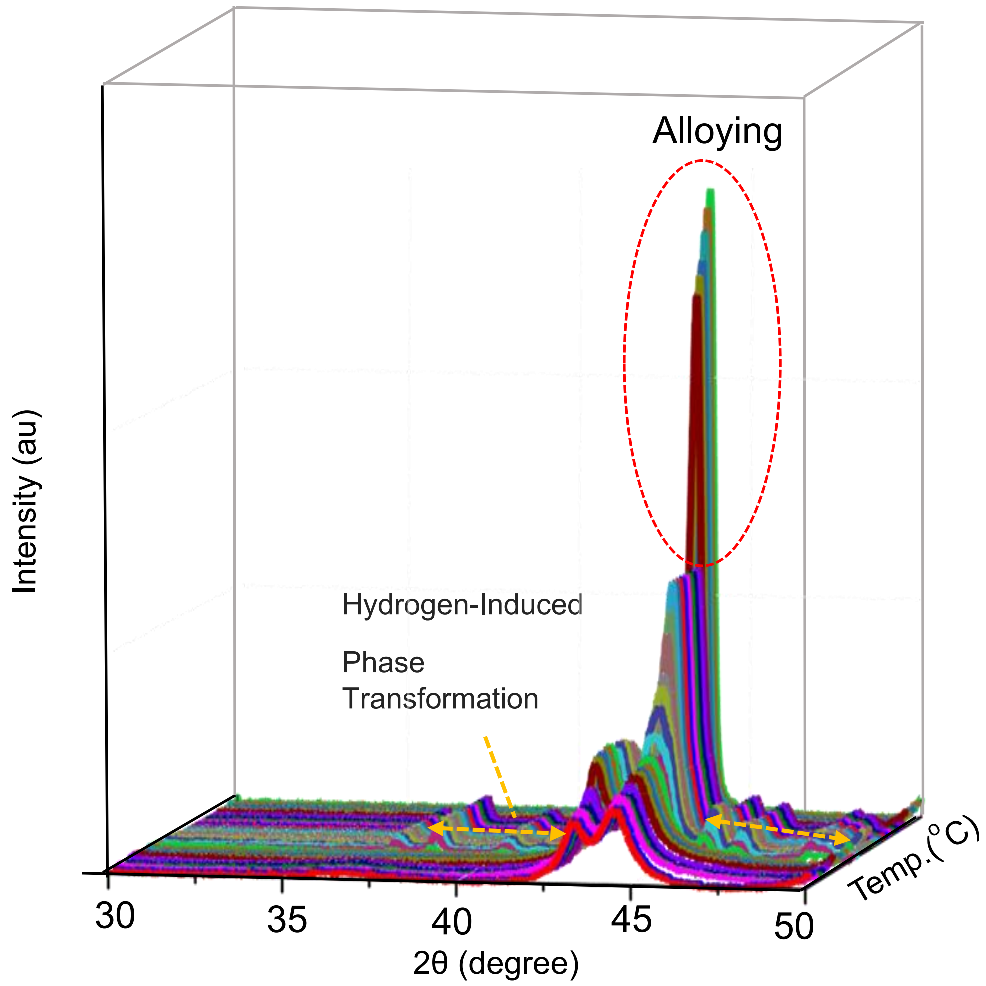

Fig S8: Detailed in situ XRD plotting was conducted from room temperature up to 700 °C, providing insights into phase transitions and structural evolution within this temperature range.

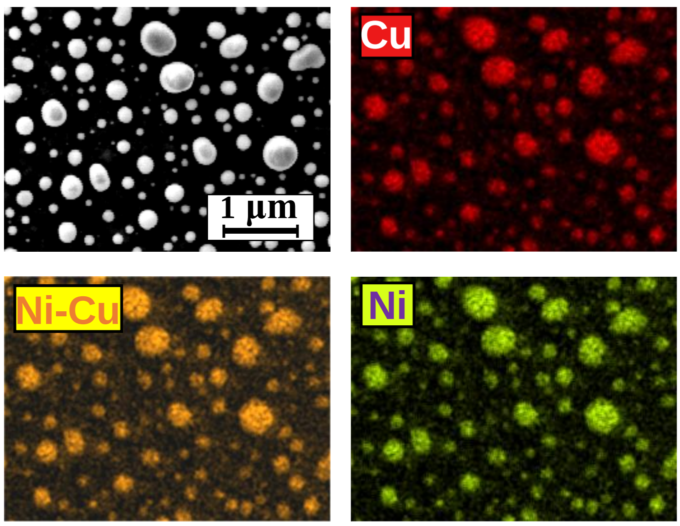

Fig S9: SEM-EDX of Ni-Cu 70-30 after exposure to 800°C in the inert atmosphere.

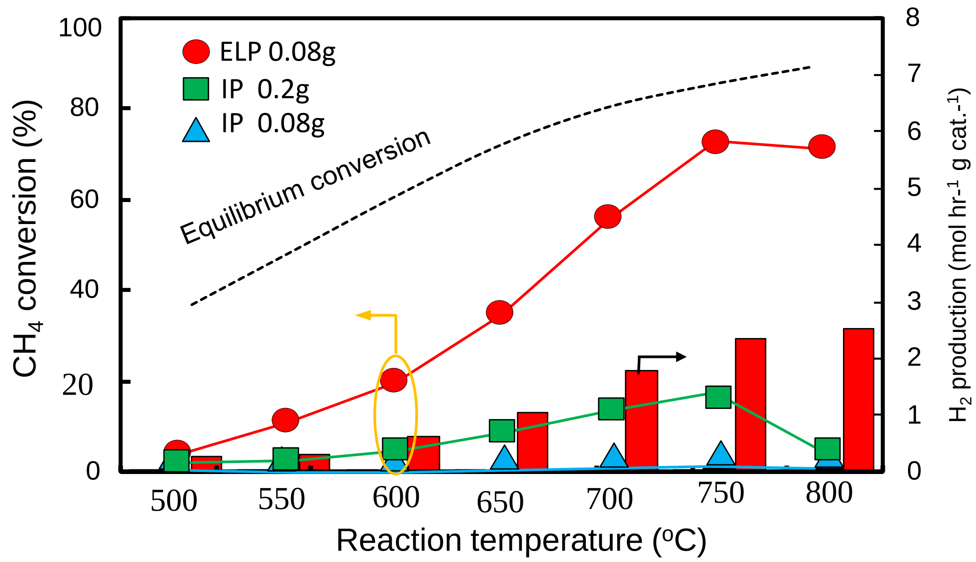

Fig S10: Comparative temperature dependency test for ELP derived Ni-Cu catalyst with the Impregnation method-based catalyst under same weight loading condition and increased weight by 2.5 times.

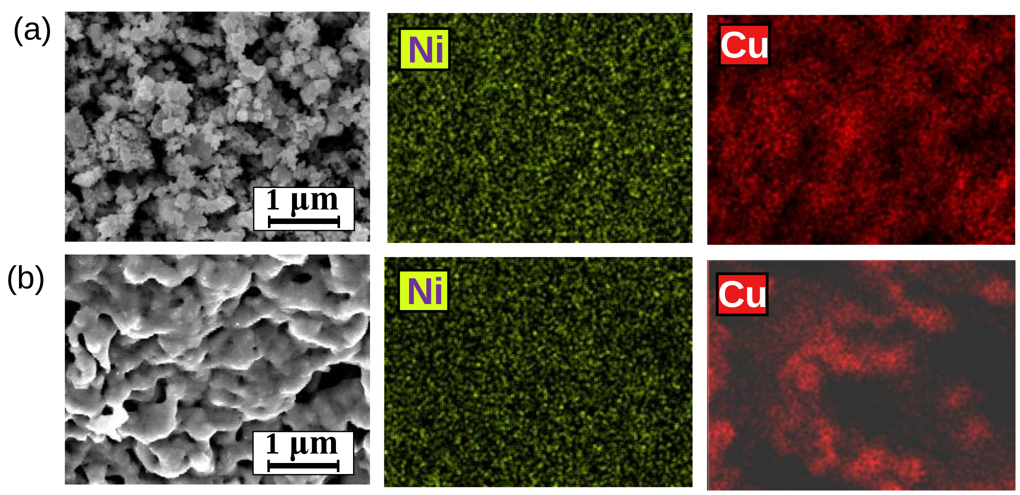

Fig S11: FE-SEM image of the (a)Fresh and (b) reduced catalyst surface prepared by impregnation method .

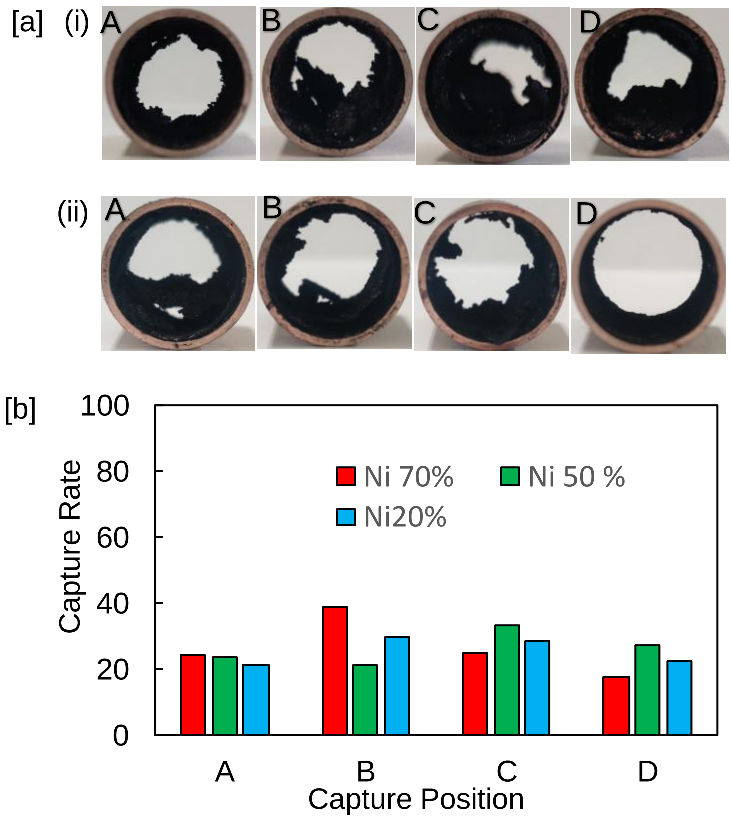

Fig S12: [a](i) Image showing carbon capture by ELP derived 50-50 catalyst. [a](ii) Image showing carbon capture by ELP derived 20-80 catalyst [b] comparative carbon capture performance of different Ni loaded ELP catalyst.