Electronic supplementary information

Mono and bimetallic metal catalysts based on Ni and Ru supported on alumina coated monoliths for CO_2 methanation

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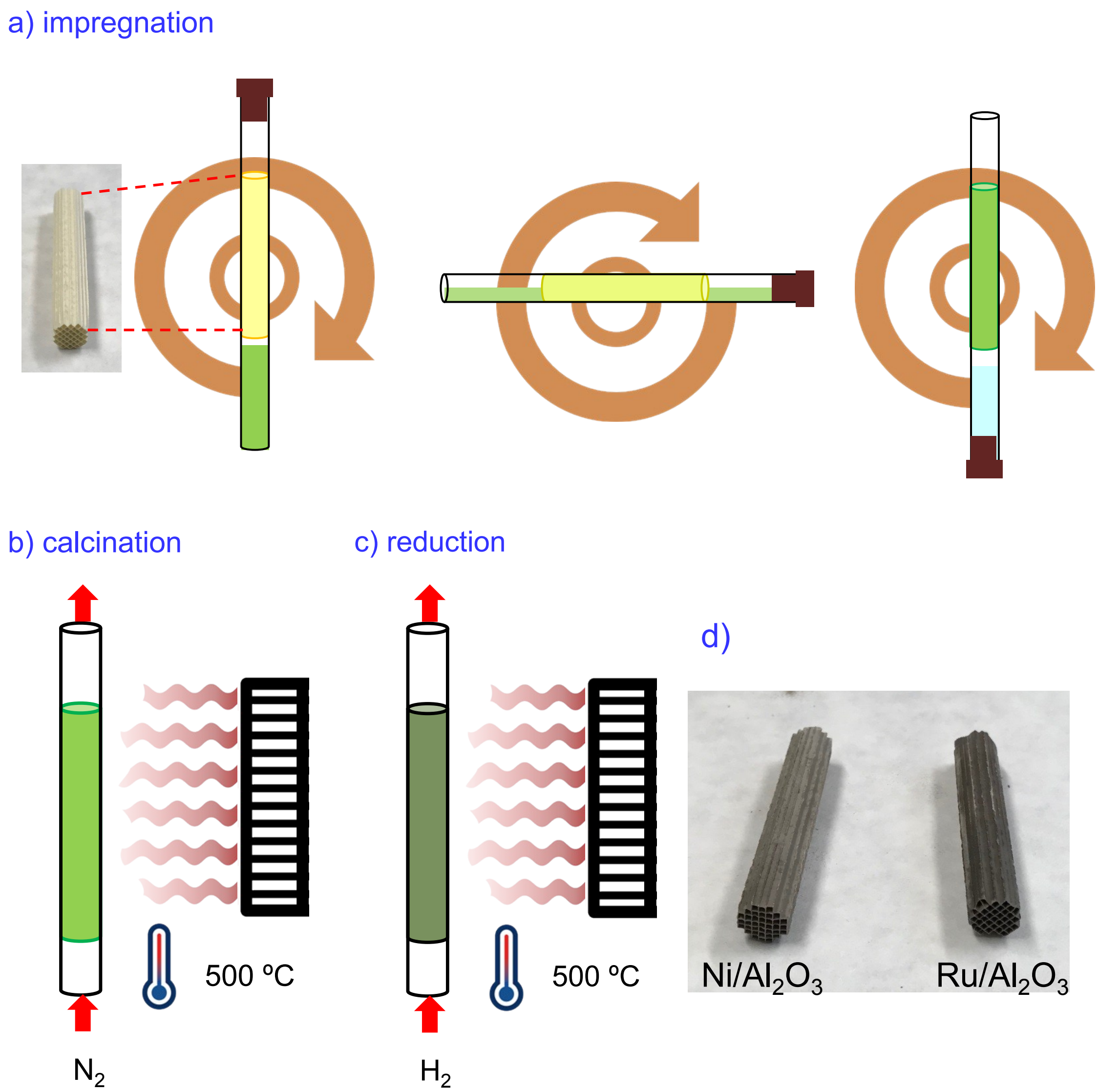

Scheme 1. Illustration of the preparation steps

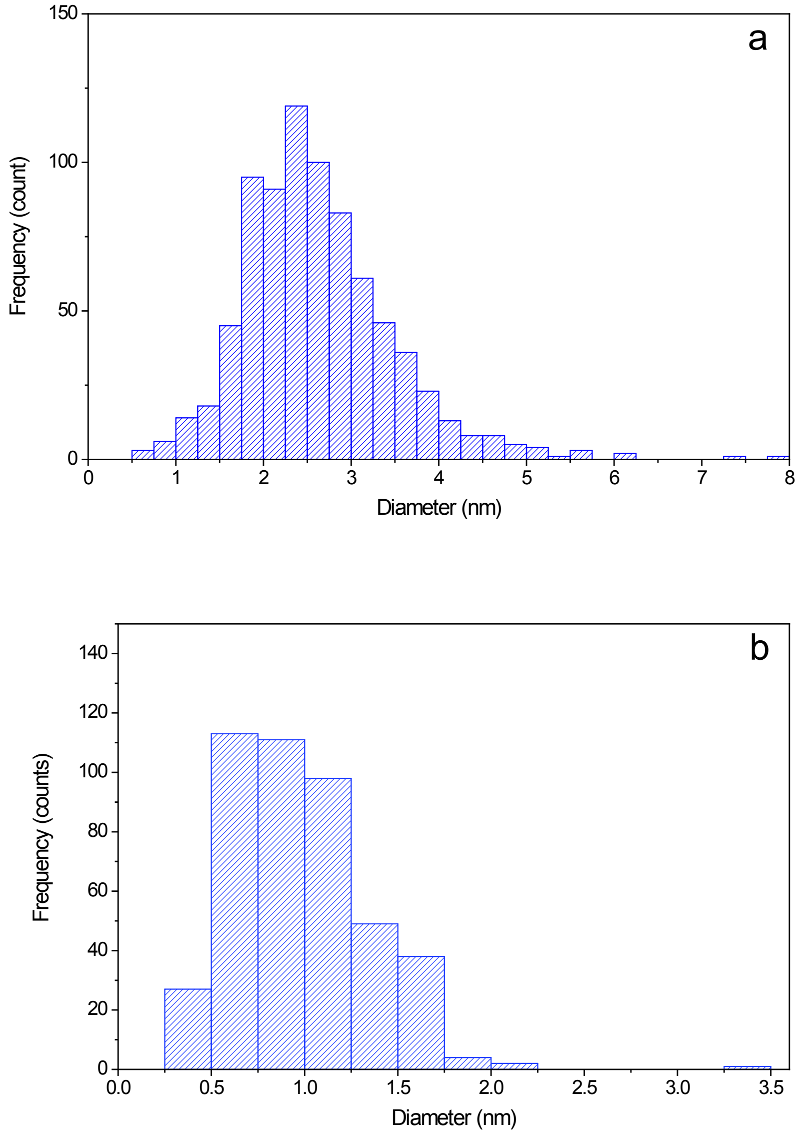

Figure S1. Particle size distribution for monometallic catalyst Ni (a) and Ru (b) derived from statistical analysis of HAADF-STEM images

Study of the effect of the internal and external mass transfer

The Weisz-Prater criteria was applied to assess the absence of mas transfer limitations, according to the following equations:

$$Ca = \frac{r_{CO2} \cdot \rho_{cat}}{K_g \cdot am \cdot C_{CO2}} < \frac{0{,}05}{n} \qquad \text{(Equation 1)}$$

$$WP = \frac{r_{CO2} \cdot \rho_{cat} \cdot \delta_c^2 c}{D_{CO2,e} \cdot C_{CO2}} < \frac{n+1}{2} < 1 \qquad \text{(Equation 2)}$$

Where r_{CO2} is the reaction rate, ρ_{cat} is the apparent catalytic layer density, K_g is the mass transfer coefficient, a_m is the geometric surface area, C_{CO2} is the CO_2 concentration in the feed gas, δc is the characteristic dimension of the coating layer, $D_{CO2,e}$ is the effective diffusion coefficient and n is the reaction order.

The parameters used in equation 1 and 2 are listed in Table S1. Some of these parameters were withdrawn from reference [S1] and the geometrical values of the monolith were withdrawn from [S2]. The characteristic dimension of the coating layer was an averaged value withdrawn from SEM images of alumina coated monoliths reported in our previous work [S3].

The values attained are Ca=0,0033 and WP=1,6 10^{-12} for the experimental conditions of P=1, T=380 ºC and a flow-rate of 60 ml/min. Assuming a reaction order n=0 in agreement with literature [7], both criteria are met, confirming the absence of mass transfer limitations.

Table S1. Values of parameters used in equations 1 and 2.

Parameter	description	Units	Value
r_{CO2}	CO_2 reaction rate	Kmol $kg^{-1}s^{-1}$	8.51 10^{-5}
ρ_{cat}	True density of γ-alumina	Kg m^{-3}	3650
K_g	mass transfer coefficient	m s^{-1}	1.01512
a_m	geometric surface area	m^2 m^{-3}	2735.44
C_{CO2}	CO_2 concentration in the feed gas	Kmol m^{-3}	3.98 10^{-6}
δc	characteristic dimension of the coating	m	1.0 10^{-6}

	layer		
$D_{CO2,e}$	effective diffusion coefficient	m^2s^{-1}	$7.73\ 10^{-7}$
n	and n is the reaction order	-	0

References

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S2. T. Vergunst, F. Kapteijn, J.A. and Moujin , *Ind. Eng. Res*. 2001, **40**, 2801-2809

S3. E. García-Bordejé, I. Kvande, D. Chen and M. Rønning, *Adv. Mater.*, 2006, **18**, 1589-1592.