

Supplementary Information

In-situ Growth of Phosphorus-doped Boron Nitride on Commercial Alumina as a Robust Catalyst for Direct Dehydrogenation of Ethylbenzene

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Figures

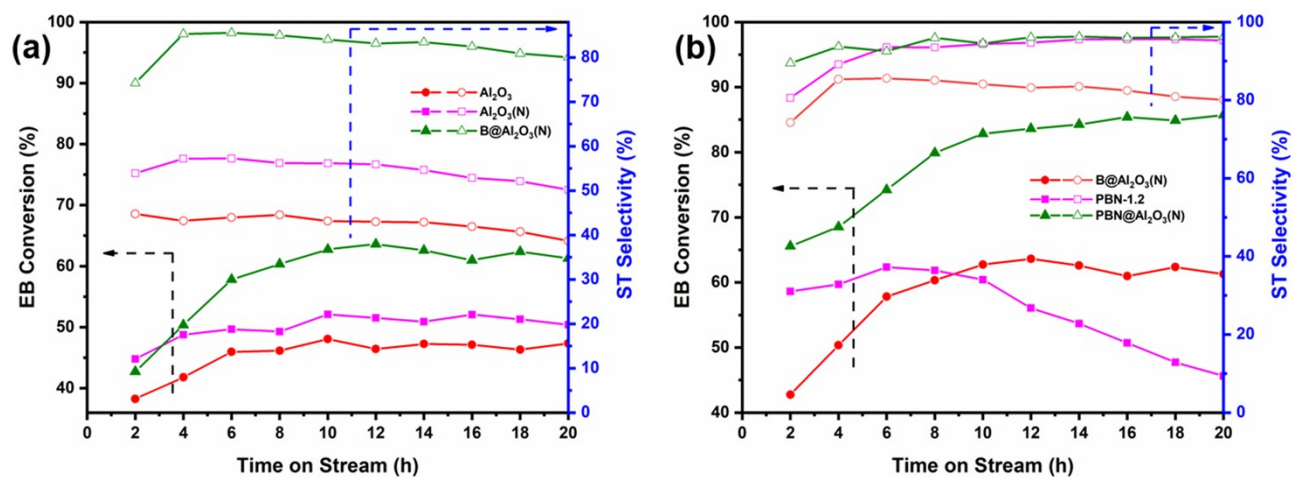


Fig. S1 The catalytic performance of Al_2O_3 , $\text{Al}_2\text{O}_3(\text{N})$, $\text{B@Al}_2\text{O}_3(\text{N})$, $\text{PBN@Al}_2\text{O}_3(\text{N})$ as well as PBN-1.2 samples for DDH of ethylbenzene to styrene. Reaction conditions: 2 mL catalyst, 2.8% ethylbenzene in N_2 , $20 \text{ mL} \cdot \text{min}^{-1}$, 600°C .

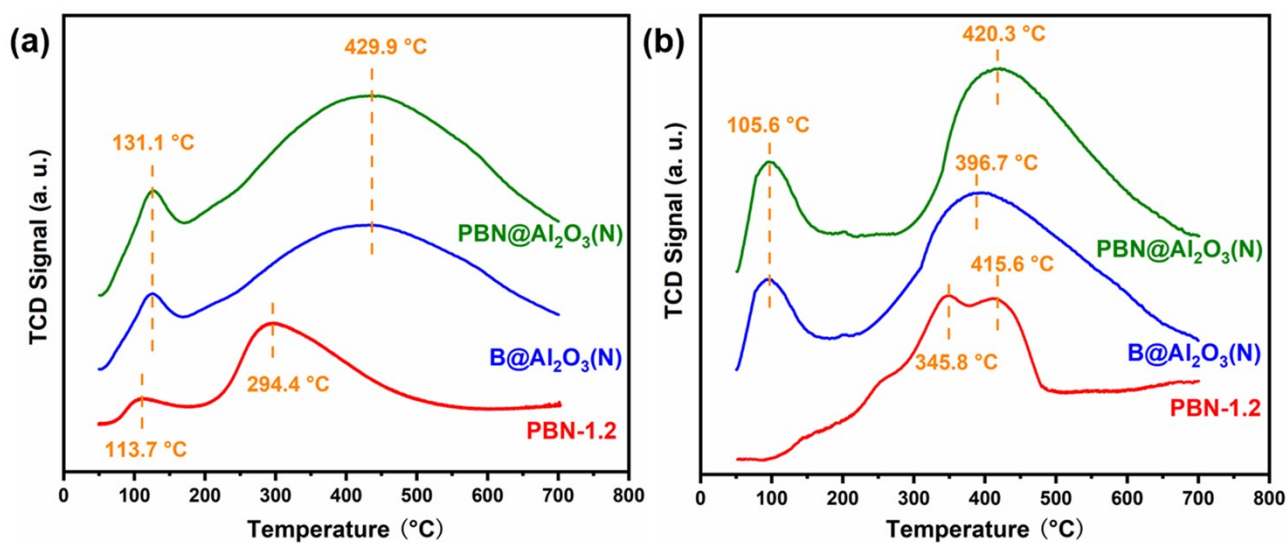


Fig. S2 (a) The NH_3 -TPD and (b) CO_2 -TPD profiles of PBN-1.2 , $\text{B@Al}_2\text{O}_3(\text{N})$ and $\text{PBN@Al}_2\text{O}_3(\text{N})$ samples.

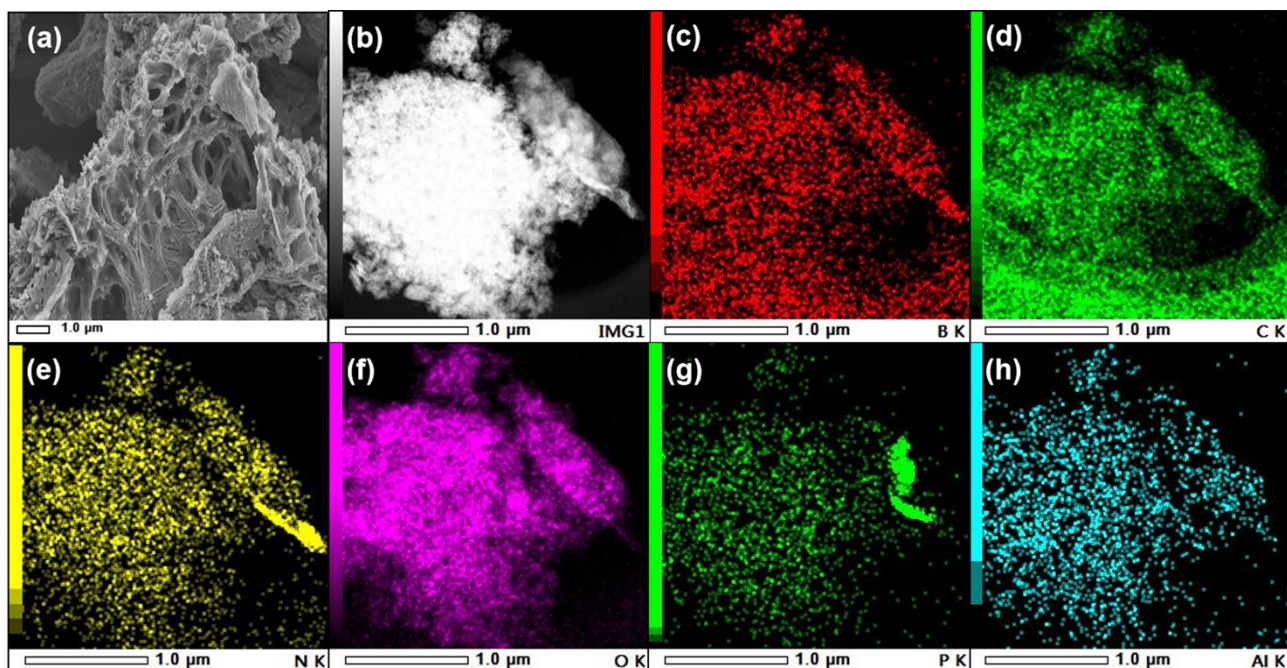


Fig. S3 (a) HRTEM image and (b-h) the selected area as well as B, C, N, O, P, Al elemental mapping of PBN@Al₂O₃(N) sample.

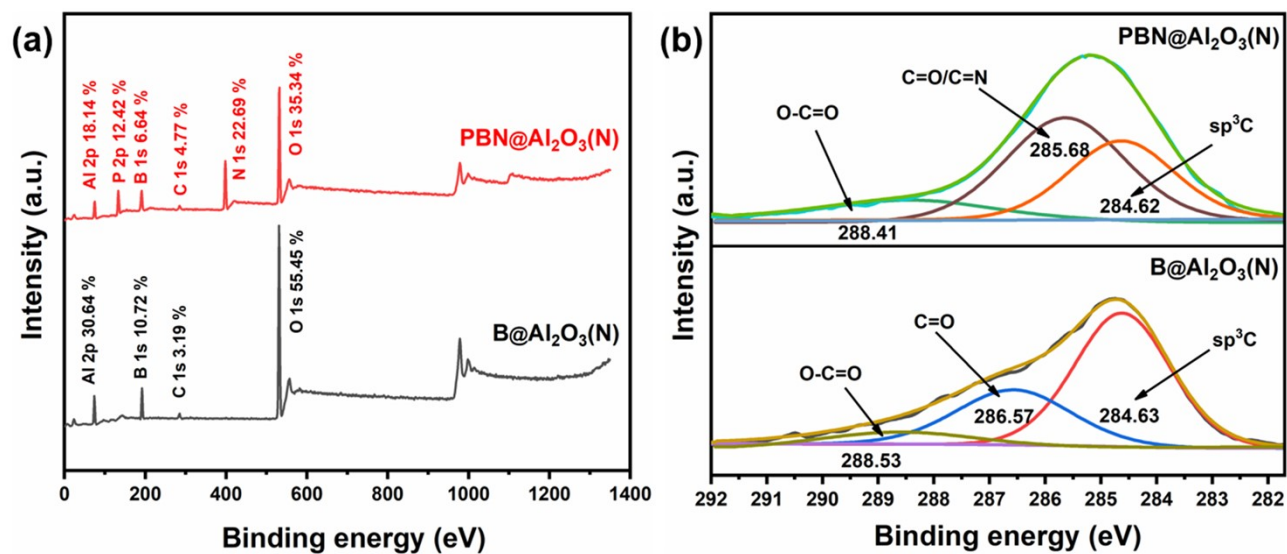


Fig. S4 (a) The survey and (b) C 1s spectra of B@Al₂O₃(N) and PBN@Al₂O₃(N) samples.

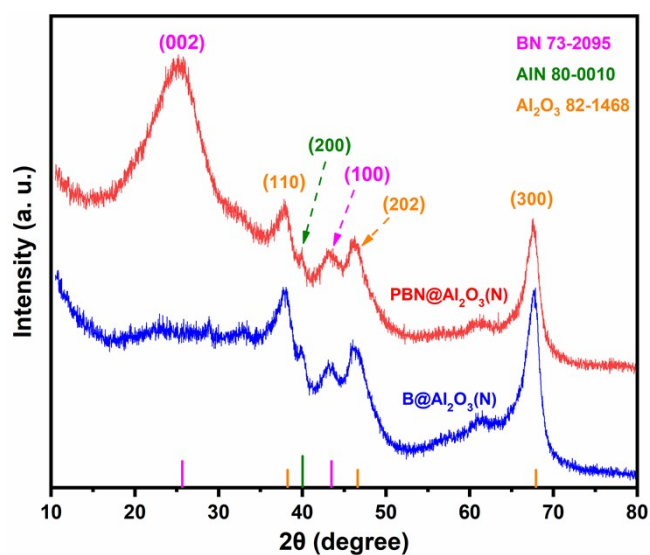


Fig. S5 The XRD patterns of $B@Al_2O_3(N)$ and $PBN@Al_2O_3(N)$ catalysts.

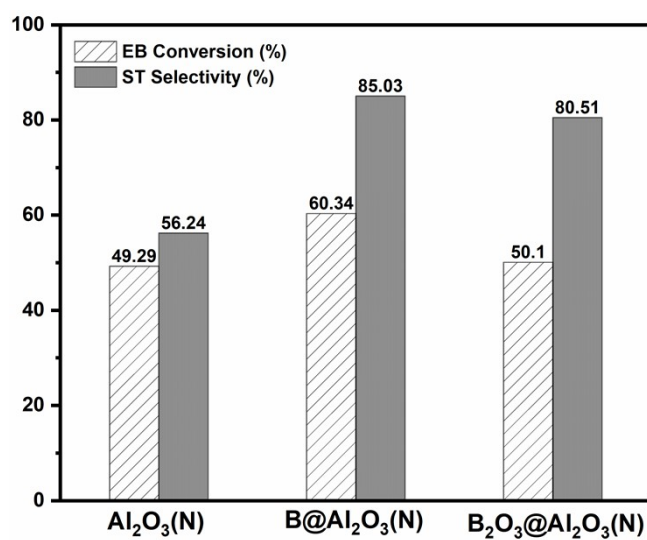


Fig. S6 The catalytic performance of $Al_2O_3(N)$, $B@Al_2O_3(N)$ and $B_2O_3@Al_2O_3(N)$ for DDH of ethylbenzene to styrene (data from 8 h reaction).

Tables

Table S1. Atomic content (in weight) revealed by ICP of B@Al₂O₃(N) and PBN@Al₂O₃(N) catalyst.

Catalyst	B (wt%)	P (wt%)
B@Al ₂ O ₃ (N)	2.48	-
PBN@Al ₂ O ₃ (N)	1.63	2.26

Table S2. The catalytic performance comparison of PBN@Al₂O₃(N) and those reported in literatures.

Catalyst	Reaction conditions	EB conversion in the stable stage (%)	ST selectivity in the stable stage (%)	ST yield in the stable stage(%)	Time of keeping stable(h)
PBN@Al ₂ O ₃ (N)	80 mg catalyst (surface PBN), 600 °C, 2.8% EB inlet, 20 mL·min ⁻¹	93.51	95	88.83	>300
ND@NMC/SiC ^{S1}	300 mg catalyst, 600 °C, 10% EB inlet, 30 mL·min ⁻¹	38.3	96.7	37.03	115
ND/CNF FLG ^{S2}	300 mg catalyst, 600 °C, 2.8% EB inlet, 30 mL·min ⁻¹	53.5	85.9	45.96	140
FLG-GO@ND ⁸	300 mg catalyst, 550 °C, 2.8% EB inlet, 30 mL·min ⁻¹	35.1	98.6	34.61	50
Nanodiamond ¹⁸	50 mg catalyst, 550 °C, 2.8% EB inlet, 10 mL·min ⁻¹	21.01	97.3	20.5	50
ND/CNT-SDS ¹⁹	25 mg catalyst, 550 °C, 2.8% EB inlet, 10 mL·min ⁻¹	22.5	98.2	22.1	50

(S1) H. Ba, J. Luo, Y. Liu, C. Duong-Viet, G. Tuci, G. Giambastiani, J. -M. Nhut, L. Nguyen-Dinh, O. Ersen, D. Su, C. Pham-Huu, *Appl. Catal. B: Environ.*, 2017, **200**, 343-350.

(S2) H. Ba, L. Truong-Phuoc, Y. Liu, C. Duong-Viet, J. -M. Nhut, L. Nguyen-Dinh, P. Granger, C. Pham-Huu, *Carbon*, 2016, **96**, 1060-1069.

Note: The mass of surface PBN of 80 mg on PBN@Al₂O₃(N) of 2 mL was estimated according to the ICP and XPS results.

Table S3. Surface composition of PBN@Al₂O₃(N) catalyst before and after induction period.

Sample	Surface composition of XPS (at%)						The ratio of N ₂ P=O to N ₃ P-OH species
	B	C	N	O	P	Al	
Fresh PBN@Al ₂ O ₃ (N)	6.64	4.77	22.69	35.34	12.42	18.14	1:0.90
Induction PBN@Al ₂ O ₃ (N)	6.23	6.02	22.57	35.85	11.94	17.39	1:0.93