

## Supplementary information

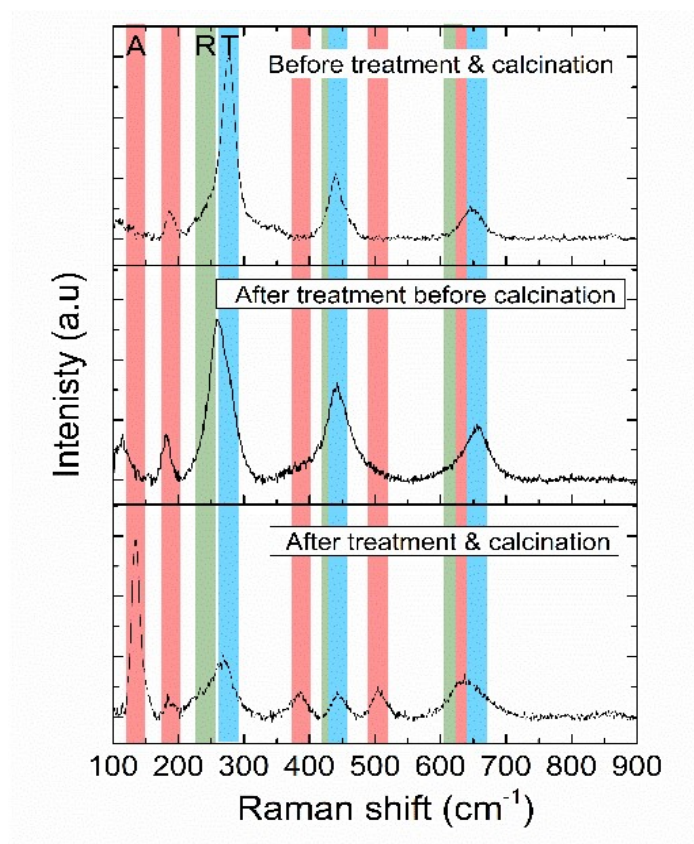
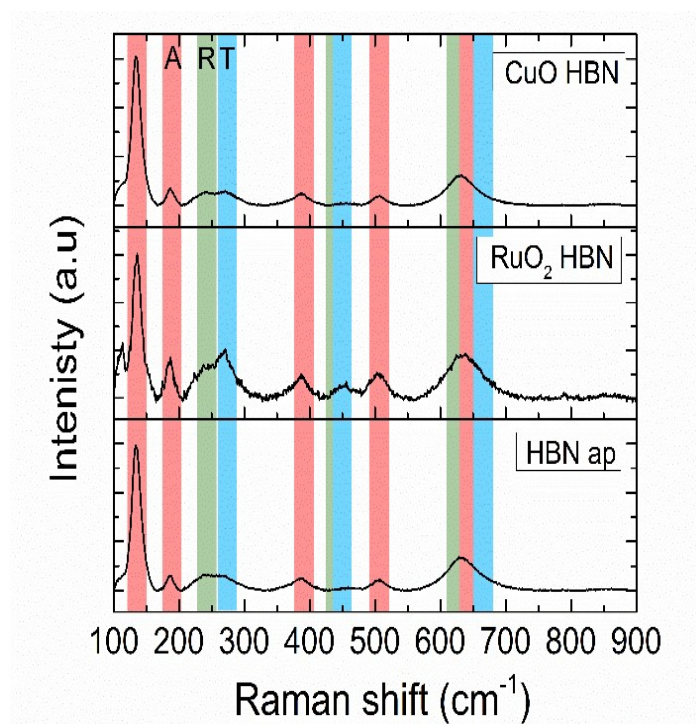
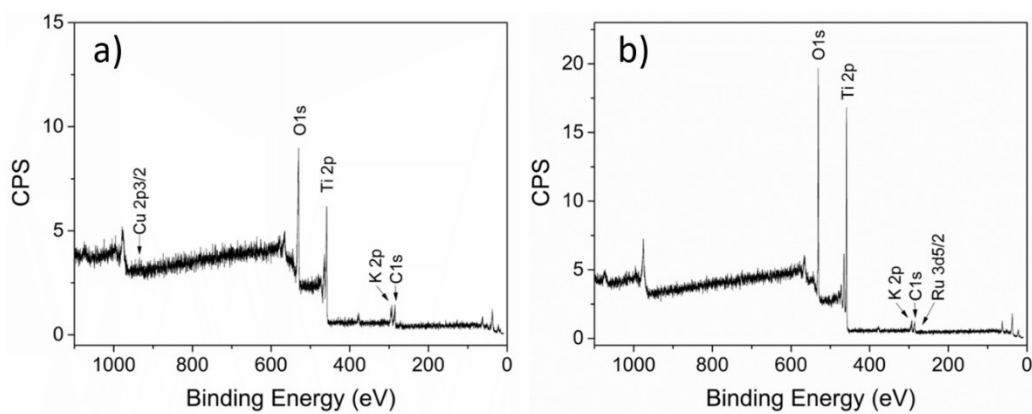


Figure S1 - Raman spectra investigation of the phase altering step from potassium titanates to anatase phase.

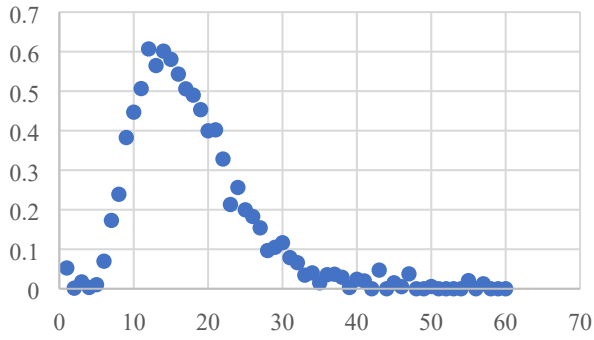


**Figure S2** - Raman spectra of the RuO<sub>2</sub> HBN and CuO HBN samples with as-prepared HBN ap. The figure shows very similar spectra with no Ru or Cu related peaks.

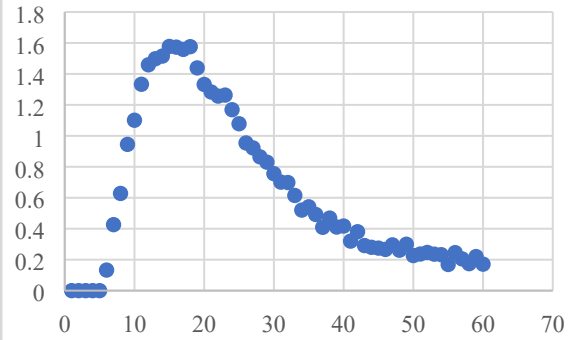


**Figure S3** - XPS survey spectra for a) CuO HBN and b) RuO<sub>2</sub> HBN samples with annotated peaks.

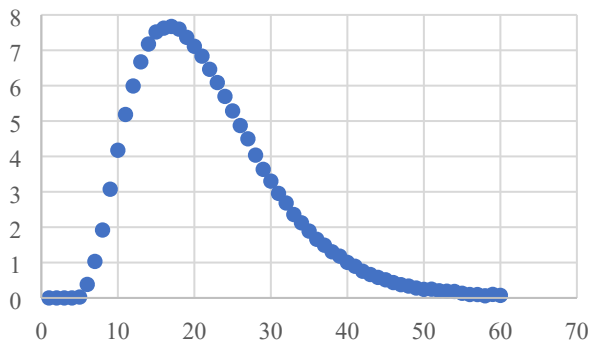
CH4 HBNs BP



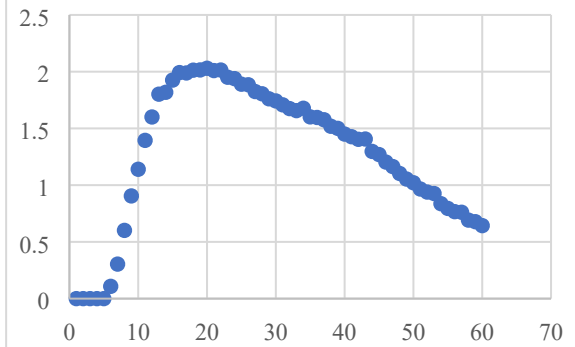
CO HBNs BP



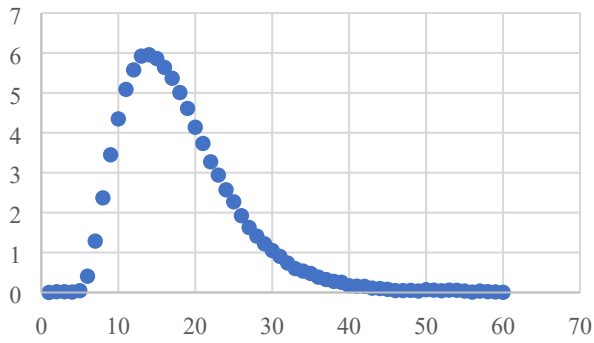
CH4 HBNs AP



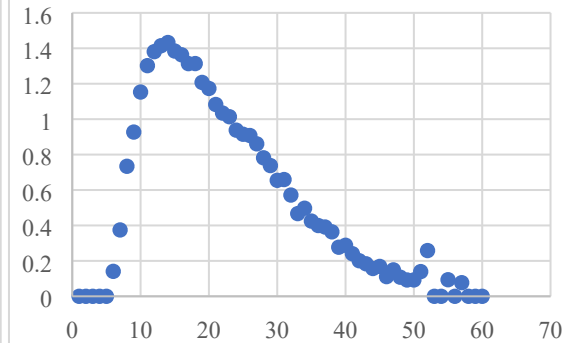
CO HBNs AP



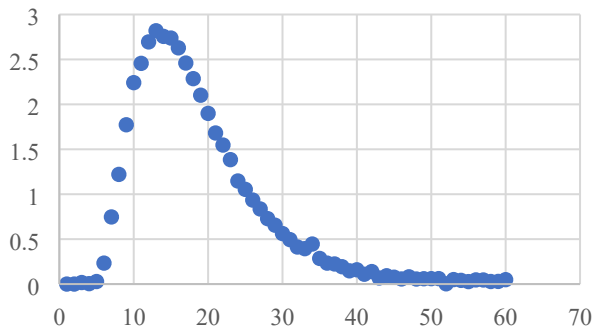
CH4 RuO2-HBNs



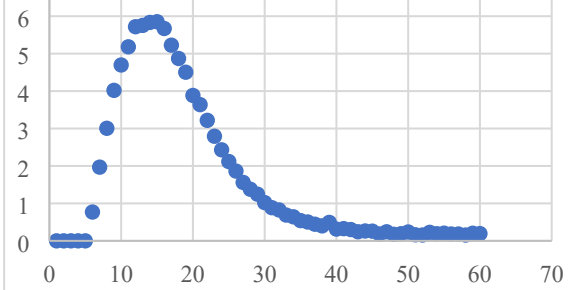
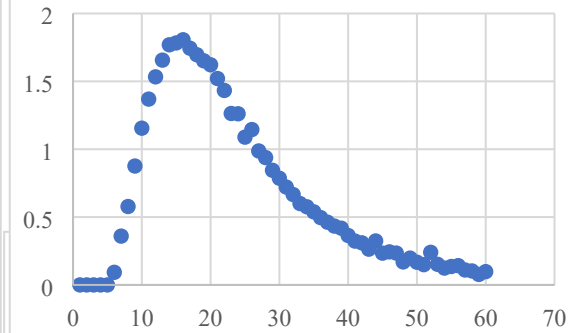
CO RuO2-HBNs

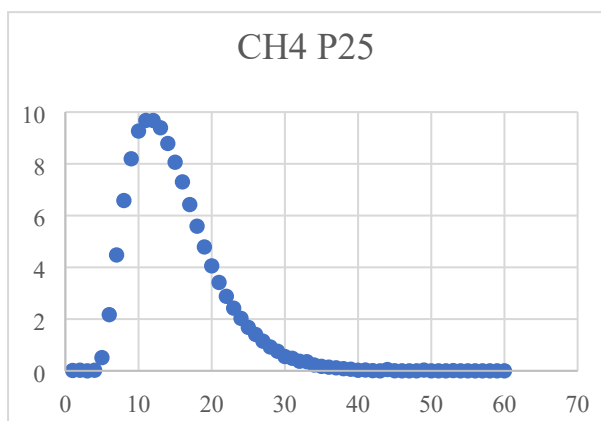


CH4 CuO-HBNs



CO - CuO-HBNs





**Figure S4** – Gaseous products production ( $\mu\text{mols/g}_{\text{cat}}$ ) plotted against GC cycles for all the examined samples. Each cycle takes 4 minutes to complete, the data above represent 4 hours of reaction.