Supplementary Information

Performance Evaluation of Ru-Pt Alloy Nanoparticles Catalyst for Hydroxylammonium nitrate (HAN) Based Propellant

Xiushuang Zhou, Yu Shen, Xubo Li, Yongmin Huang*

School of Chemistry and Molecular Engineering, East China University of Science and Technology, Shanghai 200237, P.R.China;

*Corresponding E-mail: huangym@ecust.edu.cn

Table S1. Pore structure parameters of catalyst samples.

catalyst	S_{BET}（m^2/g）	Pore diameter (nm)	Total pore volume (cm^3/g)
Ru/Al_2O_3	157.65	3.96	0.20
$Ru\text{-}Pt/Al_2O_3$	128.01	3.85	0.17

The infrared absorption experiment of the samples was performed on a Thermo Scientific Nicolet iS20 Fourier Transform Infrared (FTIR) Spectrometer with a scanning range of 400–4000 cm^{-1}, and the gaseous products were introduced into the infrared gas cell.

The infrared spectroscopic data (Fig. S1) reveal the presence of methanol, as evidenced by the C–O stretching vibration band (ν(C–O)) at 1030 cm^{-1} and the symmetric/antisymmetric stretching vibrations of CH_3 ($\nu_s/\nu_{as}(CH_3)$) within the 2850–3000 cm^{-1} region. The sharp N=O stretching vibration peak (ν(N=O)) at 1800 cm^{-1} validates the presence of NO molecules, while the sharp O–N–O asymmetric stretching vibration peak (ν_3(N–O)) at 1620 cm^{-1} confirms NO_2 formation. Additionally, the observation of an in-plane bending vibration (δ(N–N–O)) at 580 cm^{-1} and an asymmetric stretching vibration (ν_3(N–N–O)) spanning 2000–2300 cm^{-1} is correlated with the generation of N_2O species.

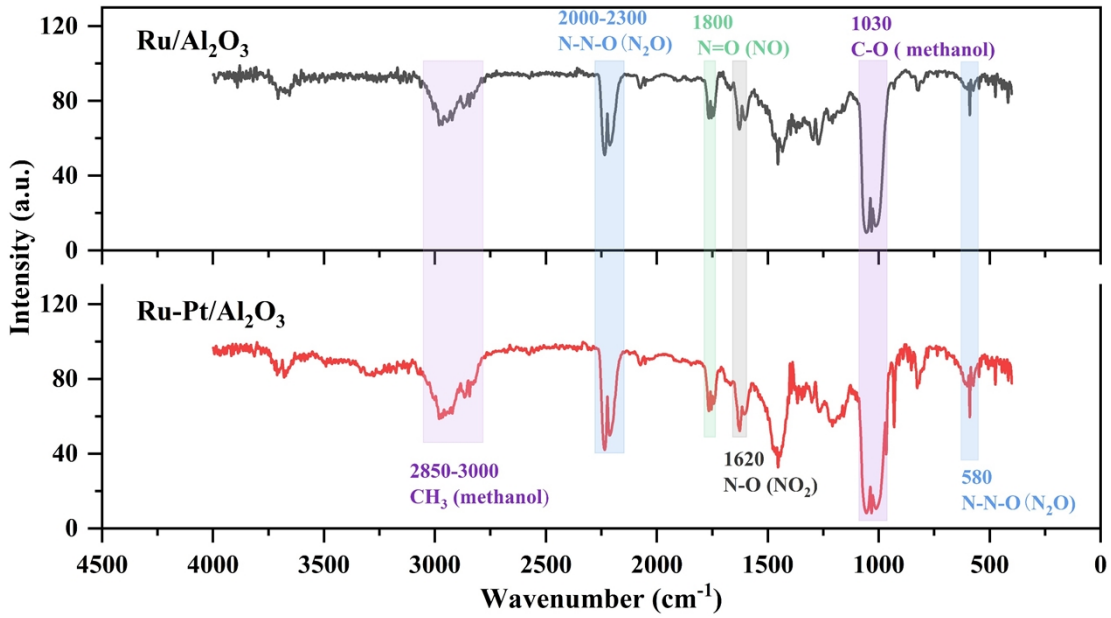

Fig. S1. IR spectrum of decomposition products of HAN based propellant.

The gas chromatography mass spectrometer was carried out on GC1290 gas chromatography and MSQ8100 mass spectrometer of SUNNY HENGPING instrument. The instrumental parameters were set as follows: inlet temperature at 100°C, column oven temperature at 80°C, auxiliary temperature at 90°C, and ion source temperature at 230°C.

The propellant decomposition over Ru/Al_2O_3 and $Ru\text{-}Pt/Al_2O_3$ catalysts predominantly generated nitrogen (N_2), carbon dioxide (CO_2), and nitrous oxide (N_2O) as dominant gaseous products as shown in Fig. S2 in the gas chromatographic (GC) analysis. The gaseous products contained a major fraction of N_2, which was assigned a reference value of 1. Subsequently, the relative molar ratios of CO_2 and N_2O to N_2 were quantitatively calculated. Fig. S3 displays the electron ionization mass spectrum (EI-MS) corresponding to the target chromatographic peak resolved in GC chromatogram, enabling structural elucidation of the eluted compound.

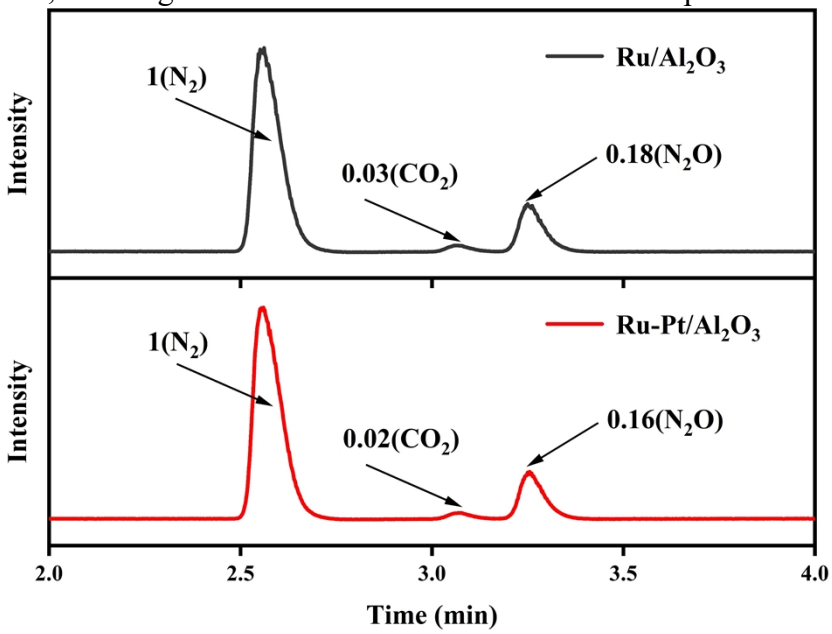

Fig. S2. GC chromatogram of decomposition products of HAN based propellant.

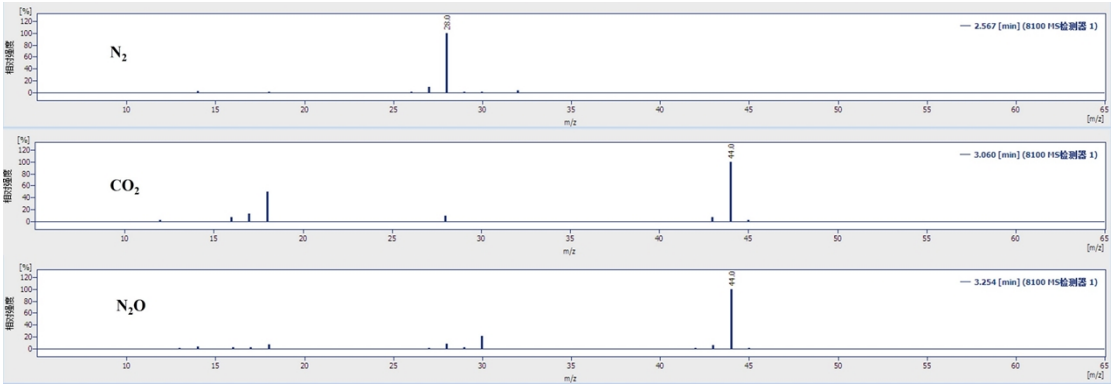

Fig. S3. The mass spectrum of the corresponding peak in GC chromatogram.

Table S2. Hot firing test conditions.

Propellant	HAN
Propellant Feed Pressure [MPa]	1.0, 1.2, 1.6, 1.8
Firing Mode	Continuous:10 s, 100 s Pulse:0.05 s ON/1 s OFF, 0.1 s ON/1 s OFF
Catalyst Preheat Temp. [°C]	120

Table S3. Test matrix of the experimental campaign.

Sequence	Type of Experiment	Cold/Hot Start-up	Feeding Pressure (MPa)	Time (s)	number
1	Pulse Mode	Hot	1.0	0.05/1	10
2	Continuous	Hot	1.2	10	1
3	Continuous	Hot	1.6	10	1
4	Pulse Mode	Hot	1.6	0.1/1	10
5	Continuous	Hot	1.8	10	1
6	Pulse Mode	Hot	1.8	0.1/1	10
7	Continuous	Hot	1.0	10	1
8	Pulse Mode	Hot	1.0	0.1/1	10
9	Continuous	Hot	1.6	100	1

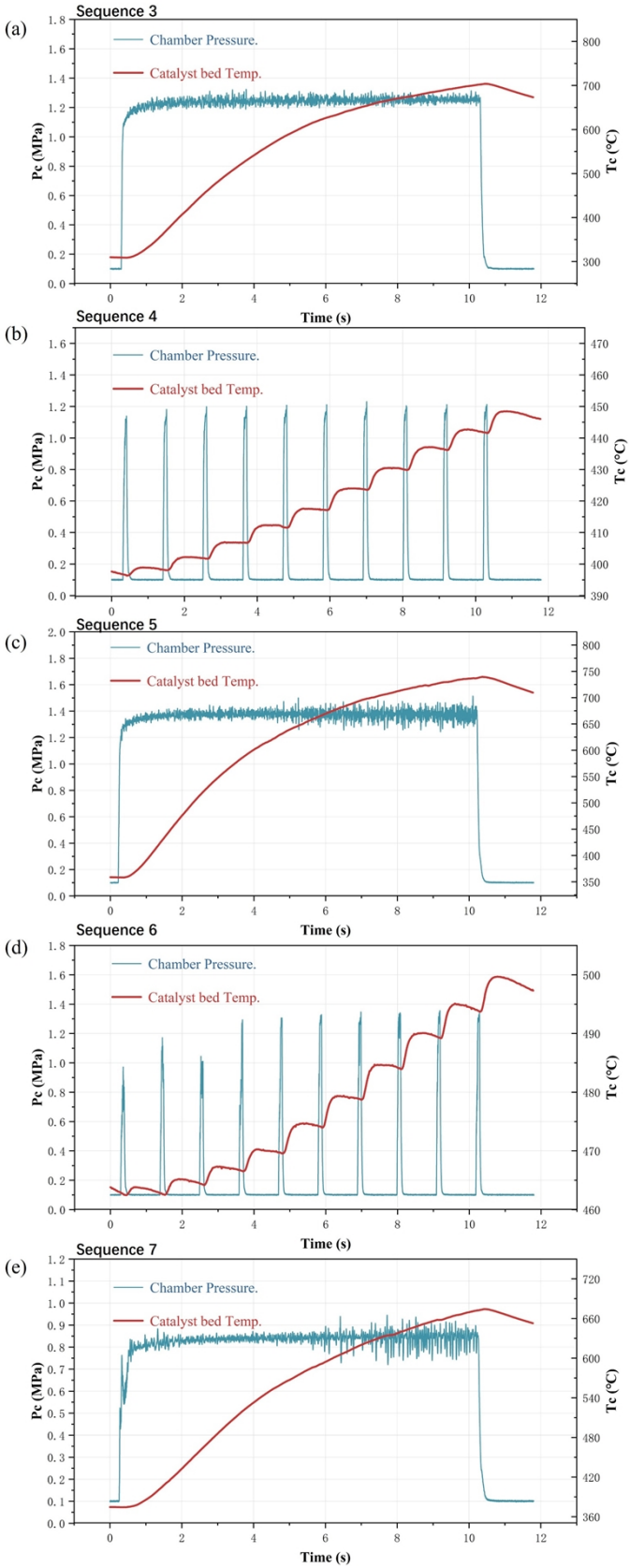

Fig. S4. Typical combustion pressure and catalyst bed temperature profile of (a) Sequence 3, (b) Sequence 4, (c) Sequence 5, (d) Sequence 6 and (e) Sequence 7.

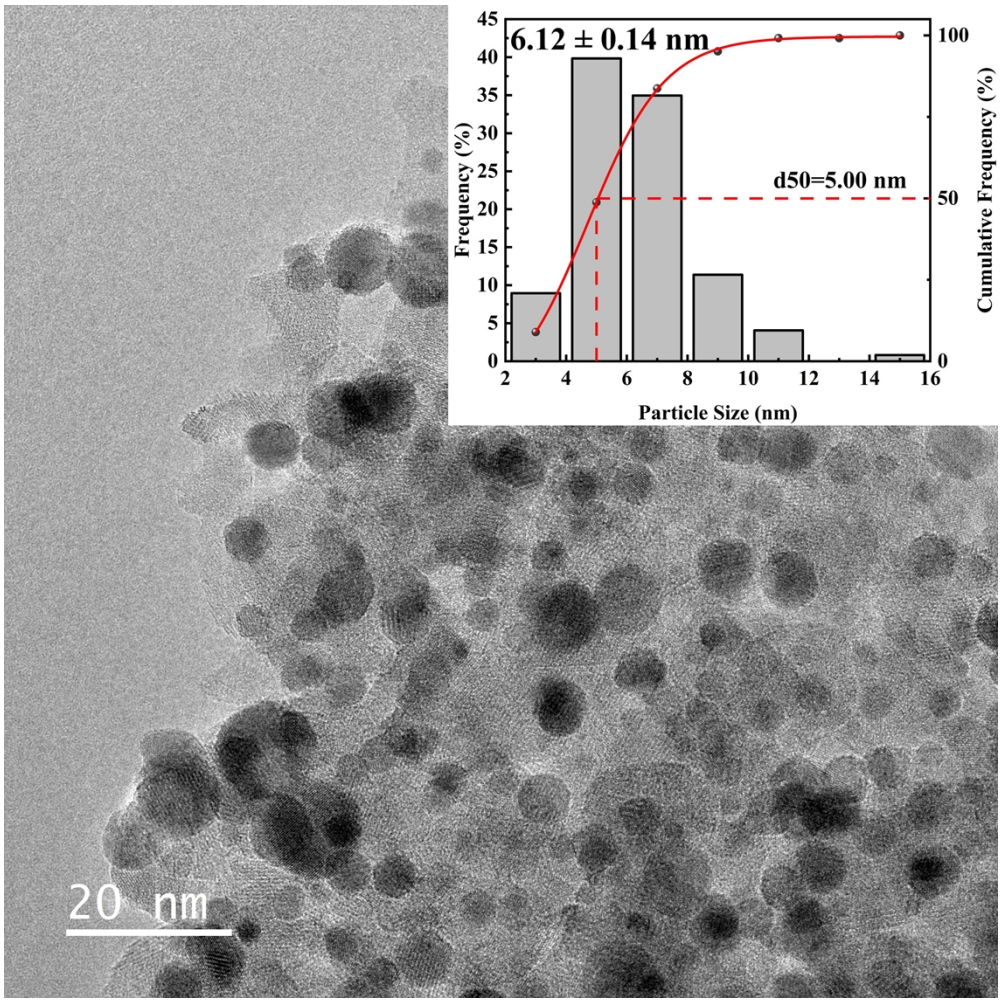

Fig. S5. TEM image and the size distribution of the used Ru-Pt/Al_2O_3.

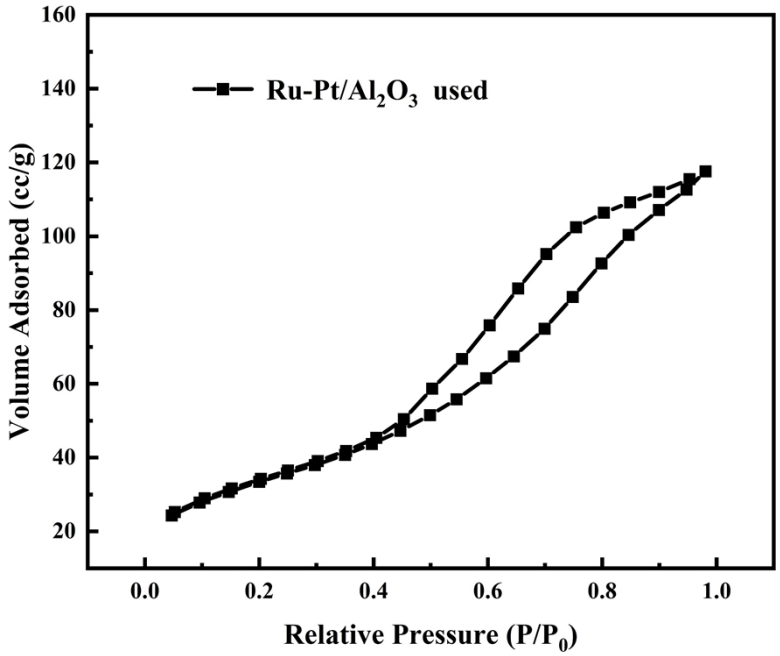

Fig. S6. N_2 adsorption-desorption isotherm of the used Ru-Pt/Al_2O_3.