CO_2-assisted Low-Temperature Gasification of Petroleum Sludge for Hydrogen Generation using Activated Carbon Catalysts

Behzad Valizadeh, Haneul Shim, Seungje Lee, Young-Kwon Park*

School of Environmental Engineering, University of Seoul, Seoul, 02504, Korea

* Corresponding author: Young-Kwon Park(TEL: +82-2-6490-2870, E-mail: catalica@uos.ac.kr)

Introduction

The extensive production of petroleum sludge (PS) in petrochemical industries poses significant environmental challenges due to the complex chemical combination and its hazardous nature. Conventional PS treatment methods are time-consuming, costly, and can lead to further environmental pollution. Additionally, reliance on fossil fuels contributes to greenhouse gas emissions and environmental problems. This study introduces an eco-friendly solution by using low-cost AC catalysts from sawdust to convert PS into H_2-rich gas via CO_2-assisted Low-temperature-gasification (LTG). Various catalysts, environments (CO_2 and N_2), and temperatures (500–700 °C) were examined. This study opens new possibilities for the utilization of low-cost AC catalysts and cost-effective LTG process for the PS valorization into green H_2.

Experiment

Sample

- Petroleum Sludge

- Obtained from a local industrial plant in Korea.

- Chemical agents were purchased from Sigma-Aldrich.

Catalyst

- Activated biochar (H_3PO_4,$ZnCl_2$,KOH)

Proximate of Feedstock (wt %)

- Proximate analysis

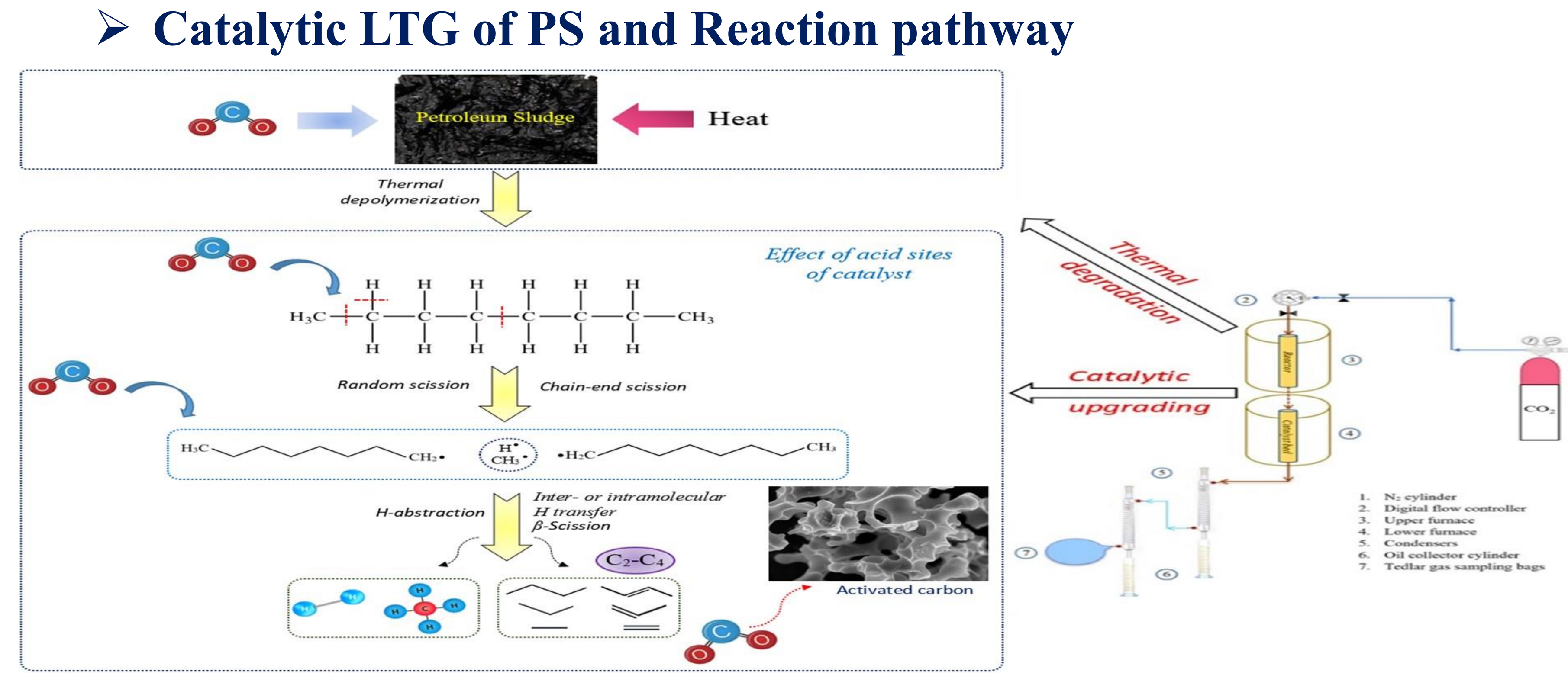
Moisture	Volatile matter	Fixed carbon	Ash
19.4	79.6	0.6	0.4

Ultimate analysis of Feedstock (wt %)

- Ultimate analysis

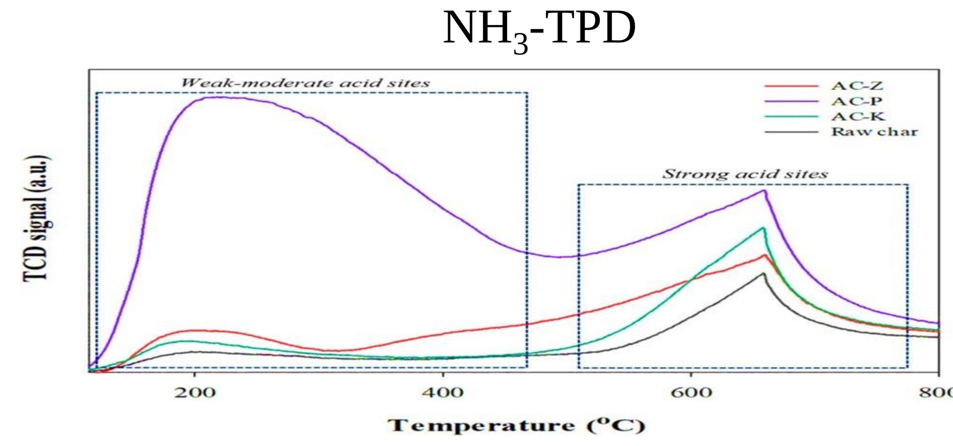
C	H	O	S
82.2	14.3	2.8	0.7

Catalytic LTG of PS and Reaction pathway

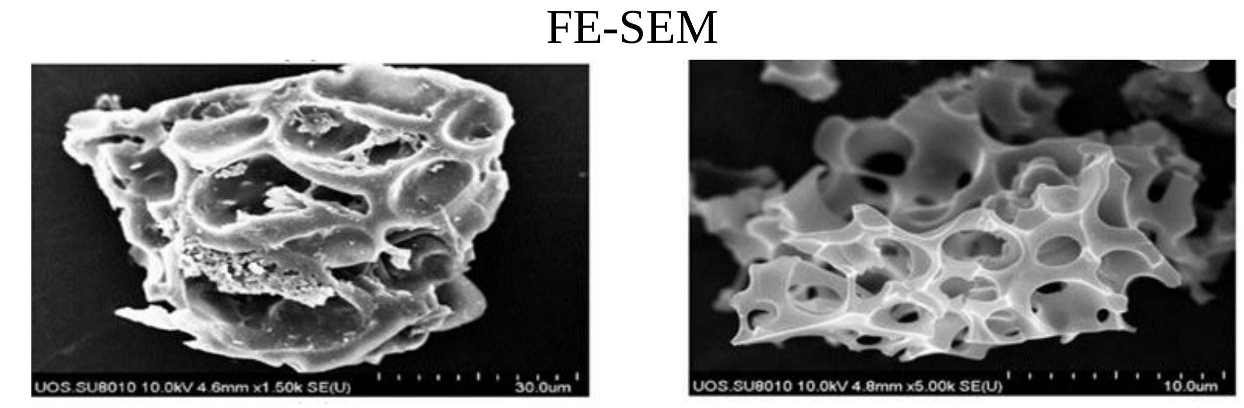


Catalyst characterization

NH_3-TPD

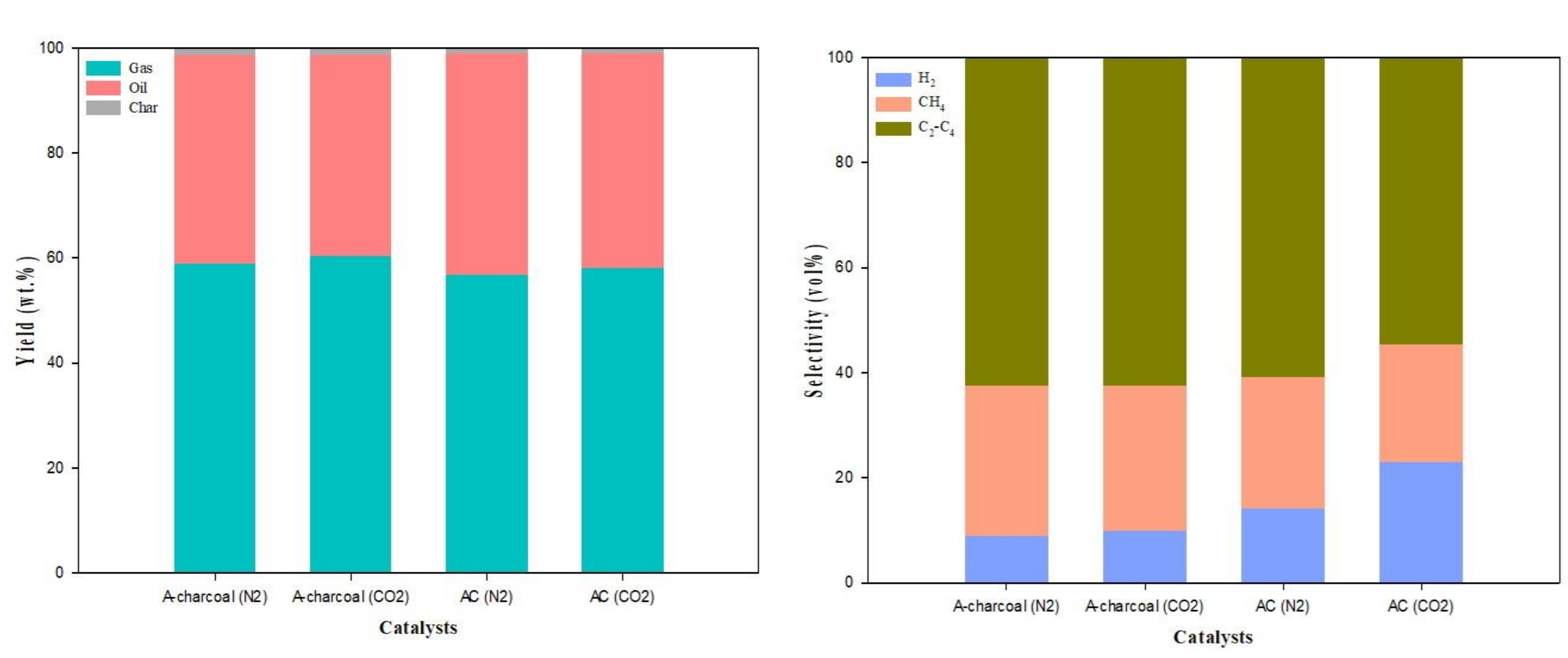


FE-SEM



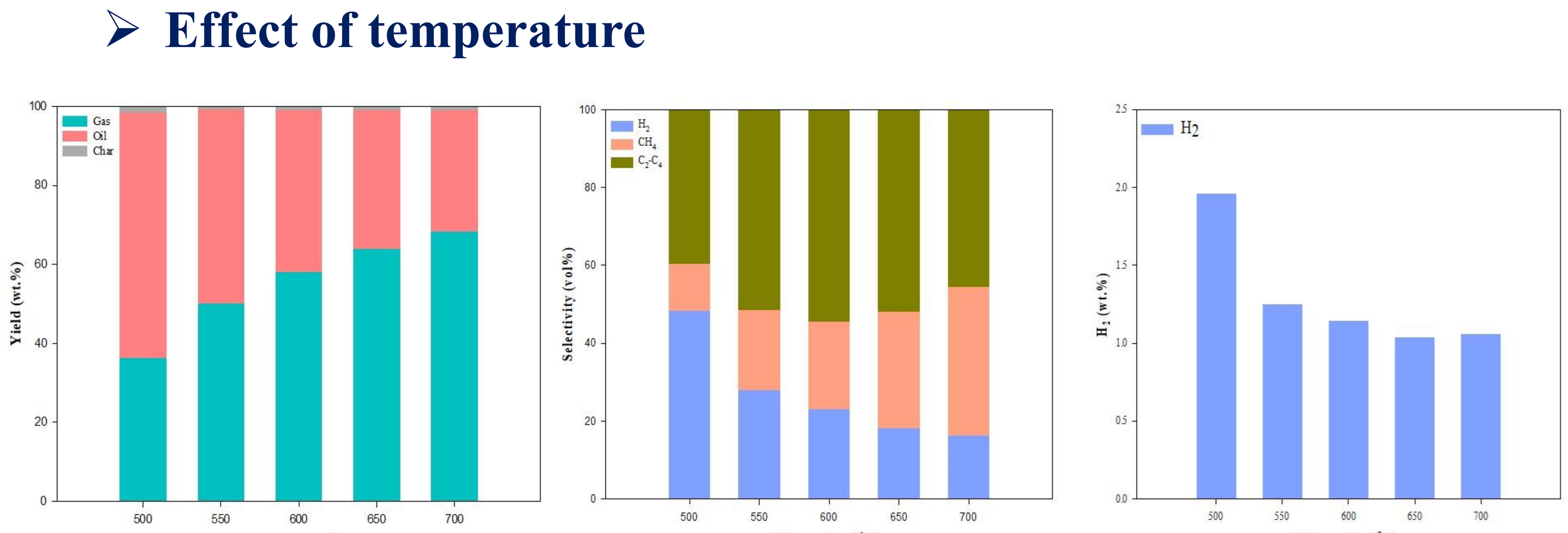
Result

Effect of Environment (N_2/CO_2)



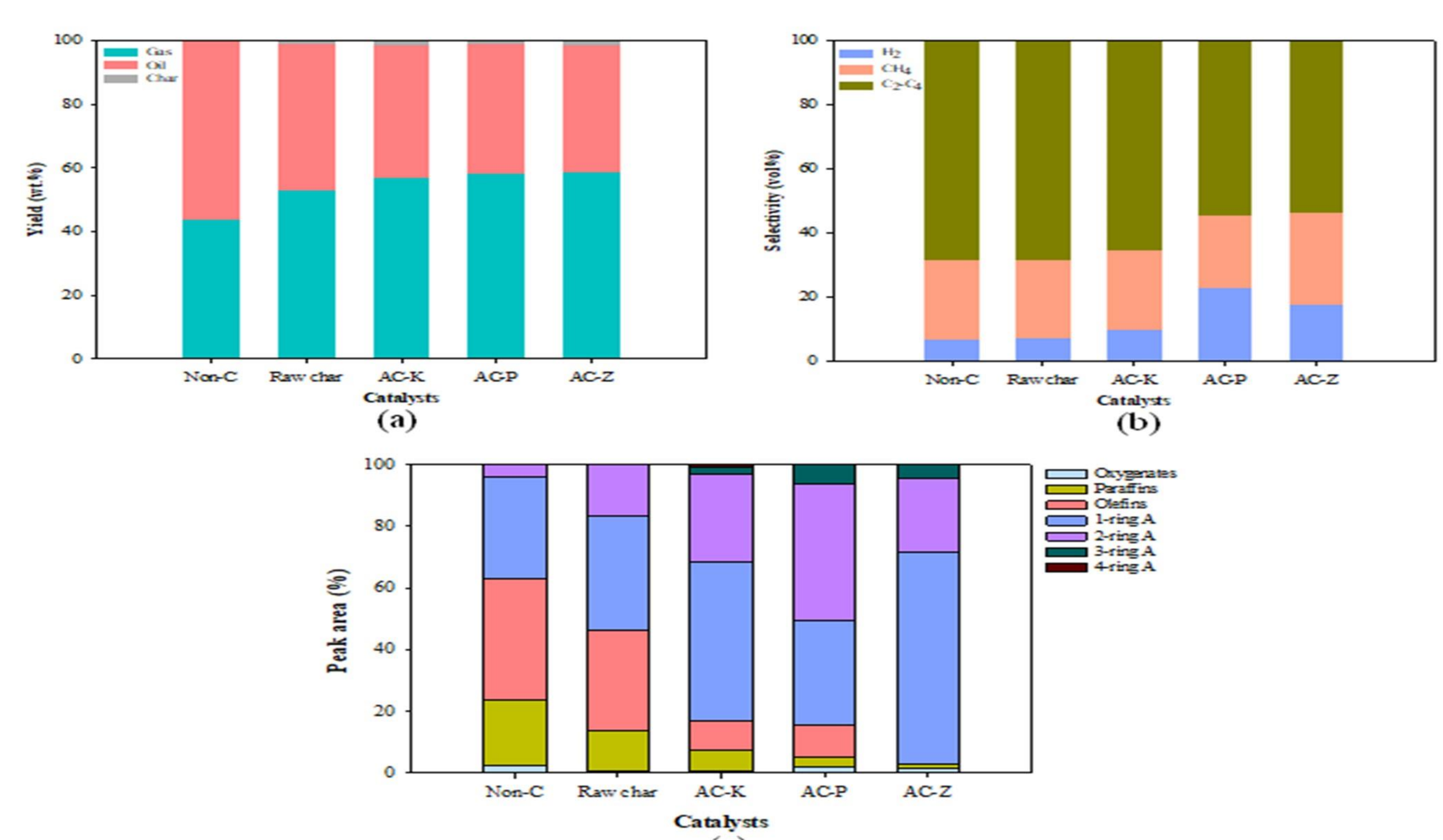
- **Disregarding catalyst and environment type, yield of different products did not change considerably. In the case of activated carbon, H_2 selectivity increased under CO_2 (22.94 vol%) than under N_2 (14.09 vol%).**

Effect of temperature



- **The yield of gas enhanced by increasing the reaction temperature, reaching to a maximum of 68.20 wt.% at 700 °C. Conversely, the selectivity and the yield of H_2 increased by decreasing the temperature, reaching to maximum of 48.41 vol% and 1.96 wt.% at 500 °C, respectively.**

Effect of different chemical activation of AC



- **The use of all catalysts increased the gas yield at the expense of oil yield, in particular using H_3PO_4 - and $ZnCl_2$-treated catalysts.**

- **The use of sawdust char (un-treated) did not change H_2 selectivity compared non-catalytic case.**

- **The use of activated carbon treated with different activation agents enhanced H_2 selectivity as following sequence: AC (H_3PO_4) > Ac ($ZnCl_2$) > AC (KOH).**

Conclusion

- Chemical activation improved the physicochemical properties of AC catalysts, resulting in enhanced production of green hydrogen in LTG of PS.
- AC catalyst prepared by H_3PO_4 activation showed the highest activity.
- CO_2 condition indicated an assistive role in LTG of PS outperforming N_2.
- This work was supported by the Ministry of Environment's waste resource energy recycling professional training project (YL-WE-22-001)