Production of value added olefins from catalytic pyrolysis of waste plastic straw

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Introduction

This study explores sustainable solutions for recycling plastic waste, focusing on polypropylene commonly used in plastic straw production. Pyrolysis under anaerobic conditions is used to decompose waste plastic straws (WPS), generating BTEXs oil and gases with high olefin selectivity, while reducing carbon dioxide emissions. Two-stage catalytic pyrolysis (TSCP) is compared with one-stage ex-situ catalytic pyrolysis (ESCP) by adding alumina catalyst in-situ to the primary stage. The study shows potential for establishing a circular economy, generating a source for plastic production, and reducing carbon dioxide emissions.

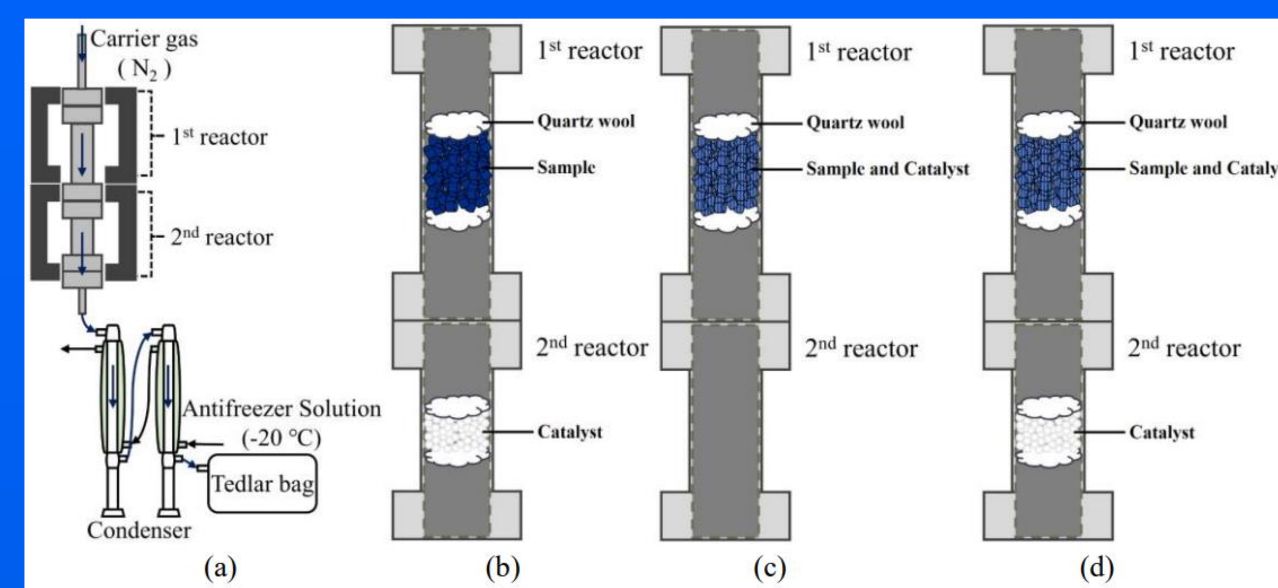

Figure 1: The fixed-bed pyrolysis reactor
(a) The reactor, (b) ESCP, (c) ISCP, and (d) TSCP

Results & Discussion

> Characterization of feedstock

Table 1: The results of the proximate analysis and the elemental analysis of WPS

Sample		WPS
Proximate analysis (wt. %)	Moisture	0.0
	Volatile	99.7
	Fixed Carbon	0.0
	Ash	0.3
	Sum	100
Elemental analysis[a] (wt. %)	C	85.7
	H	14.1
	O	0.0
	N	0.2
	S	0.0
	Sum	100

[a] Dry and ash-free basis.

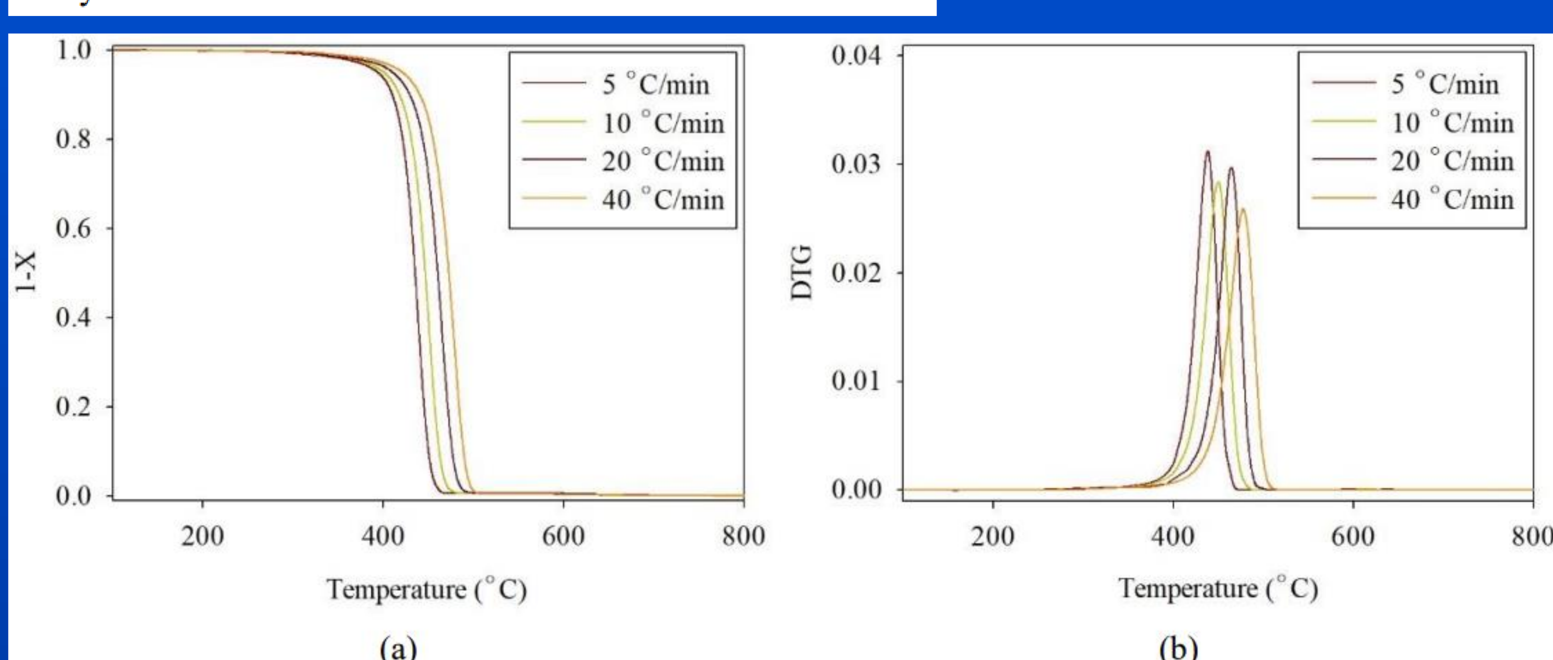

Figure 2: Non-catalytic TG curve and DTG curve
(a) TG curve, and (b) DTG curve

> Characterization of catalysts

Table 2: Physical properties of ZSM-5 catalysts

Ex-situ Materials	S_{BET}[a] m^2g^{-1}	V_{total}[a] cm^3g^{-1}	V_{micro}[b] cm^3g^{-1}
ZSM-5(30)	422	0.33	0.17
ZSM-5(80)	468	0.30	0.21
ZSM-5(280)	390	0.21	0.18

[a] Calculated via BET method.
[b] Calculated via the t-plot method.

Table 3: Physical properties of alumina catalysts

In-situ Materials	SiO_2/Al_2O_3[a]	S_{BET}[b] m^2g^{-1}	V_{total}[b] cm^3g^{-1}	V_{meso}[c] cm^3g^{-1}	d_{mean}[b] nm
Silica-Alumina	5.6	549	0.77	0.76	5.63
Al-SBA-15	8.5	334	0.66	0.64	7.87
Al-MCM-41	28.6	943	0.87	0.80	3.67

[a] Ratio calculated from XRF results.
[b] Calculated via BET method.
[c] Calculated via the BJH-plot method.

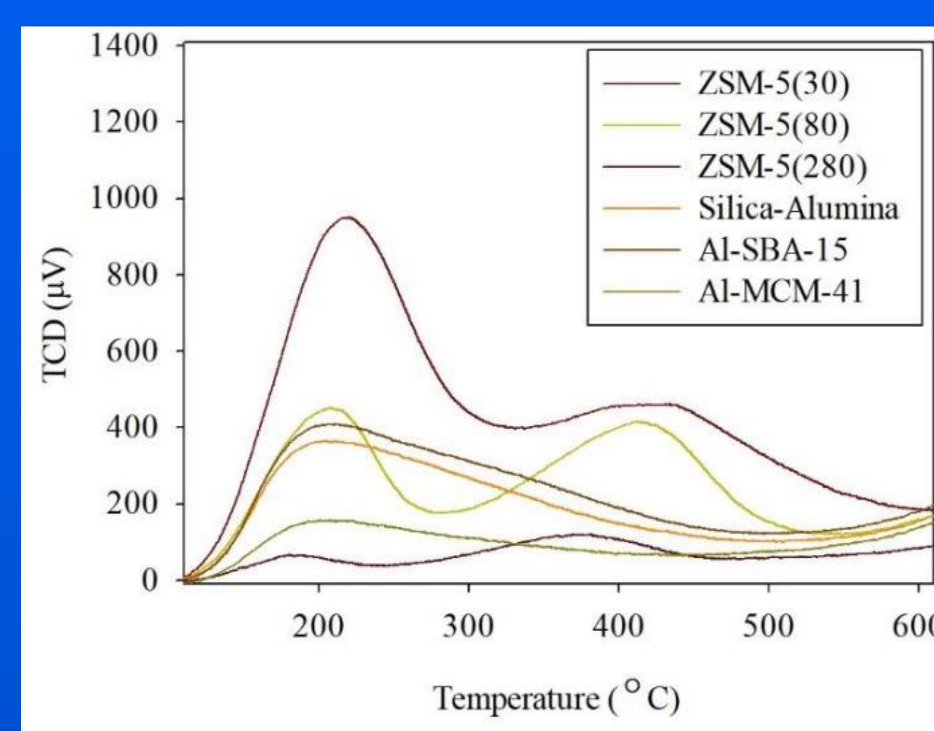

Figure 3: NH_3-TPD results of catalysts

> Fixed-bed pyrolysis results

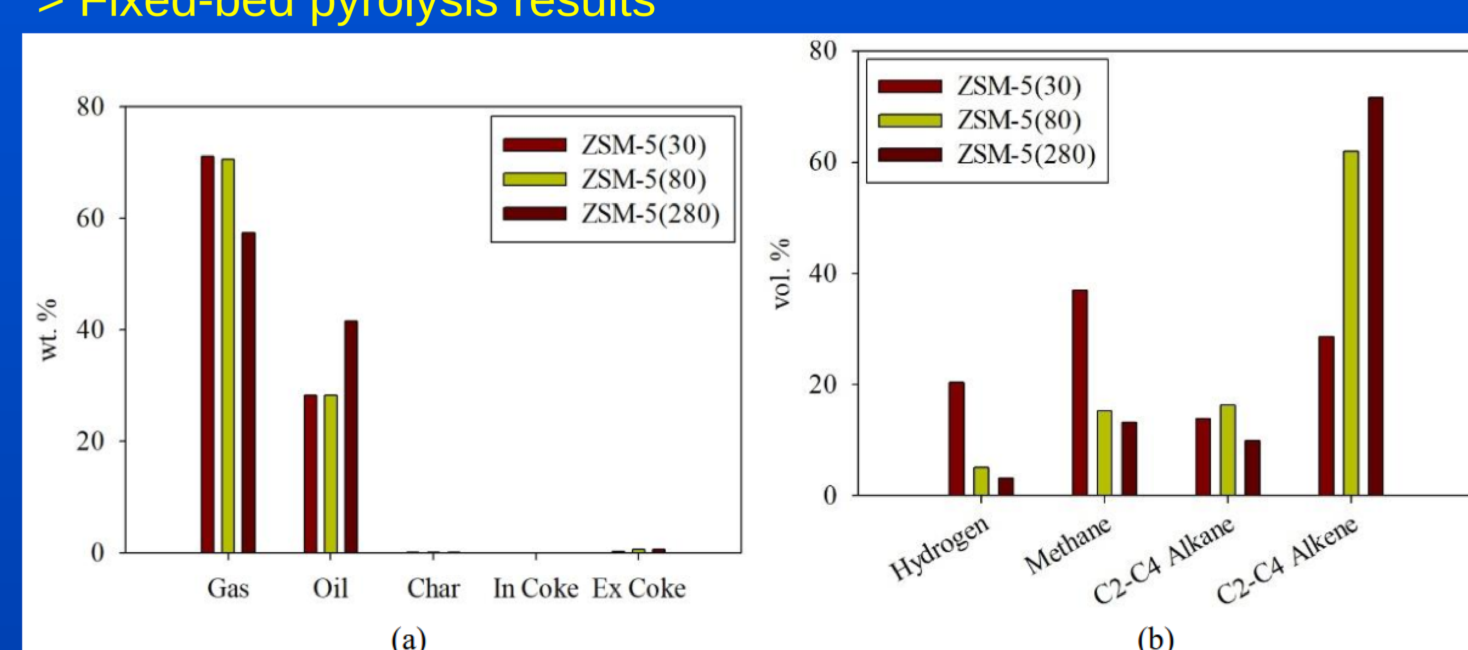

Figure 4: Pyrolysis products yield and the selectivity of gas components of ESCP
(a) ESCP products yield, and (b) ESCP gas components selectivity

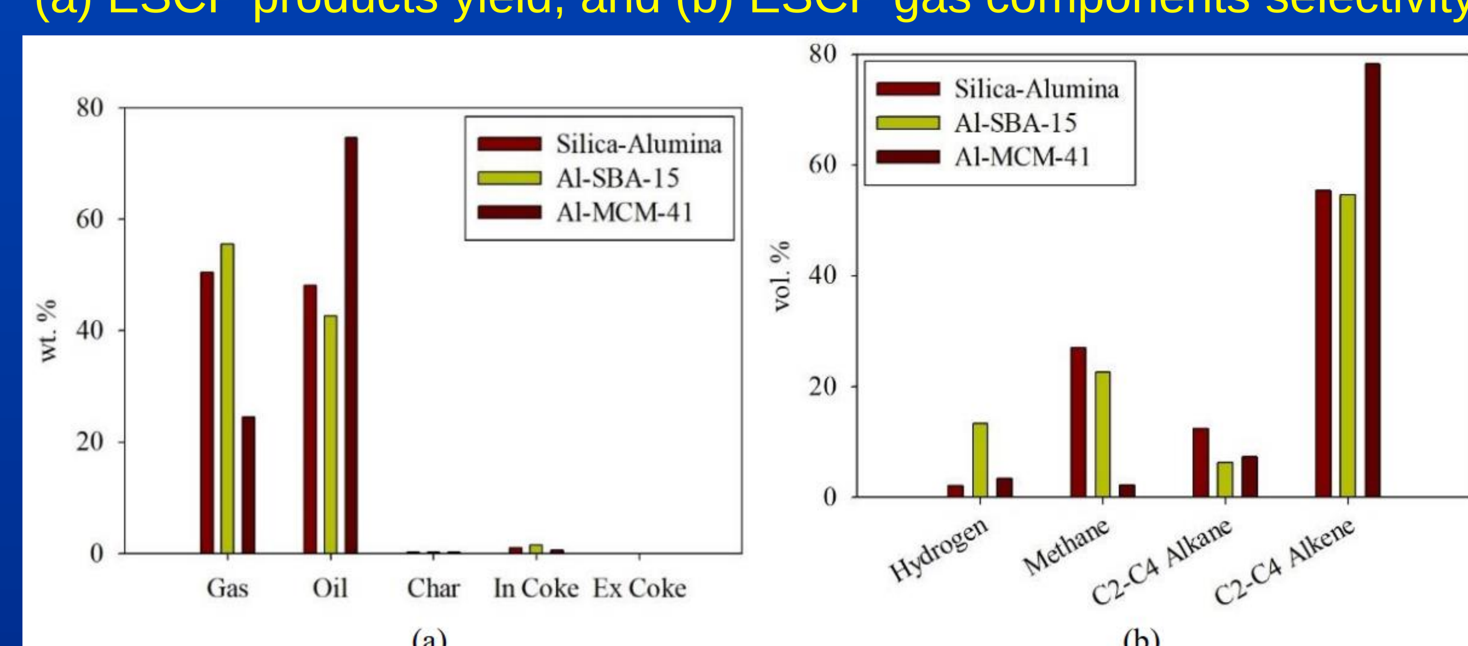

Figure 5: Pyrolysis products yield and the selectivity of gas components of ISCP
(a) ISCP products yield, and (b) ISCP gas components selectivity

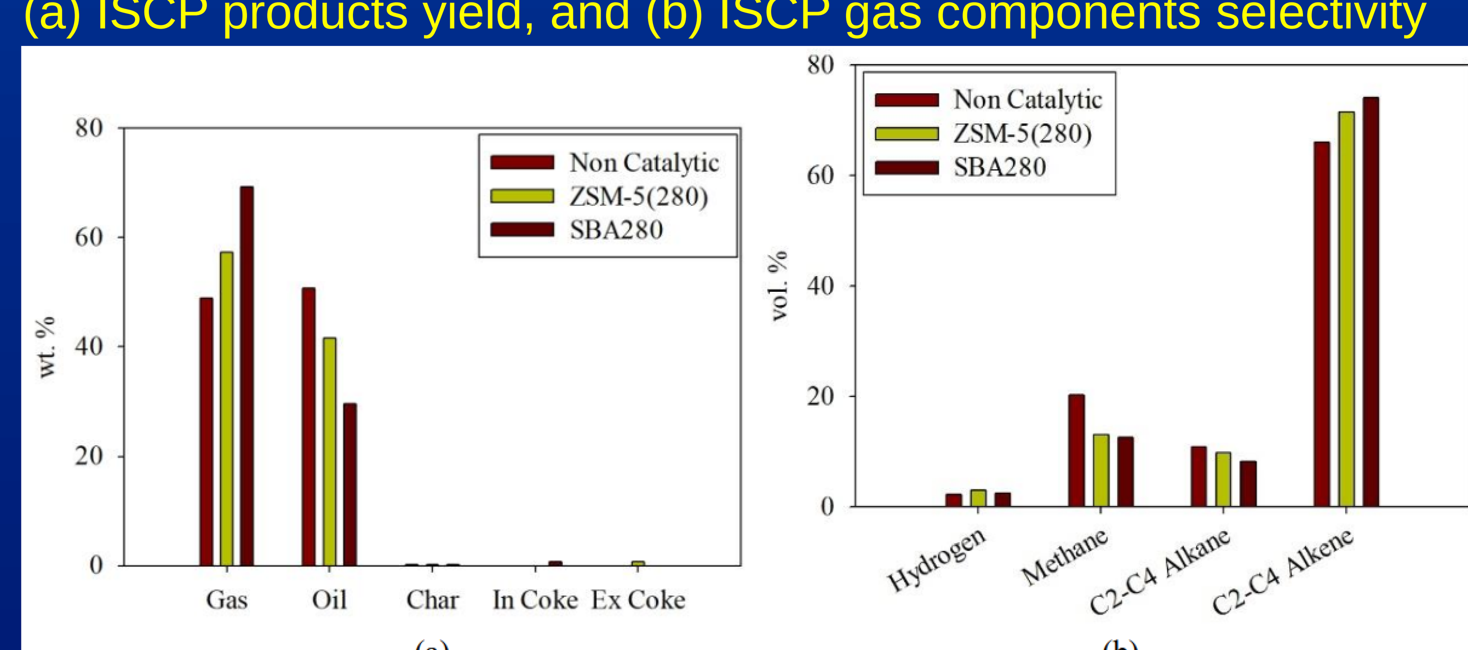

Figure 6: Pyrolysis products yield and the selectivity of gas components of TSCP
(a) TSCP products yield, and (b) TSCP gas components selectivity

Conclusions

As a result of ESCP, Z280 showed the highest olefin gas selectivity, while ISCP of S15 resulted in the highest gas yield. Therefore, TSCP was carried out using Z280 and S15, and it was confirmed that the gas yield and olefin gas selectivity were higher, and the ex-situ coke yield was lower than those in conventional ESCP. The lower coke yield leads to an extended lifetime of the ex-situ catalyst and enables a stable and prolonged production of olefin gas.

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