9^{th} International Conference on Clean Coal Technologies (CCT 2019)

Comparison of the Blending Effects of Three Types of Biomasses with Low Rank Lignite on Pyrolysis and Combustion Processes

Dr. Arzu Kanca

Outline

1. Introduction

- Energy profile of Turkey
- Renewable and Non-renewable energy potential of Turkey

2. Objective of the Study

Mixing of bio and fossil feedstocks as an energy source

3. Experimental Methodology

4. Results and Discussion

- Conventional analyses of Cotton waste (CW), Walnut shell (WS), Hazelnut shell (HS), and YC lignite (YCL)
- Pyrolysis and oxidation characteristics of coal, biomass, and blends

5.Conclusions

Introduction-Energy Profile of Turkey

Table 1. Energy generation profile of Turkey.

Resources	Generation (TWh)	Generation share (%)
Natural gas	108.1	37
Hydraulic	58.3	20
Domestic coal	44	15
Import coal	51.1	17
Renewables	26.5	10
Other	7.5	1
Total	295.5	100

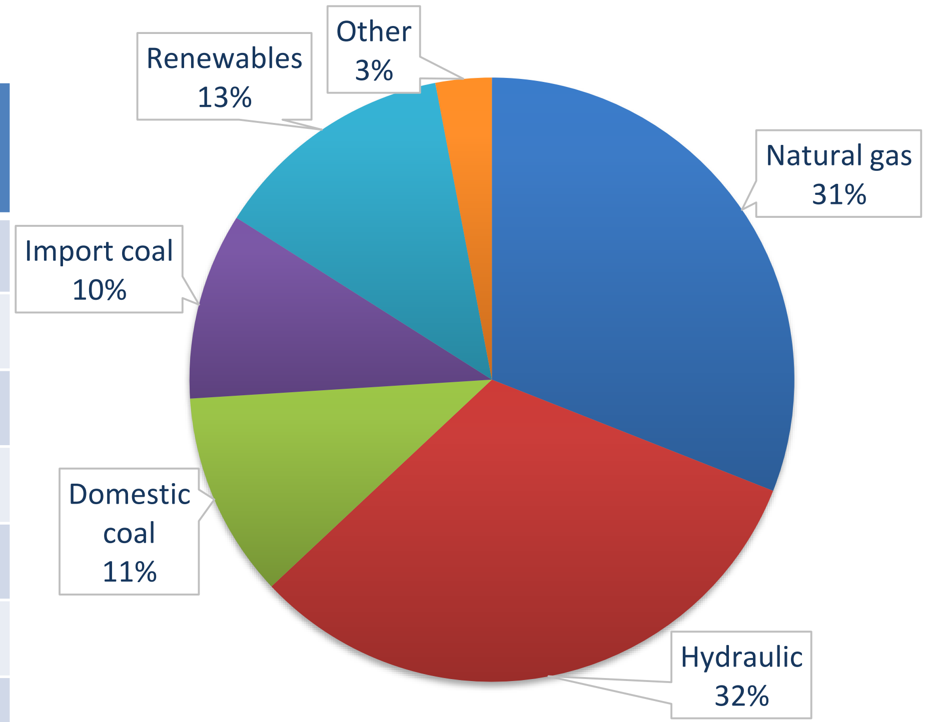


Figure 1. Install capacity shre of energy resources

Two main characteristics of the Turkish energy markets are growing energy demand and dependency on imports.

EPIAS Electricity market report, 2018 install capacity and generation Outlook in Turkey.

Introduction- Install capacity share of renewables

Table 2. Renewable energy profile of Turkey.

Source	Installed capacity (MW)	Number of plants
Hydraulic	27,273	618
Wind	6,516	161
Solar	3,421	3,619
Geothermal	1,064	40
Biomass	**575**	**98**

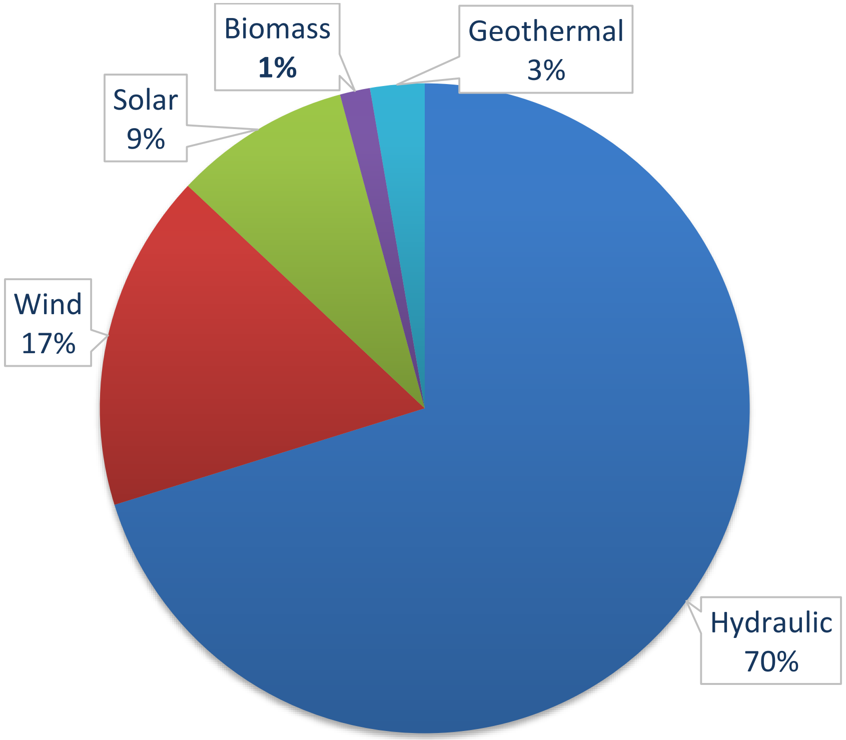


Figure 2. Install capacity share of renewable energy resources.

EPIAS Electricity market report, 2018 install capacity and generation Outlook in Turkey.

Introduction-Renewable and Non-renewable energy resources

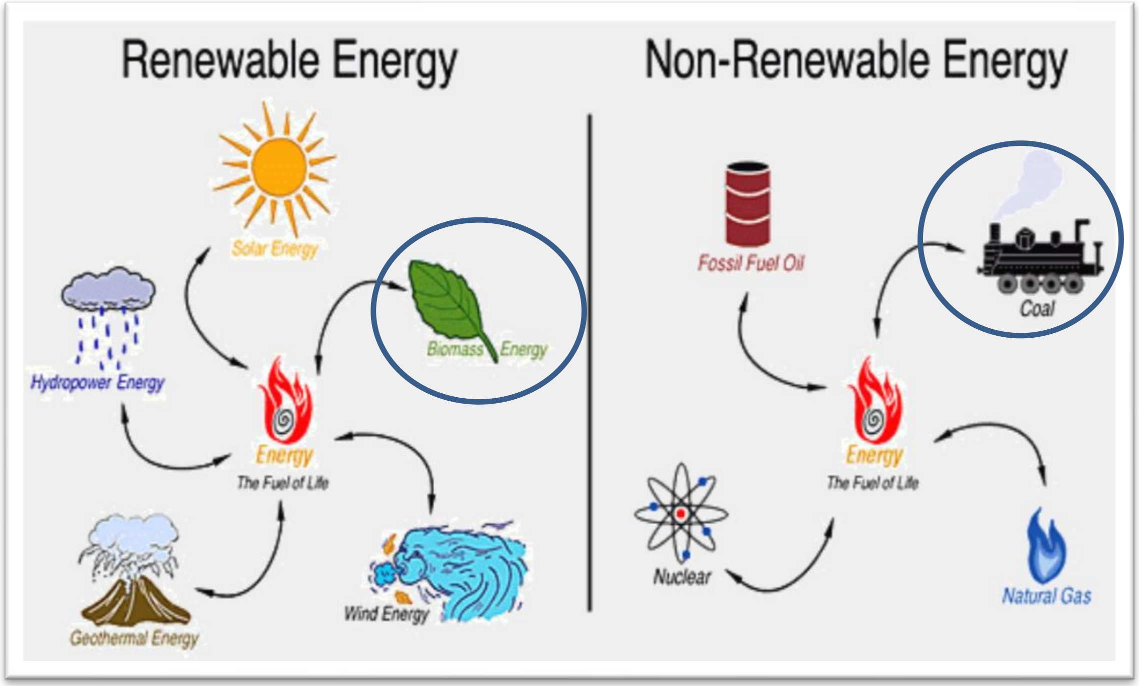


Figure 3. Renewable and non-renewable energy resources

Cotton Waste, Walnut Shell, and Hazelnut Shell are the large scale plant based biomass in Turkey.

http://technologygreenenergy.com/natural-resources-solar-energy/

Coal and lignite meet the demands for nearly 25% of Turkey's electricity generation. Turkey has 14 billion tons lignite and 1.3 billion tons hard coal reserves.

Objective

Research questions!

How can we improve the coal utilization challenges?

How can we increase the biomass utilization as an energy resources?

Co-operation?

The aim of this study is to compare the blending effect of **coal** and **biomass** on carbonization and combustion characteristics

- **Definition** of the raw materials.
- **Comparison** of their individial characteristics.
- **Evaluation** of pyrolysis and oxidation behavior of **coal and CW, HS, and WS blends** with 50% mixture ratio.

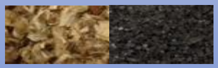
Experimental Methodology:

TGA experiments
20ºC/min, 30ºC-1000ºC
60 cc/min under N_2 flow for pyrolysis
100 cc/min underAir flow for oxidation

Obtaining of the fuel samples

Sample preparation with the homogenous particle size

Drying and mixing of the two solid samples with 50% blending ratios.



Characterization and Reaction tests

Proximate analysis Elemental analysis by CHNS analyzer

TGA-FTIR experiments under N_2 and air flow.

FTIR analyses
CH_4 ~3000 cm^{-1},
CO ~2200 cm^{-1},
CO_2~2300 cm^{-1},
H_2S~1340 cm^{-1},
SO_2~1380 cm^{-1}

Figure 4. Experimental flow diagram.

Results-Conventional Characterization of Fuels

Table 3. Proximate and C&S Analyses

	CW	**WS**	**HS**	**Lignite**
Moisture (%)	6.48	9.76	10.09	3.19
Volatile (%)	**69.56**	**83.06**	**78.28**	24.83
Ash (%)	5.93	0.56	1.16	**48.38**
Sulfur (%)	0.25	0.020	0.022	**1.98**
Carbon (%)	40.64	38.13	38.48	35.90
Heating value (kcal/kg)	3744.5	4268.9	4386.0	3615.0

Lignite sample is high in ASH and SULFUR, while its heating value is LOW!

Results-Cotton plant residue, HS, and WS pyrolysis

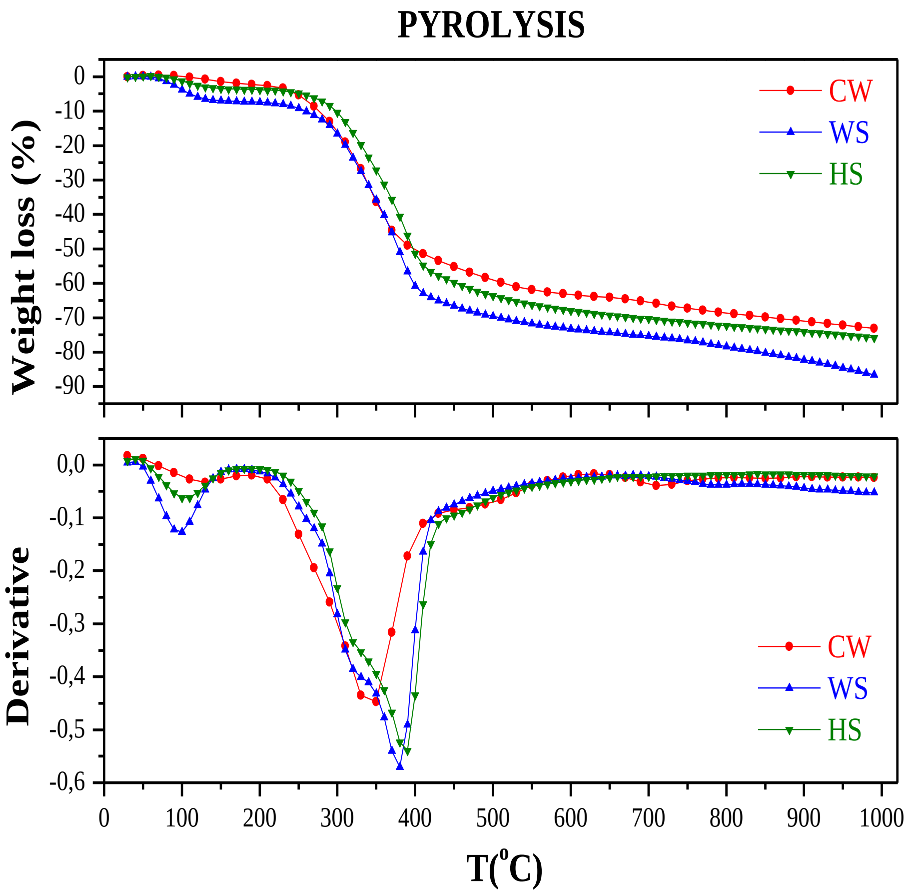


Figure 5. Comparison of biomasses during pyrolysis.

Table 4. Pyrolysis characteristics

Samples	Tpeak (°C) 1st region	Tpeak (°C) 2nd region	Total weight loss (%)
CW	350	710.1	73.1
WS	-	731.1	**86.6**
HS	-	748.6	75.8

✓ **Hemicellulose and cellulose contents of CW are more than WS and HS, while CW has the lowest lignin contents.**

Results-Cotton plant residue, HS, and WS oxidation

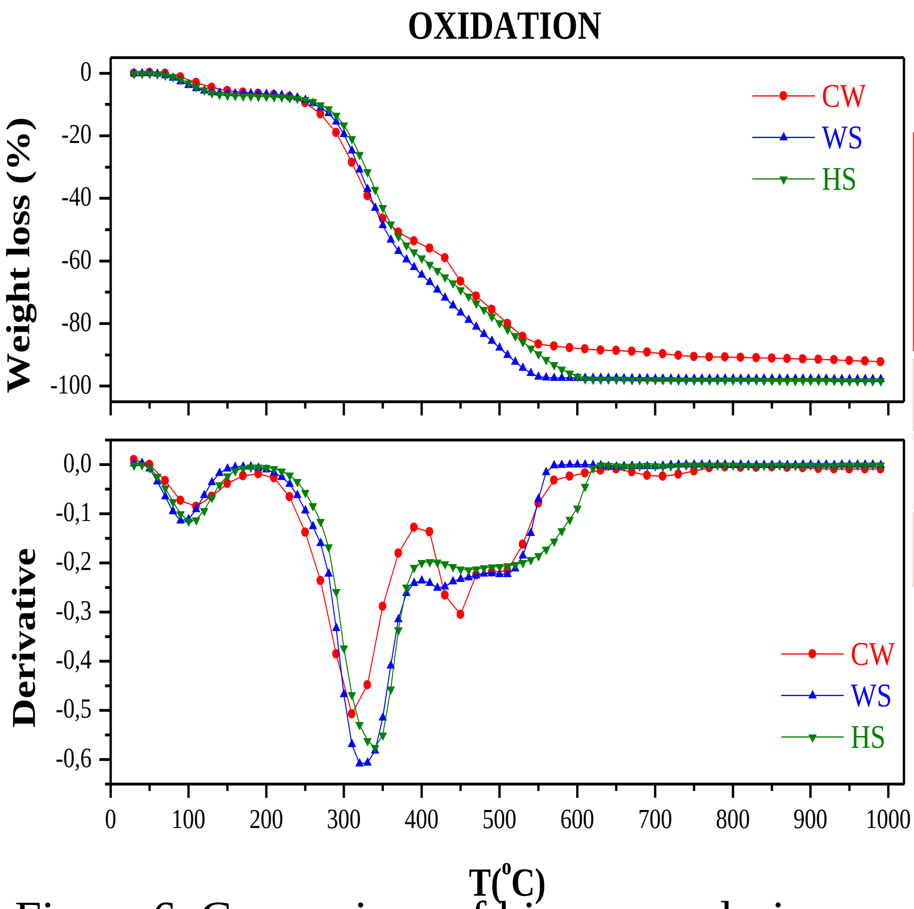


Figure 6. Comparison of biomasses during combustion.

Table 5. Oxidation characteristics

Samples	Tpeak (°C) 1st region	Tpeak (°C) 2nd region	Tig (°C)	Tb (°C)	Total weight loss (%)
CW	310.9	450.9	250.1	770	92.2
WS	321.8	425	285.5	570	97.7
HS	335.3	447.7	300	630	98.3

- ✓ **Ash compositon of biomasses is very LOW!**

- ✓ **CW, WS, and HS have differences in their chemical structure.**

Results- YC lignite and CW Blends

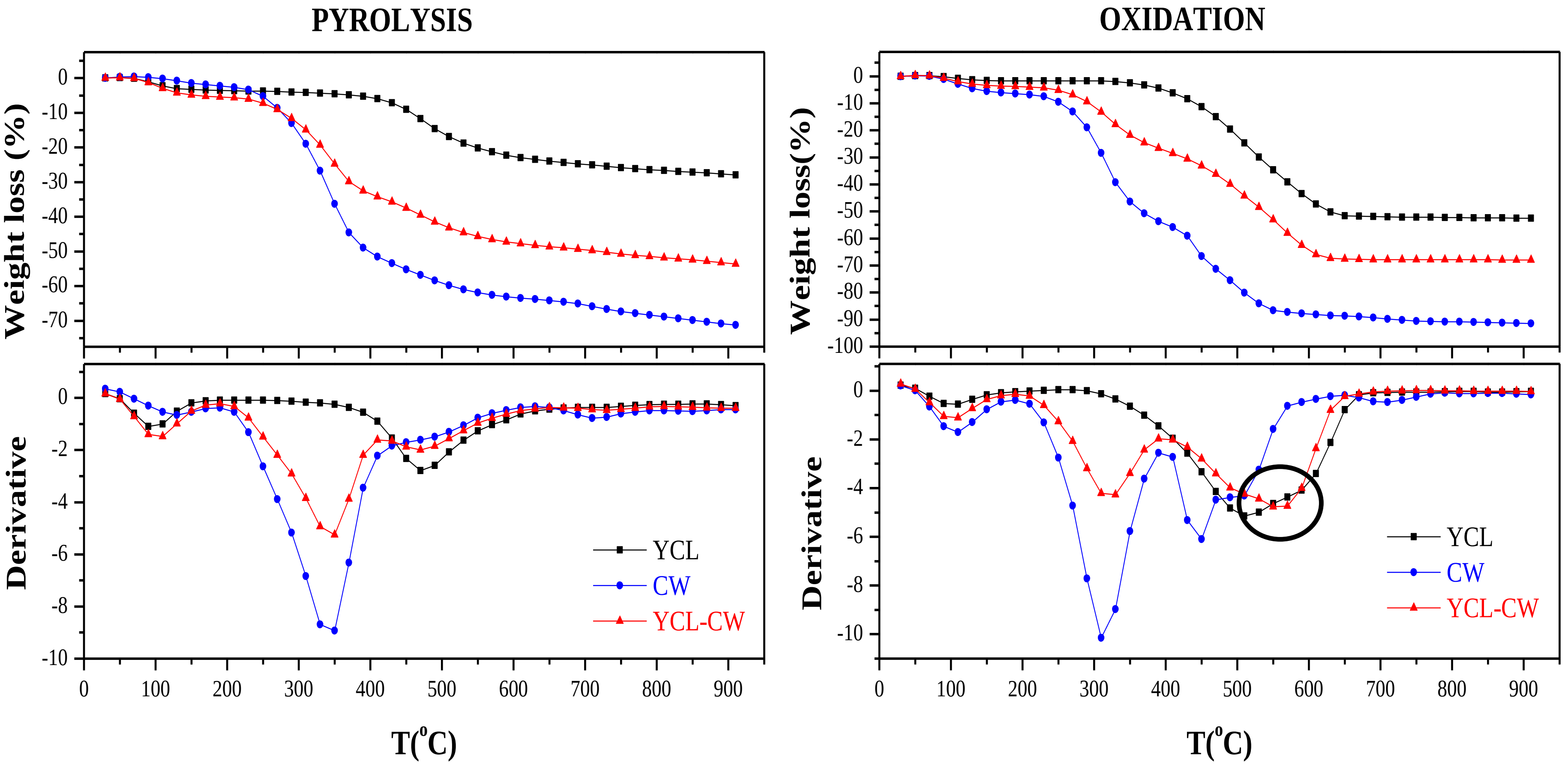


Figure 8. Pyrolysis and combustion behavior of YCL and CW blends.

No synergy between the fuels during pyrolysis, while synergistic interaction between CW and YC lignite is possible during combustion.

Results- YC lignite and WS Blends

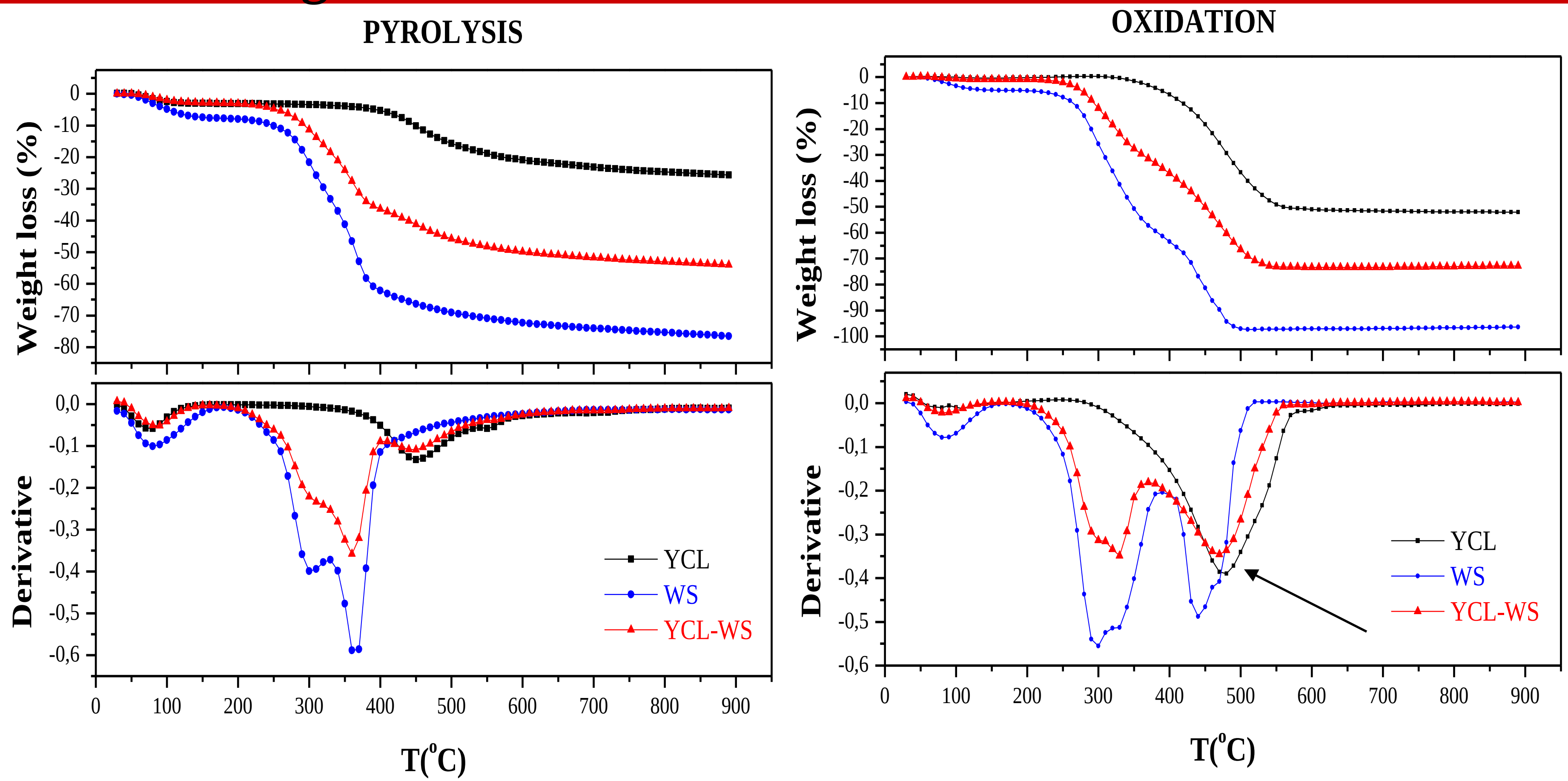


Figure 9. Pyrolysis and combustion behavior of YCL and WS blends.

Synergistic interaction between CW and YC lignite is possible during combustion.

Results- YC lignite and HS Blends

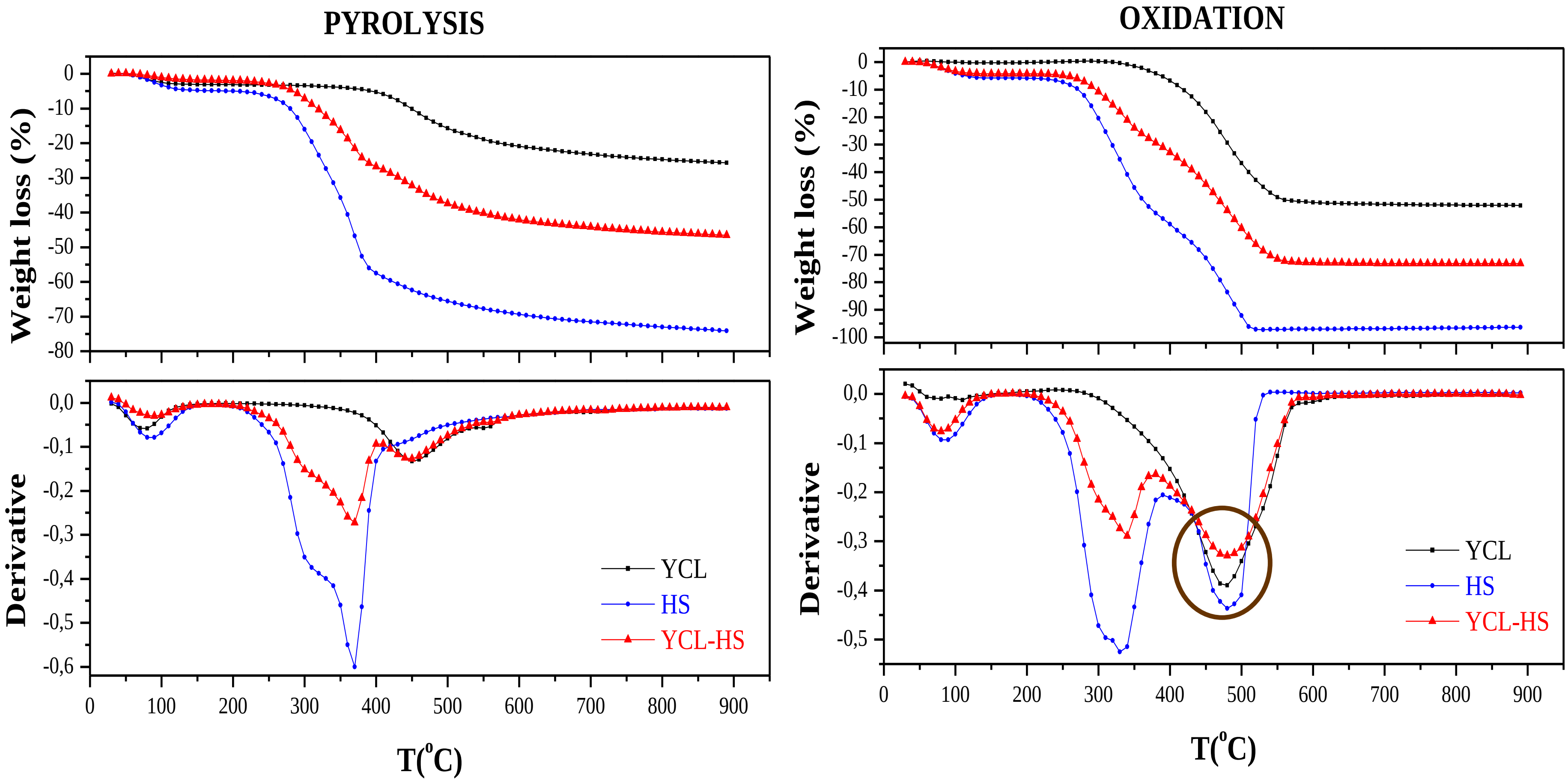


Figure 10. Pyrolysis and combustion behavior of YCL and HS blends.

Synergy between YC lignite and HS is more distinctive than the other fuel blends, during combustion.

Results- Comparison of the YC lignite and Biomass Blends

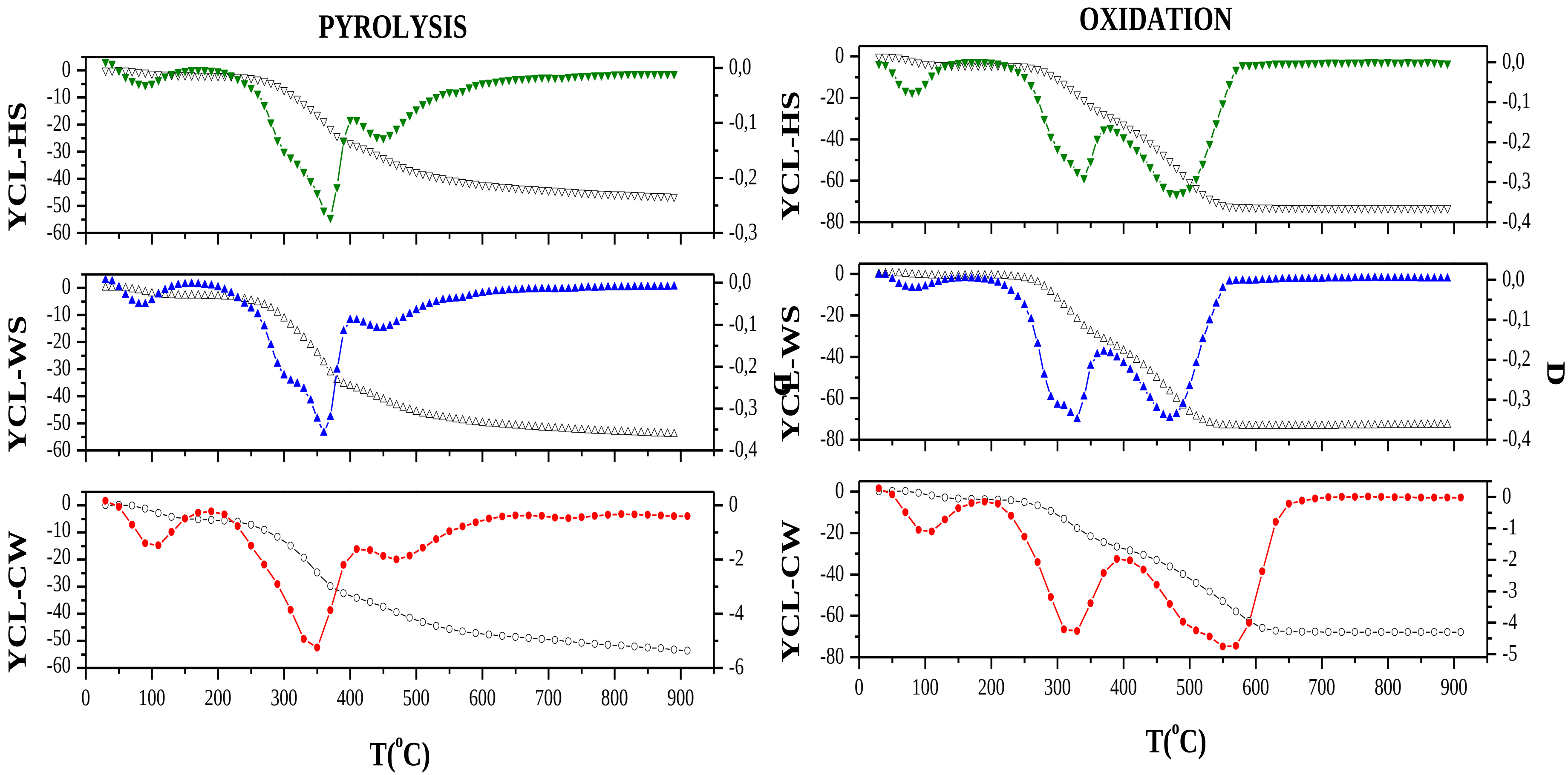


Figure 11. Comparison of YCL and biomass blends during pyrolysis and oxidation.

Different interaction behavior verifies the different chemical structure of biomasses.

Results- Comparison with respect to H_2S emission

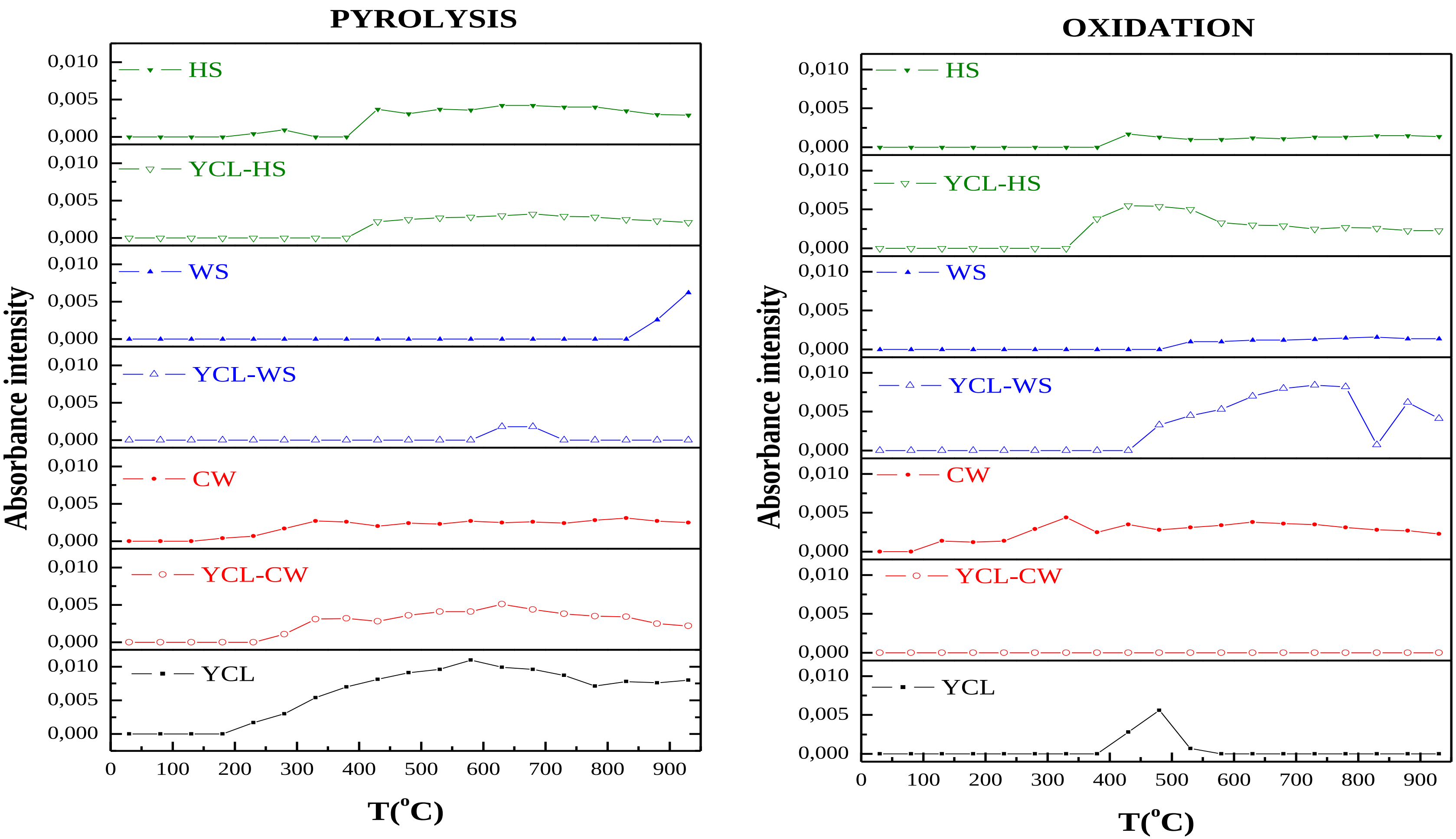


Figure 12. H_2S evolution of fuels during pyrolysis and oxidation.

The presence of biomass causes to delay in H_2S evolution during pyrolysis.

Results- Comparison with respect to SO_2 emission

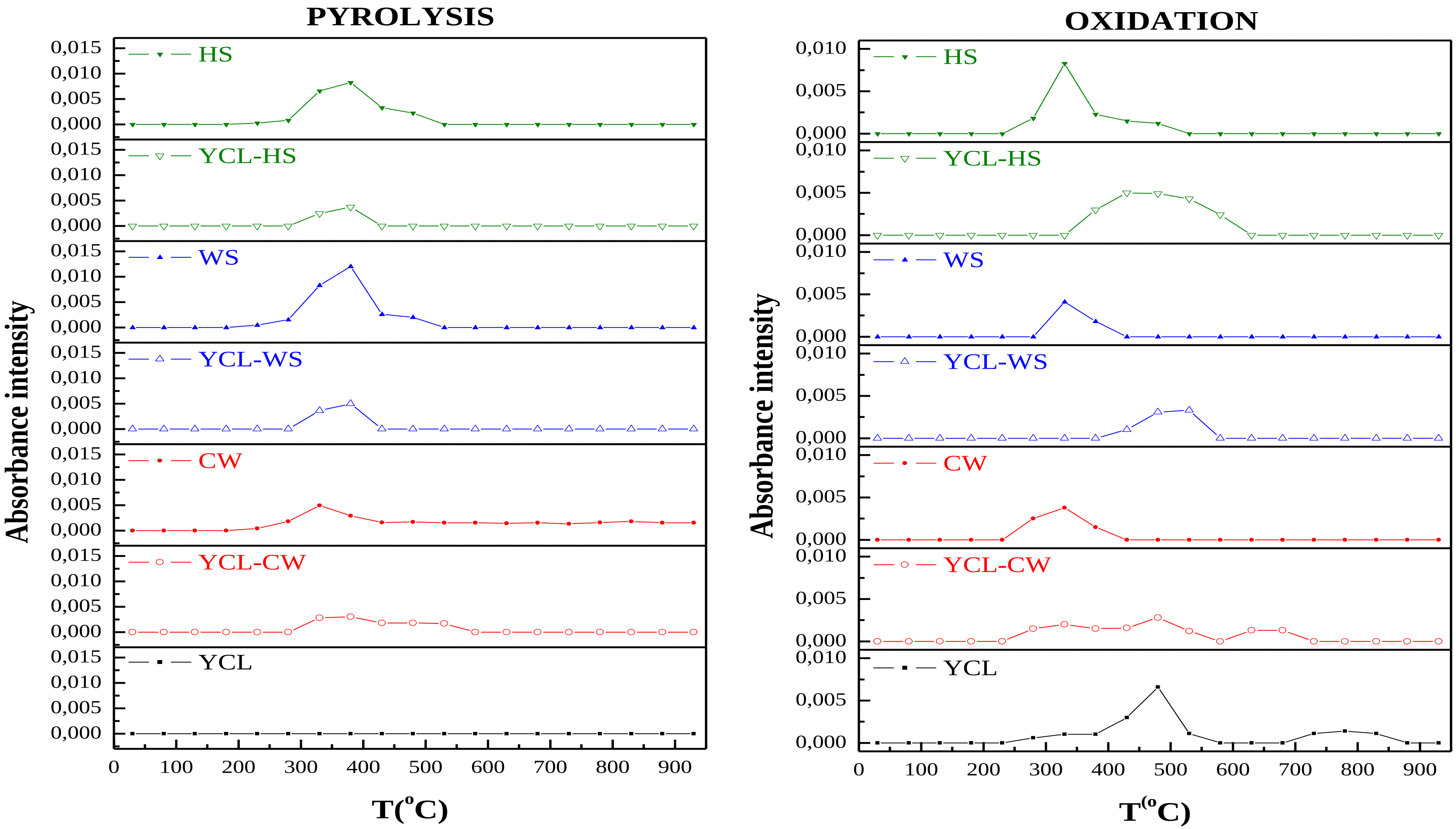


Figure 13. SO_2 evolution of fuels during pyrolysis and oxidation.

The presence of biomasses makes SO_2 evolution possible under pyrolysis condition.

Conclusions

- Coal and renewable energy are two imporatnt domestic energy resources.

- Chemical structure of biomasses are different from each other. Cellulose and hemicellulose contents of CW are higher than those of WS and HS.

- The cellulose, hemicellulose and lignin contained by biomass help to ignite and enhance the rate of pyrolysis and combustion.

- Similar heating values of all fuels and synergistic interaction reveal that YC lignite, CW, WS, and HS are the promising candidates as the mixed fuel resources.

- Coprocessing of coal and biomass leads to lower sulfur emission than alone coal processing.

- The interaction between the fuels affects the evolution temperatures (also time) of sulfur based gas emissions.

Acknowledgement

Ataturk University/Scientific Research Project 2016-18.

Ataturk University/Chemical Engineering Department

Adıyaman Cotton Factory

The Turkish Coal Enterprises (TKİ)

Thank You