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Pyrolysis of polyethylene-lined waste paper cups

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Pyrolysis of polyethylene-lined waste paper cups

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Outline of the Presentation

Research Objectives

Experimental set-ups:

- Conventional batch slow pyrolysis

- Microwave slow pyrolysis

Two types of coffee cups: Canadian and Italian

Feedstocks characterizations

Operating experiences

Initial products characterizations

Research Objectives

- Comparison between conventional pyrolysis and microwave pyrolysis of polyethylene-lined paper cups
- Preliminary data generation during batch slow pyrolysis to compare, in the near future, with continuous pyrolysis

Experimental Equipment (1): Horizontal Batch Pyrolysis Reactor



Experimental Equipment (2): Microwave Batch Pyrolysis Reactor



- 2.45 Ghz
- 2.4 kW
- Borosilicate Erlenmeyer flask reactor

Coffee Cups

Chlorine-Free Paper

A thin layer of LDPE (~5%)

Canadian cups with water based ink with no added heavy metals

White Italian cups



Canadian cup



Italian cup



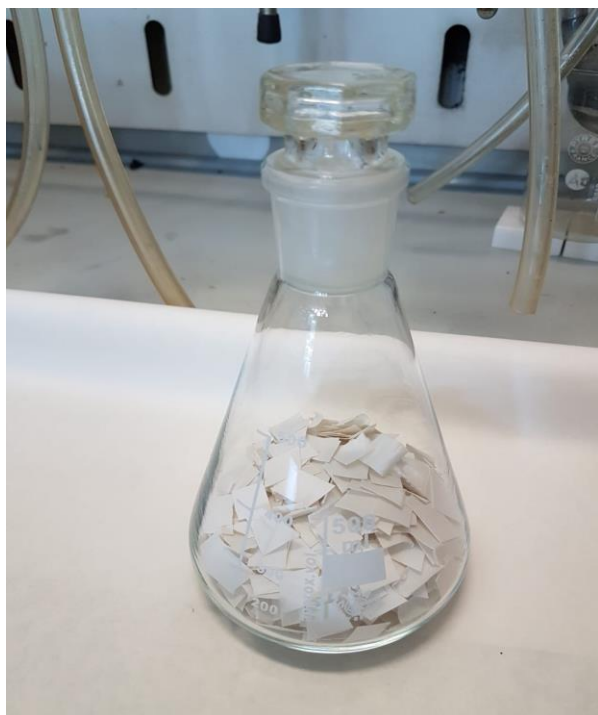
Microwave Pyrolysis

~ 30 g of shredded cups (0.5 cm x 0.5 cm) mixed with absorber

Absorber: Activated carbon or Iron powder

Heating rate: ~ 1.5 to 2 °C/s until 300 °C and then slow down to 0.8 °C/s or less

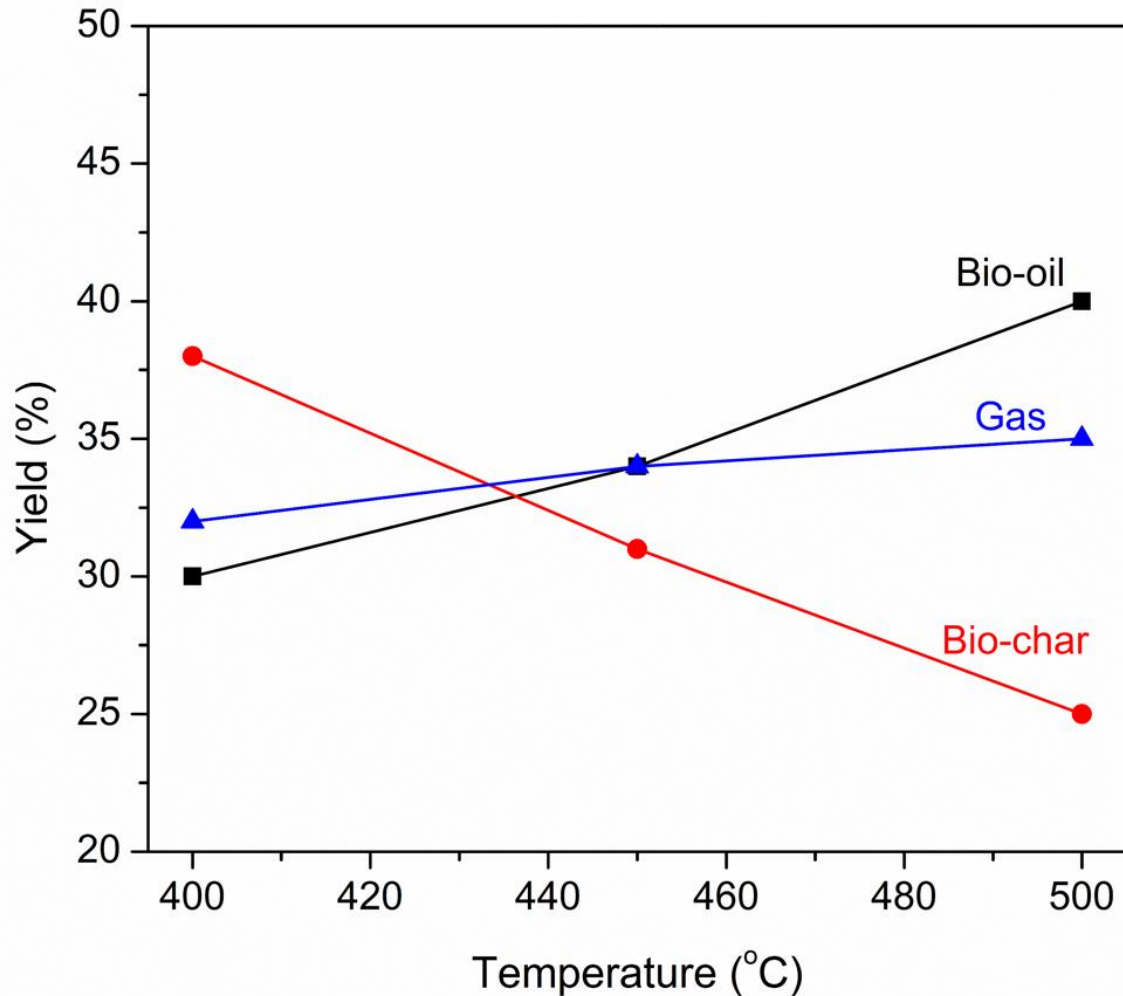
...but with the Canadian cups....



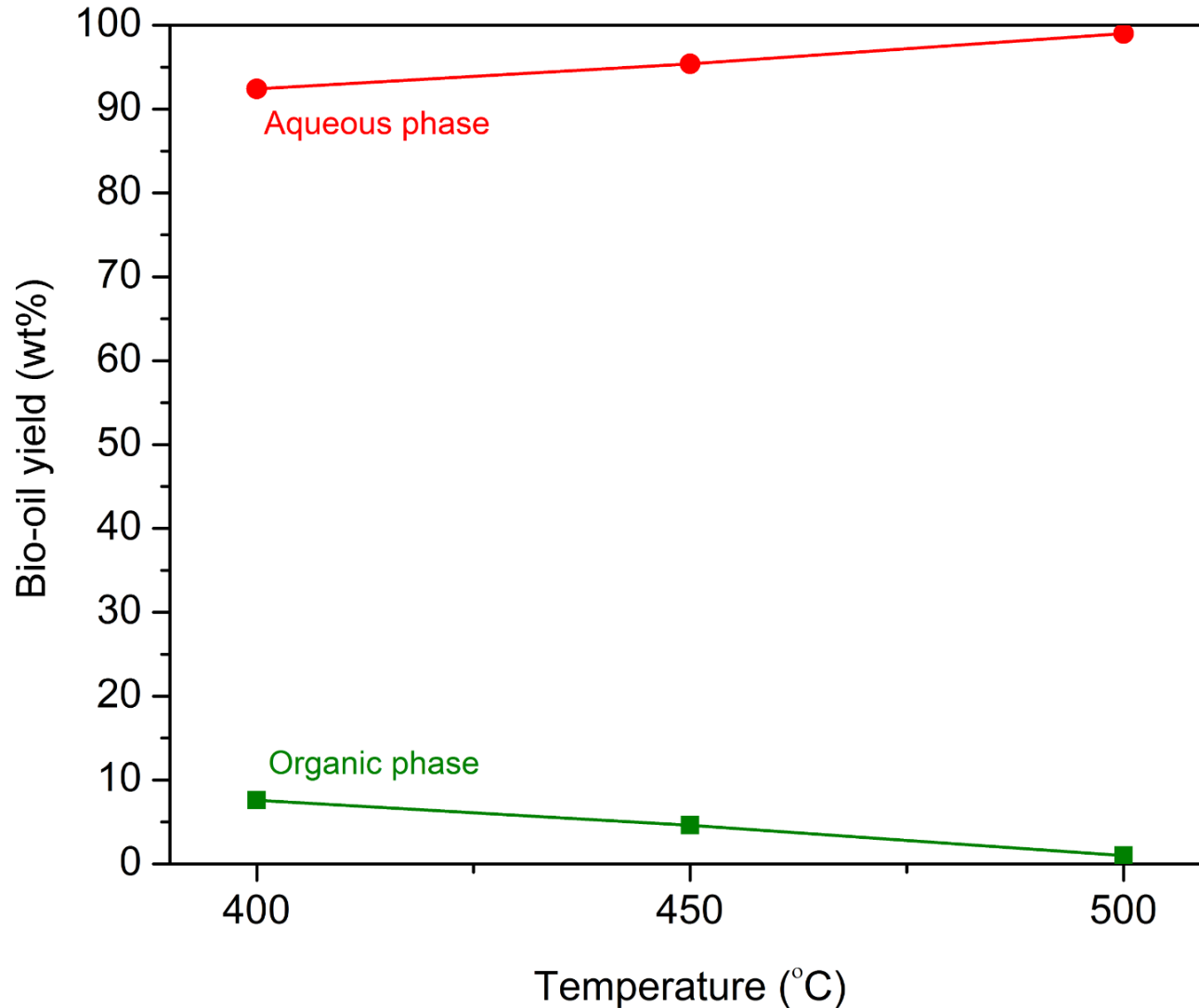
Canadian cups react violently if an absorber is used!
i.e.

NO ABSORBER NEEDED!

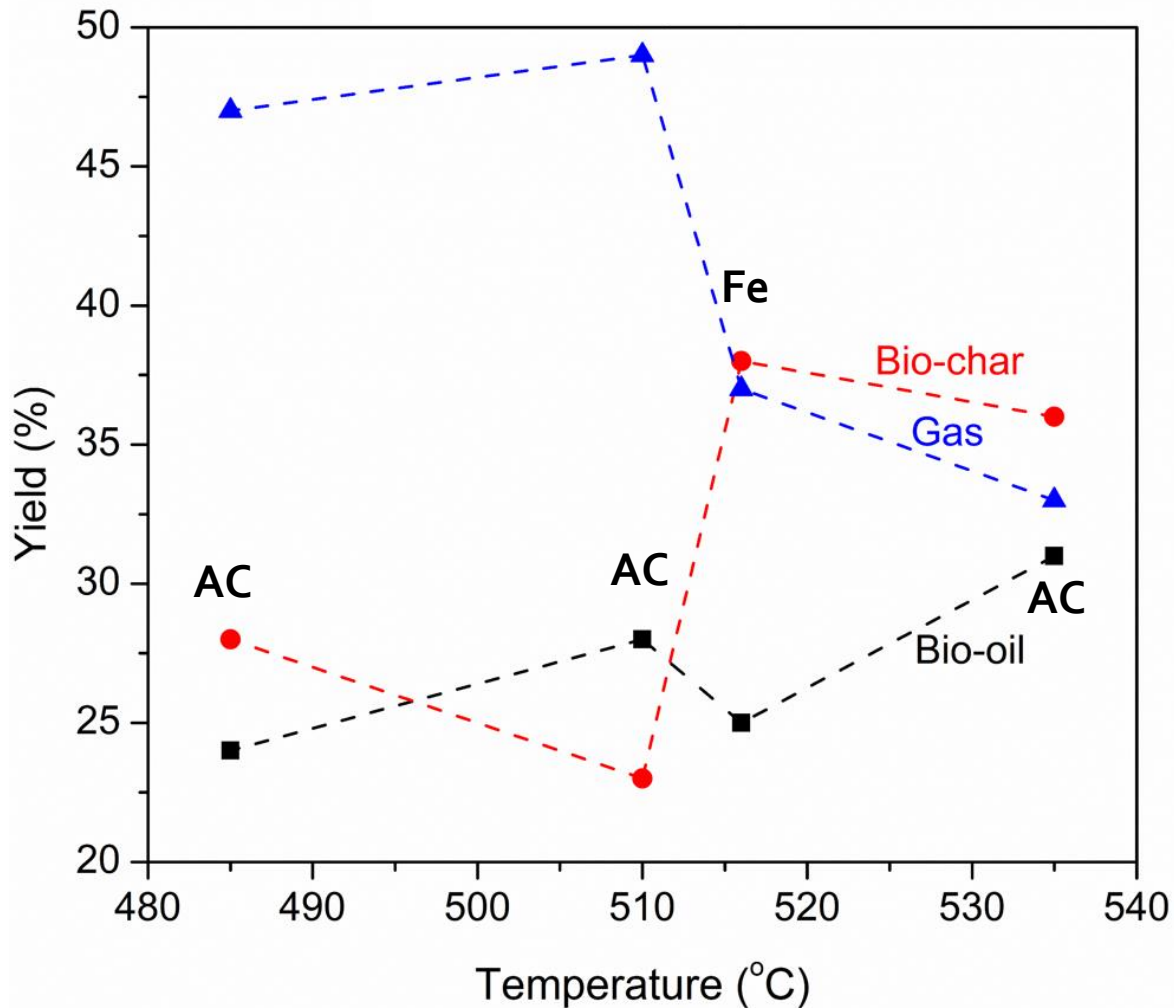
YIELDS: Conventional Pyrolyzer



YIELDS: Conventional Pyrolyzer



YIELDS: Microwave Pyrolyzer



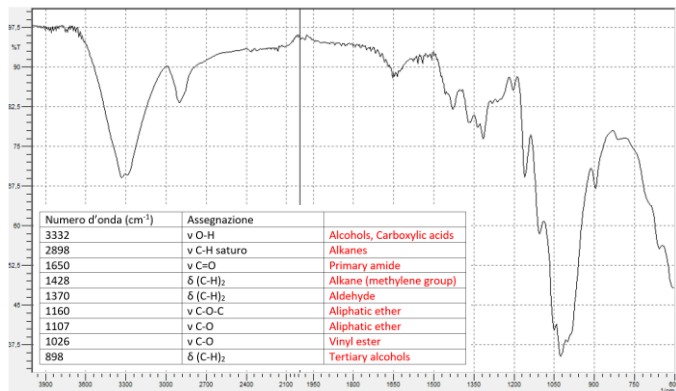
CONVENTIONAL PYROLYSIS RESULTS

	Raw Coffee cups	Bio-oil 400°C	Aqueous 400°C	Bio-oil 450°C	Aqueous 450°C	Aqueous 500°C
Calorific Value (MJ/kg)	17.9	26.8	4.3	28.3	4.3	6.2
Carbon	53.2	70.10	32.8	85.8	35.2	48.4
Hydrogen	11.3	11.7	7.1	8.6	10.2	16.5
Nitrogen	1.5	1.7	1.2	1.5	1.4	2.9
Sulphur	0	1.7	1.2	1.5	2.4	0
Oxygen	34	14.8	57.7	2.9	50.8	32.2

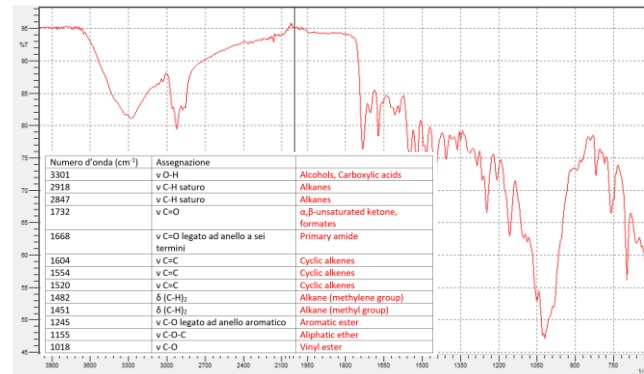
FTIR OF RAW MATERIALS

Italian Cups

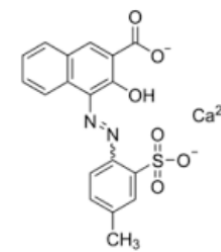
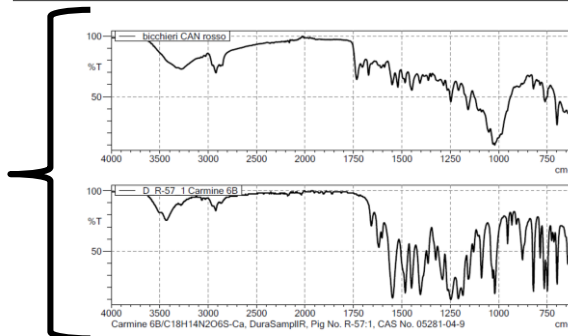
Exterior



Canadian Cups

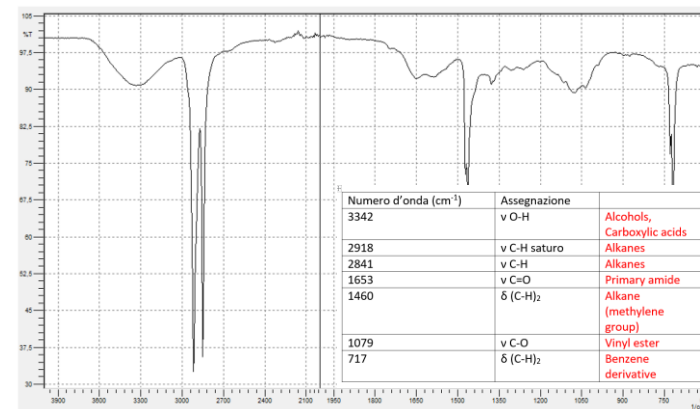
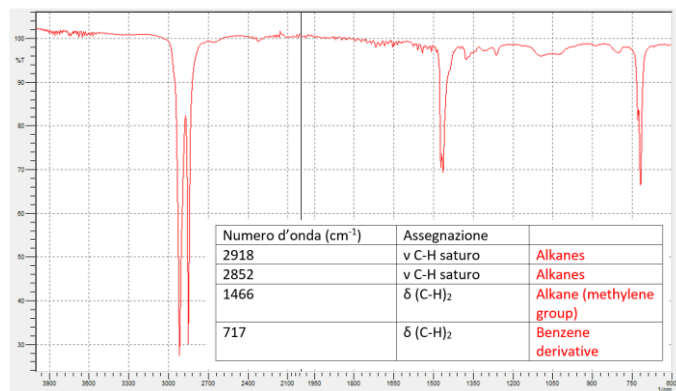


Red Dye

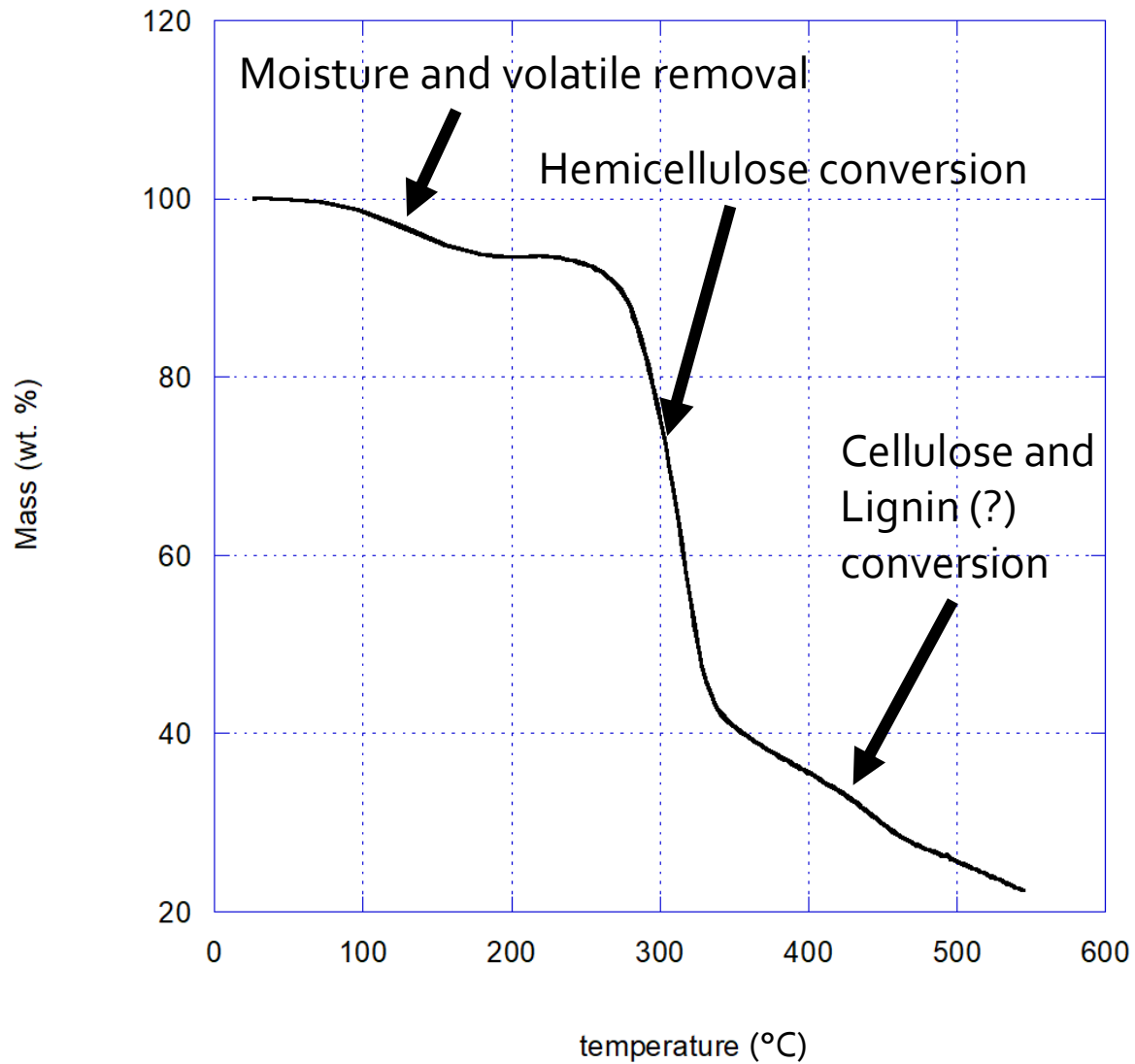


Lithol Rubine

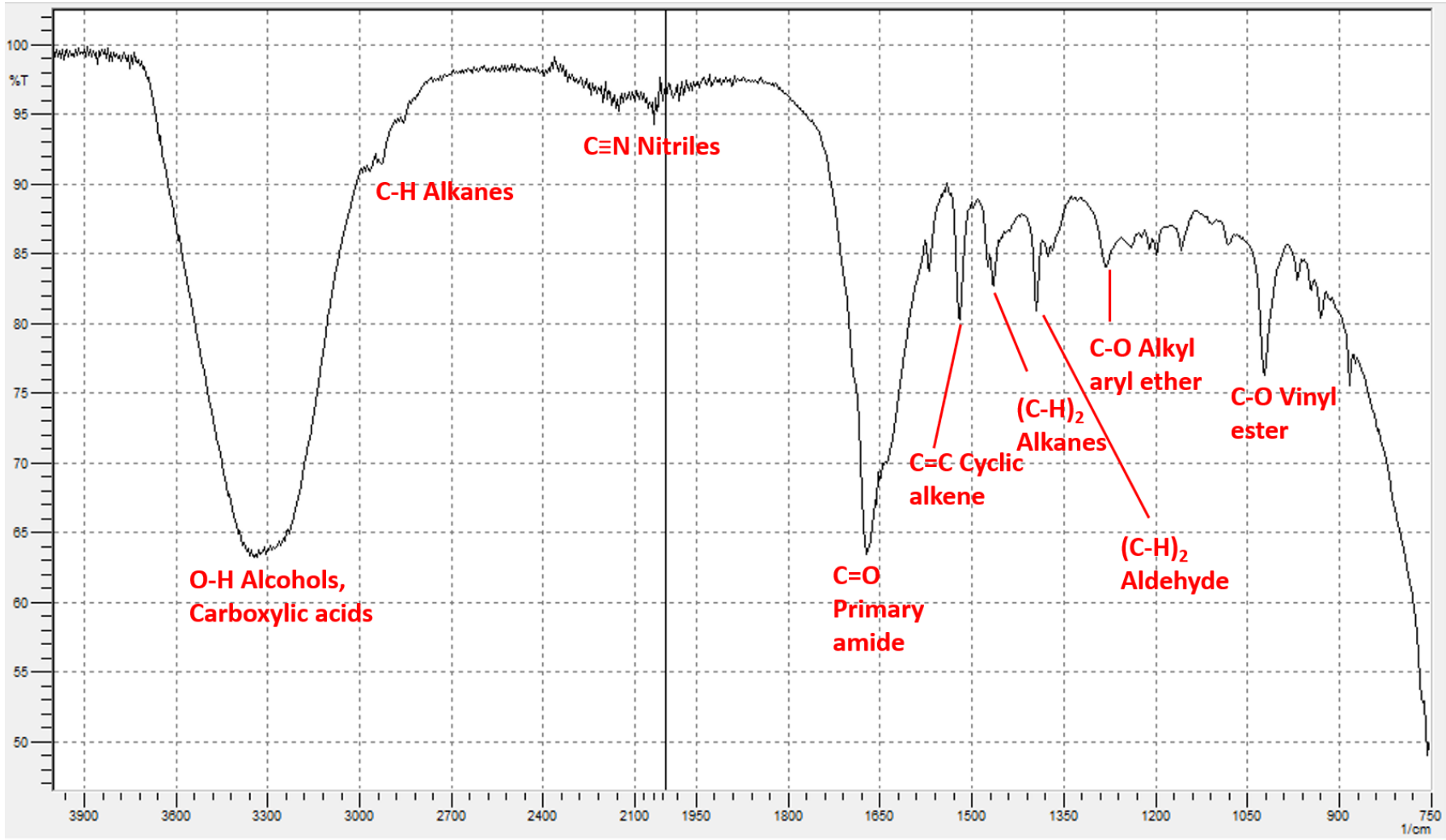
Interior



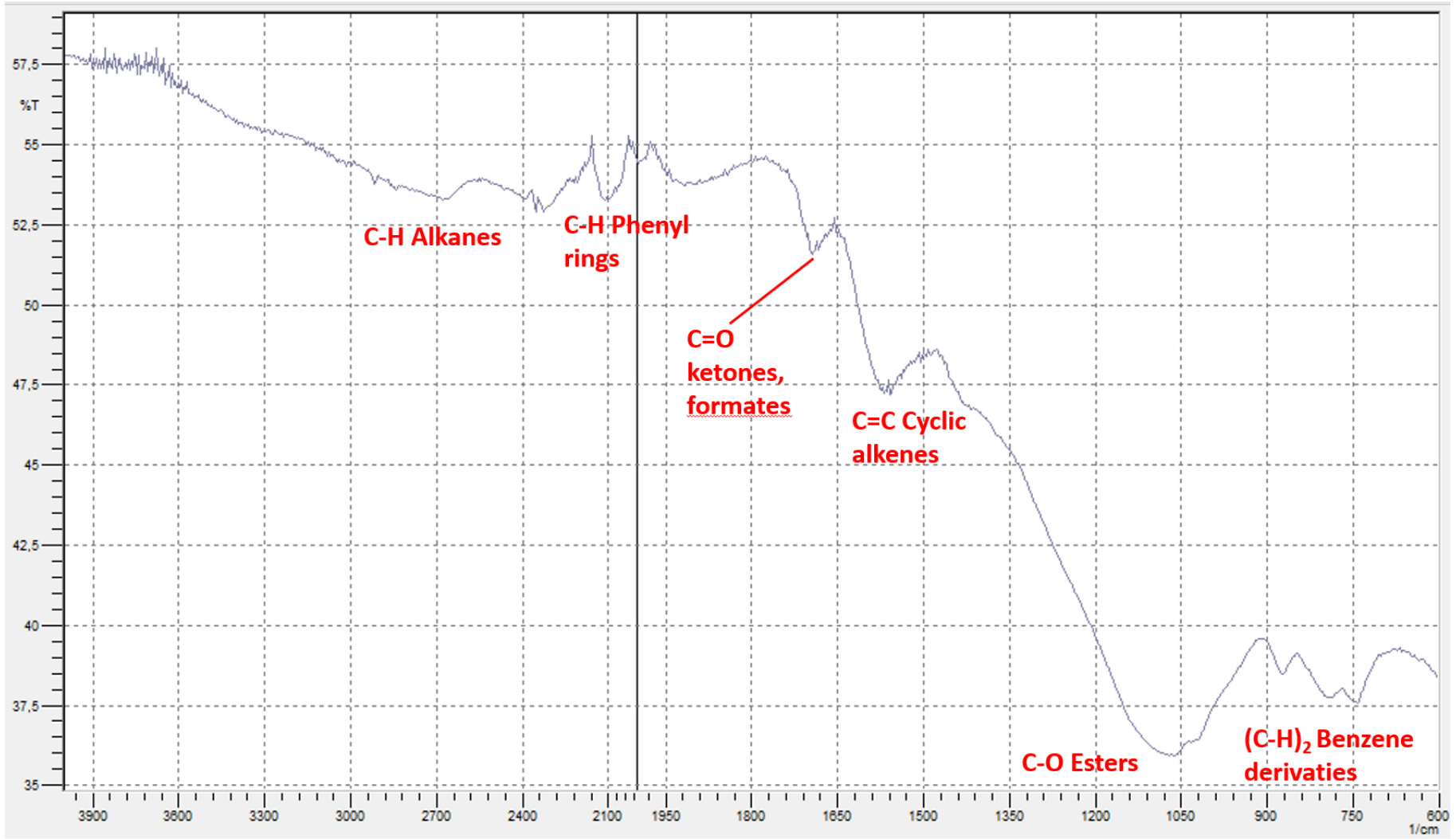
RAW MATERIAL: TGA



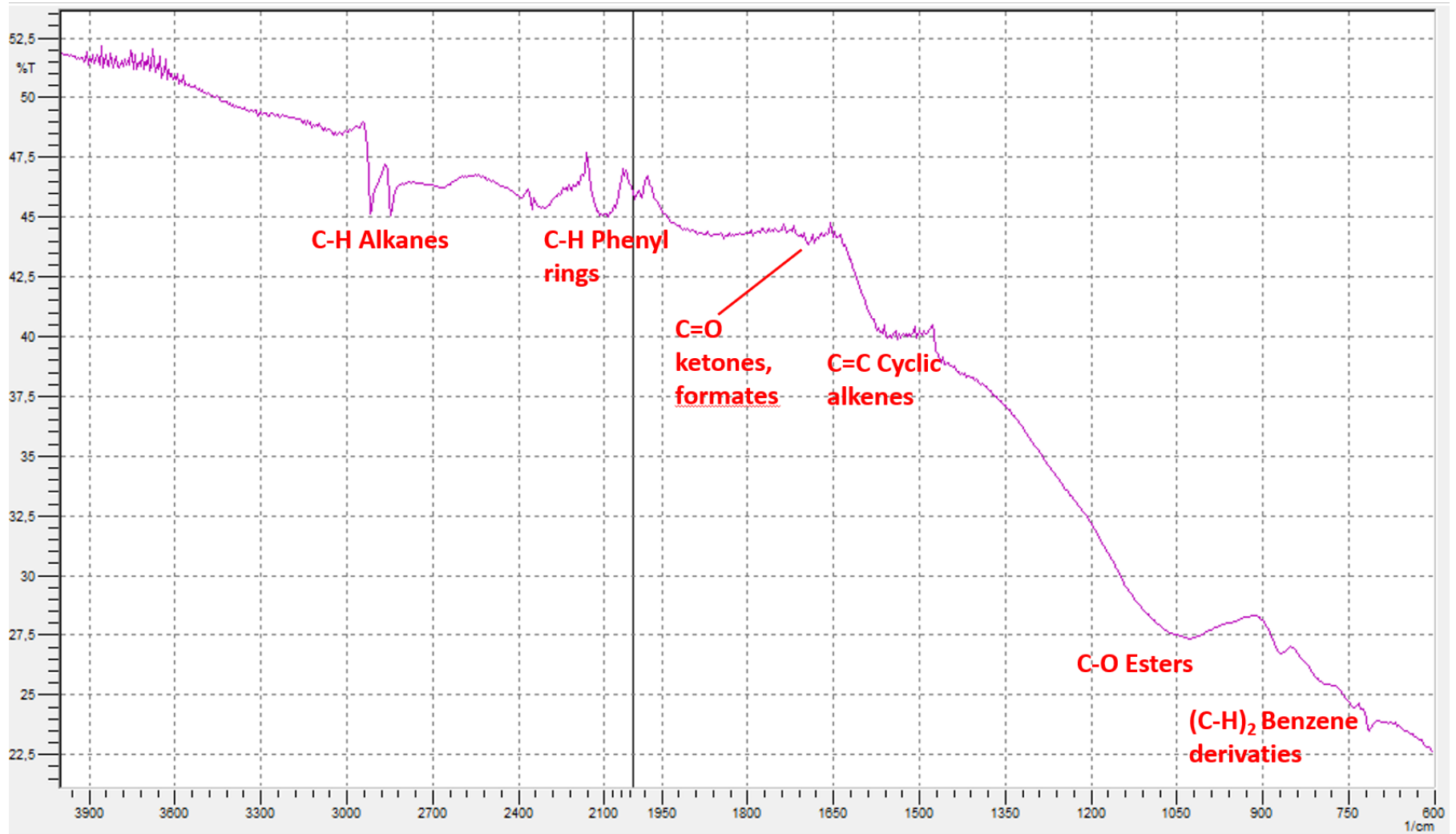
FTIR of biooil



FTIR of char [paper side]

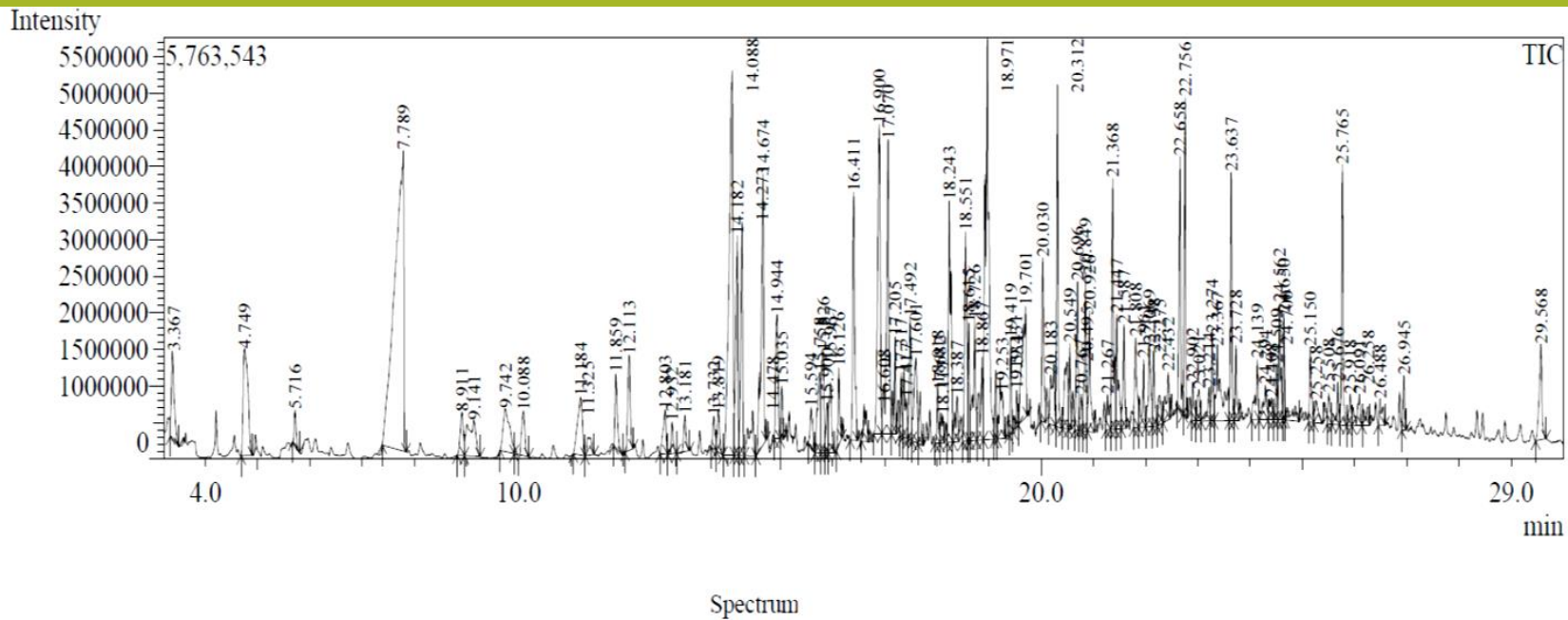


FTIR of char [polyethylene side]

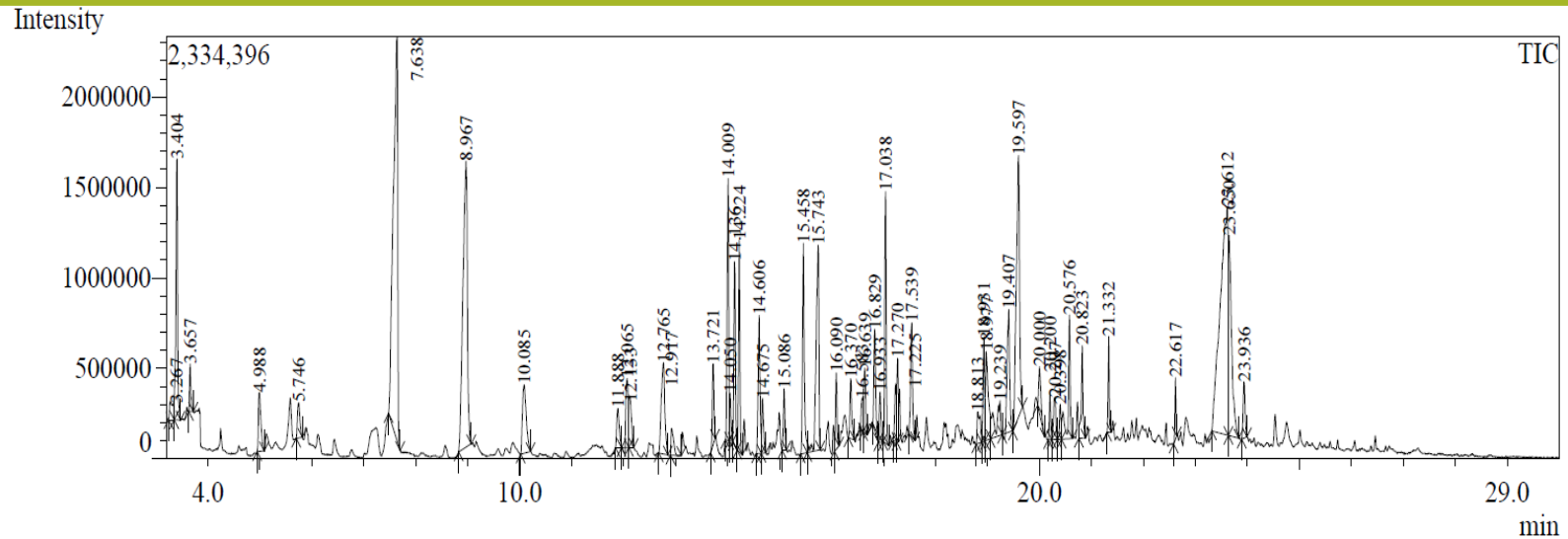


	Canadian Coffee Cups Conventional	Canadian Coffee Cups Conventional Aqueous 450°C (%Area)	Canadian Coffee Cups Conventional Whole Bio-oil 450 °C (Total % Area)	Canadian Coffee Cups Microwave ID 5 (%Area)	Canadian Coffee Cups Microwave ID 6 (%Area)	Italian Coffee Cups Microwave ID 3 (%Area)
Furfural	15.67	12.35	28.02	21.15	43.48	19.26
2-Furancarboxaldehyde, 5-methyl Ethanol, 2(1-methylethoxy)	7.43	3.1	10.53	13.59	0.43	12.25
Acetic acid	0.53	9.6	10.13	3.51	0.07	6.04
Propanoic acid, ethenyl ester	1.3	2.6	3.9	6.19	9.27	9.49
Phenol	3.1	2.64	5.74	17.2	7.02	19.58
phenol, 2-methoxy	3.9	3.8	7.7	0.34	0.05	0.05
Phenol, 3-methyl	3.6	0	3.6	0	0	0
Phenol, 2-methoxy-4-methyl	5.1	0	5.1	0.08	0	0.14
alpha-L-Galactopyranoside, methyl 6- deoxy	6.5	0	6.5	0	0	0
2-propanone,1-hydroxy	0	15.8	15.8	0	0	0
Ethyl(S)-(-)-lactate	0	0	0	0	5.1	0
3-Methylcyclopentane-1,2-dione	0	3.15	3.15	0	0	0
5-Hydroxymethylfurfural	0	3.9	3.9	0	0	0
Isopropylidenehydrazino)pyridazine- 3(2H)-thione	0	5.9	5.9	0	0	0.25
1,6-Anhydro-beta-D-glucopyranose (levoglucosan)	0	12.9	12.9	0	0	0
	0	4.3	4.3	0.38	0.06	0.05

Oily phase 450°C



Aqueous phase 450°C



Spectrum

Conclusions

Polyethylene coffee cups can be pyrolyzed either conventionally or with microwave technology

Careful with Canadian cups in microwaves!

A significant aqueous fraction is produced together with a small oily fraction of high calorific value

Initial characterizations show interesting results

Recommendations

More testing

More characterization

Continuous fast pyrolysis

Thank You