BLACK CYCLE

Move to the green revolution







Overview of the use of pyrolysis technology, roadblock and key success factors

Ramón Murillo Jennifer Shaw-Taberlet

Goals and Agenda Goals

Share the different application areas of the Pyrolise technology and identify the roadblocks and key success factors for the deployment of this technology



Agenda

Animated by : Ramon Murillo (CSIC) & Jennifer Shaw-Taberlet (AXELERA)

- Introduction and transitions and objectives (3') Ramon
- Pyrolysis overview (20')
 Ramon and Alberto



1. Introduction



<u>Linear economy model:</u> after use → throw away



<u>Circular economy model:</u> to maximize the use of the resources

EU-Parliament, 2015.



2. Chemical recycling



"Building blocks": chemical compounds with potential to be used to elaborate new products

https://www.energy.gov/science/bes/articles/bringingpower-chemical-fuels-artificial-building-blocks



Solvolysis Gasification **Pyrolysis**

3. Chemical recycling by pyrolysis

\rightarrow A brief of hystory:



Pyrolysis is the process used for the production of charcoal





4. Potential feedstocks for pyrolysis





4. Potential feedstocks for pyrolysis

OIL

crude oil

chemical industry

Plastic waste



Kim E, Choi WZ, (2019). J Mater Cycles Waste 21, 176-180

Feedstock	Elemental analysis (wt.%)					Proximate analysis (wt.%)			HHV
	С	Н	Ν	0	S	VM	FC	Α	(MJ/kg)
PS	86-93	7-9	0-6	0-2	<0.1	> 97	0-0.3	0-2	39-42
HDPE	83-87	13-15		0-1	<0.1	>86	0-13	0-2	46-50
LDPE	83-87	13-15		0-1	<0.1	>94	0-1	0-0.6	46-47
РР	85-87	12-15	0-1	0-0.2	<0.5	>95	0-2	0-9	46-47
PET	60-70	2-5	0-1	20-30	<0.1	> 86	0-14	0-0.2	20-25
WT	75-85	6-10	0-2	1-5	1-2	60-70	25-35	3-20	30-40
VVI	/5-65	0-10	0-2	T-2	1-2	00-70	20-00	5-20	50-40

Al-Salem et al., (2017). J Environ. Manage. 197, 177-198, Anuar Sharuddin et al., (2016). Energ. Convers. Manage. 115, 308-326.



Singh et al., (2020). J Energy Inst 93 (2020) 1020-1035



BLAC

4. Potential feedstocks for pyrolysis



Others?

- Waste Oils
- \circ Foam
- o Electronic residues
- o Petroleum residues
- Plastic Medical Devices and Pharmaceutical Packaging (masks...)
- \circ Algae
- Municipal solid waste
- 0 ...
- 0 ...
- 0 ...







4. About the importance of end-life-tires (ELT)



Because it shows serious environmental disposal and generation challenges, and because has embedded important raw materials susceptible to be recovered

Some facts:

- More than 1700 M of ELT are generated annually worldwide.
- Forecast to 2022: 2500 M
- EU27 + Norway + Swiss + Turkey ≈ 4 M t/year
- EEUU $\rightarrow \approx 4$ M t/year

Martínez (2021). Renew. Sust. Energ. Rev. 144, 111032



https://www.european-rubber-journal.com/news/potential-game-changer-end-life-tire-market

4. Pyrolysis of end-life-tires (ELT)



The pyrolysis of ELT can be regarded as a separation process (**chemical recycling**):

In the absence of oxygen and through temperatures above 500 °C, it is possible to release the volatile matter from the carbonaceous matrix (fixed carbon)



4. Pyrolysis of end-life-tires (ELT)





5. Some characteristics of the products

TPO \rightarrow Tire Pyrolysis Oil An interesting hydrocarbon but complex: HHV = 40-43 MJ/kg; MW_{AVG} = 420 g/mol (aprox.); C₆ – C₅₅

Structure:

HC pure (75%), HC-S1 (14%).

Tri-aromatics (26%), tetra-aromatics (13%) and penta-aromatics (22 and 30%). HC with S1 \rightarrow dibenzothiophene (31%) and benzonaphthothiophene (34%).



Property	ΤΡΟ	
C (wt.%)	86.6	
H (wt.%)	10.5	
N (wt.%)	1.3	
S (wt.%)	0.69	
O (wt.%)	0.78	
H/C	1.46	
API gravity	29.7	
IPB (ºC) ASTM D86	69.0	
T50 (ºC) ASTM D7500	253.9	
T90 (ºC) ASTM D7500	433.6	
FBP (ºC) ASTM D7500	550.9	





5. Some characteristics of the products

Raw rCB \rightarrow Raw recovered carbon black

A blend of many virgin carbon blacks + carbonaceous deposits + inorganics (up to 20 wt.%)



Standard Terminology Relating to Recovered Carbon Black (rCB)¹

D8178-19

raw rCB, *n*—solid material resulting from thermal decomposition of rubber goods which contain carbon black; exhibiting poor dispersion so requiring milling to become rCB.

recovered carbon black (rCB), *n*—solid product recovered via thermal decomposition from rubber goods which contain carbon black, which is free of wire and fabric, and when milled typically gives semi-reinforcing properties in rubber.

Raw rCB vs. vCB \rightarrow PSD, structure very heterogeneous. Differences in the chemistry surface, and in the area surface.



Martínez et al. (2020). In: Tyre Waste and Recycling, Elsevier Inc., 630p (chapter 9.2) Cardona-Uribe et al. (2021). Sustain. Mater. Technol 28, e00287.

6. Potential applications





7. Potential reactors







¡Thank you!

Ramón Murillo Instituto de Carboquímica (ICB) Grupo de Investigaciones Medioambientales (GIM) Consejo Superior de Investigaciones Científicas (CSIC) <u>ramon.murillo@csic.es</u>





Subgroup time

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Objectives of the subgroups, logistics and expected deliverables

4 working groups, 1 facilitator/group

- > Why pyrolysis is not yet so present in the market?
- What are the feedstock that interrest you in pyrolysis?
- Start with post-it to open the discussion
- Feedback working groups (5min/groups) Facilitator/groups

Conclusion

THANK YOU

BLACK CYCLE

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Together To Make The Circular Economy A Reality