Università
Ca'Foscari
Venezia
Dipartimento di Scienze
Molecolari e Nanosistemi

Valorizzazione termochimica dei rifiuti plastici: utilizzo del char come vettore per il reinserimento del carbonio in filiera.

Michela Signoretto,
Nicola Vecchini

Università Ca'Foscari Venezia
Dipartimento di Scienze Molecolari e Nanosistemi

Methods of valorization of waste

1

PHYSICAL

Mechanical extraction
Pelletizing
Distillation

2

CHEMICAL

Hydrolysis
Transesterification
Solvent extraction

3

BIOLOGICAL

Anaerobic digestion
Fermentation
Enzymatic hydrolysis

4

TERMOCHEMICAL

Combustion
Gasification
Liquefaction
Pyrolysis

Università
Ca'Foscari
Venezia
Dipartimento di Scienze
Molecolari e Nanosistemi

Pyrolysis

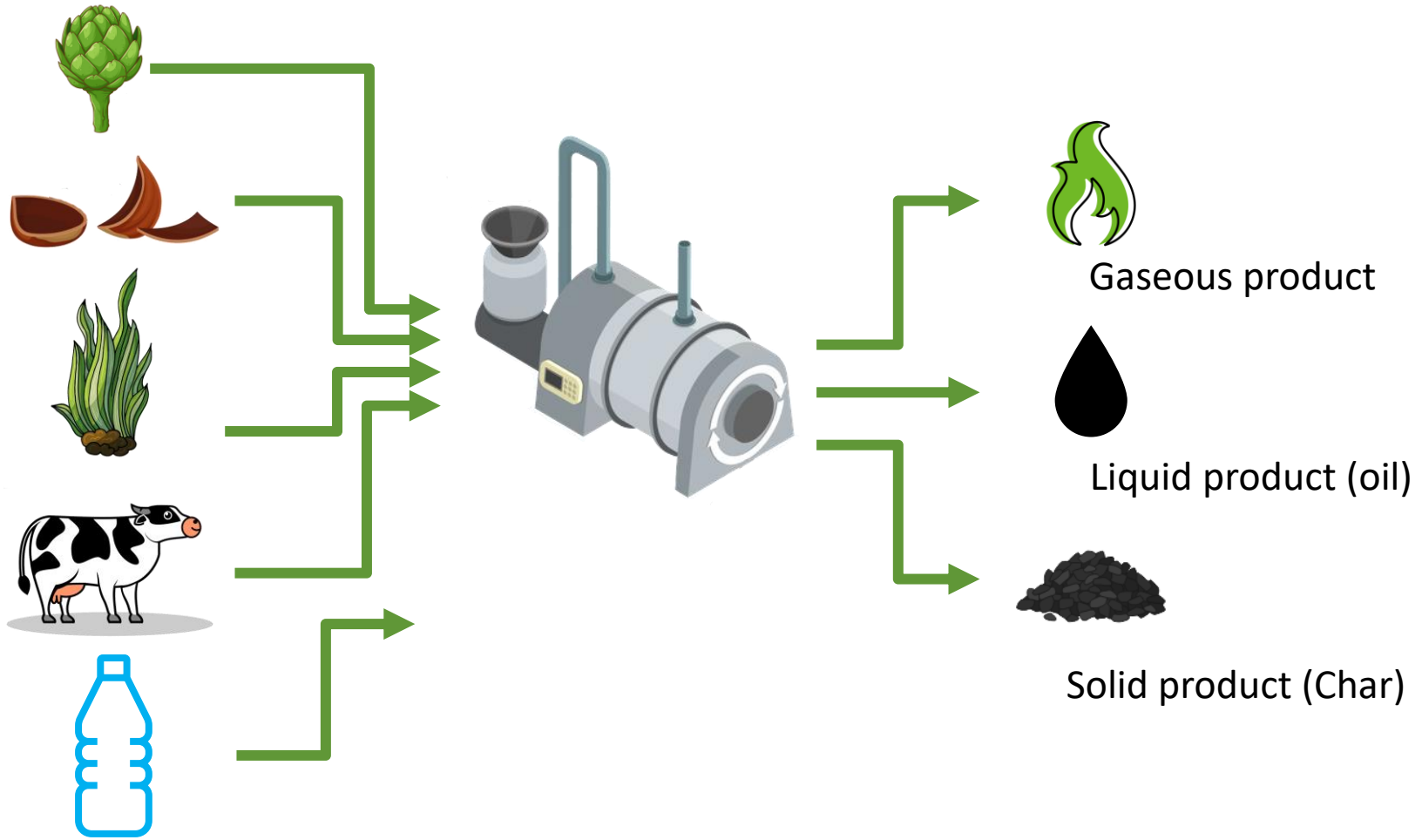
Thermochemical or heat decomposition, in an inert atmosphere(400–800°C).

The distribution and composition of the products depend on:

waste composition

Heating temperature

Heating speed



Università
Ca'Foscari
Venezia
Dipartimento di Scienze
Molecolari e Nanosistemi

Chemical Recycling: Hoop

6000 t/y secondary raw material from plastic waste

10 % w r-GAS

80 % w r-OIL

10 % w r-Char

Università Ca'Foscari Venezia
Dipartimento di Scienze Molecolari e Nanosistemi

Chemical Recycling: Hoop Process

Property technology developed to start since 2020 in collaboration with SRS (Servizi di Ricerche e Sviluppo)

www.unive.it

SORTING

FEEDSTOCK MIXED PLASTIC WASTE

PYROLYSIS REACTION

SEPARATION

CONDENSATION AND PURIFICATION

R-GAS

R-OIL ♺

UNIPLAST

standard UNI 10667-18

SOLID PRODUCT

R-Char

STEAM CRACKING PLANT

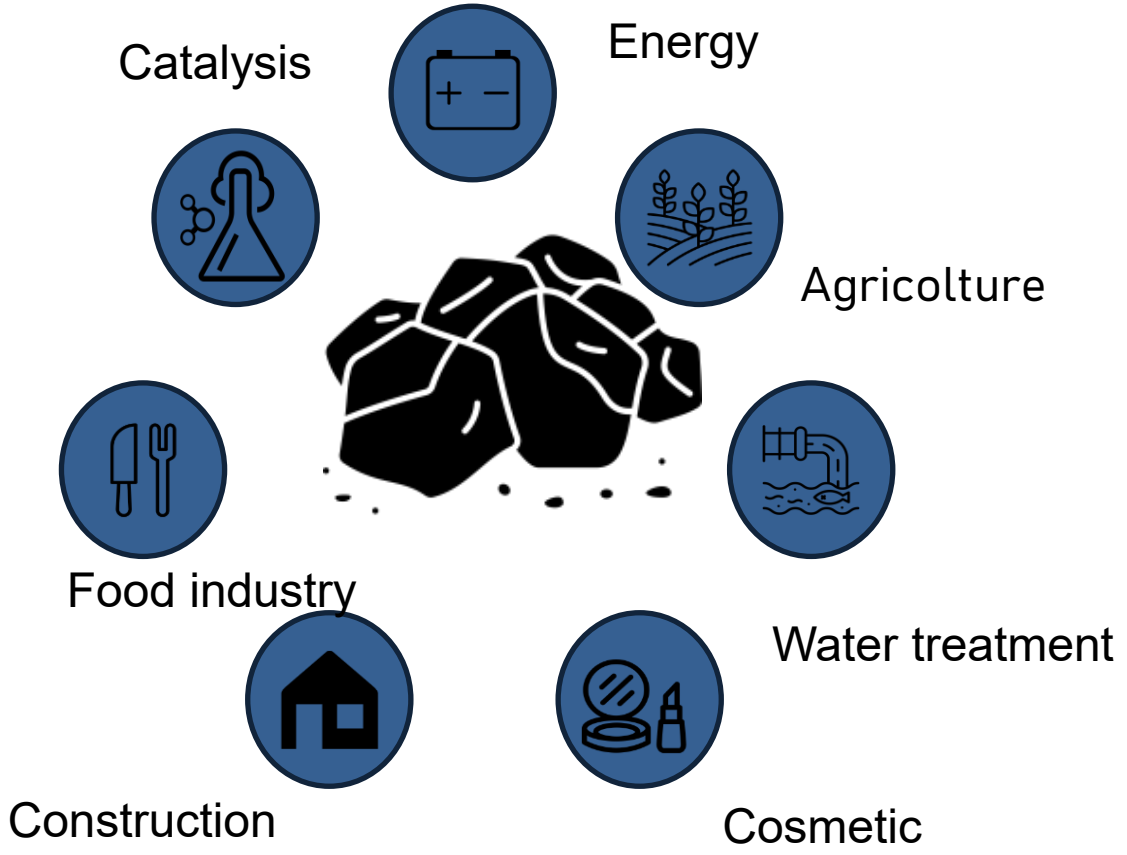
Università Ca'Foscari Venezia
Dipartimento di Scienze Molecolari e Nanosistemi

Uses of char

1. Waste chars can be used as catalytic supports, as anodes for lithium batteries, in cosmetic applications and more…

2. The trick is to find the best pyrolysis and activation conditions in order to ad hoc modulate the characteristics of the final material depending on the use you want to make.

3. The fact that the characteristics of char are also a function of the waste itself opens up a lot of possibilities for using it not only as a recycled material but also as a starting material for the creation of new products.

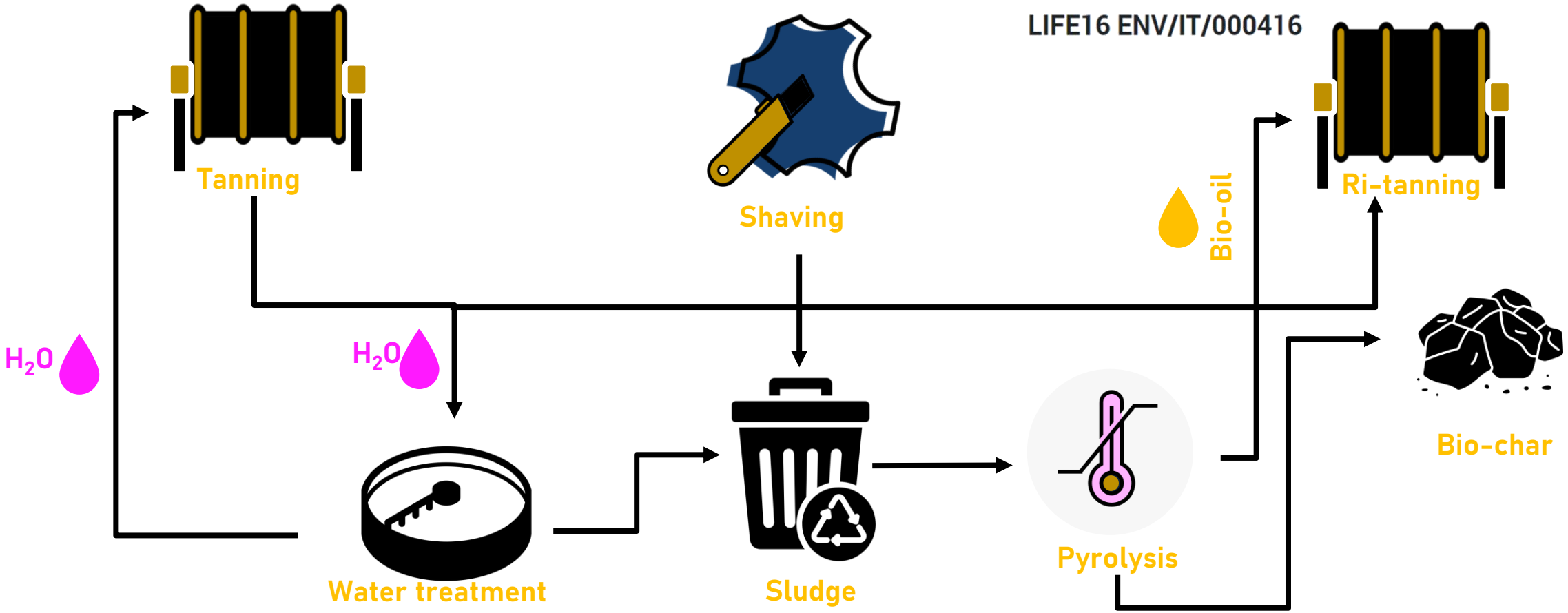


Università Ca'Foscari Venezia
Dipartimento di Scienze Molecolari e Nanosistemi

SWM: Smart Waste Management "an example"

LifeGOAST

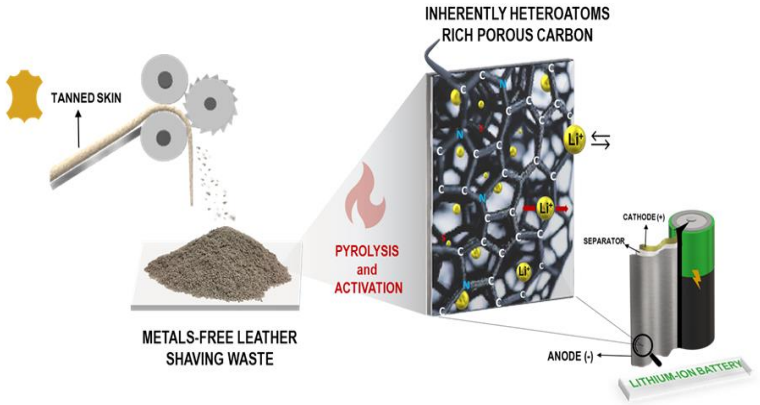
LIFE16 ENV/IT/000416



Università Ca'Foscari Venezia
Dipartimento di Scienze Molecolari e Nanosistemi

Application of Activated Carbons

✓ The applications of GOAST carbons as ANODE for LIBs

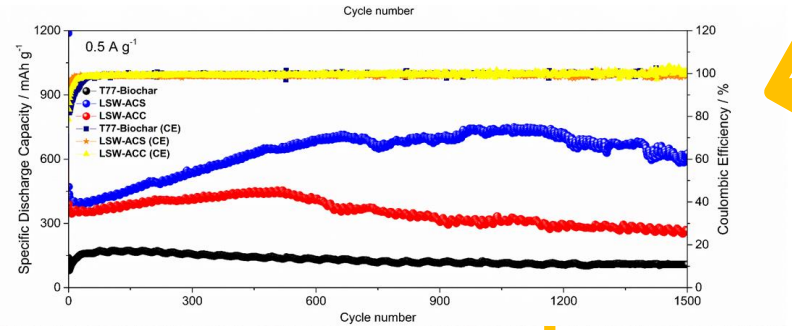


Carbons derived from GOAST shaving waste as a sustainable material **alternative to graphite** in half-cell and full-cell lithium batteries

Theree carbon materials were tested:

- GOAST biochar ( )
- Biochar activated with steam (LSW-ACS)
- Biochar activated with CO_2 (LSW-ACC)

Comparison of **the physical/chemical and electrochemical performances** of GOAST carbons

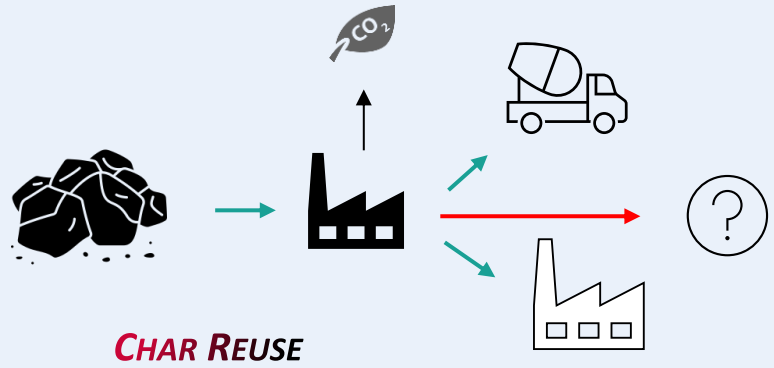


HIGH STABILITY

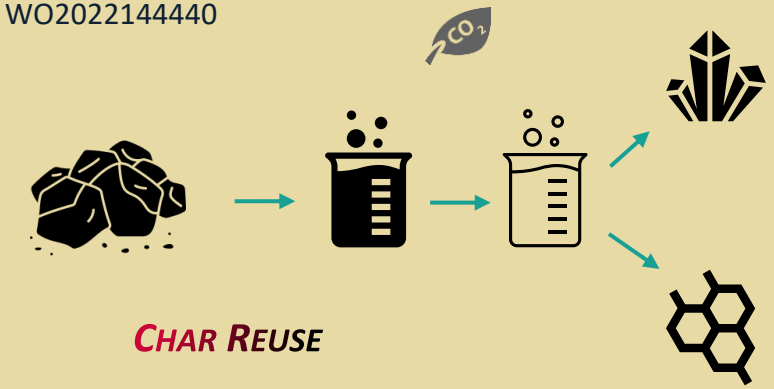
Signoretto et al., Green Chem., 2022, 24, 4119;
Signoretto et al. Energy and Environmental Materials 2024,7(2), e12567;

Università Ca'Foscari Venezia
Dipartimento di Scienze Molecolari e Nanosistemi

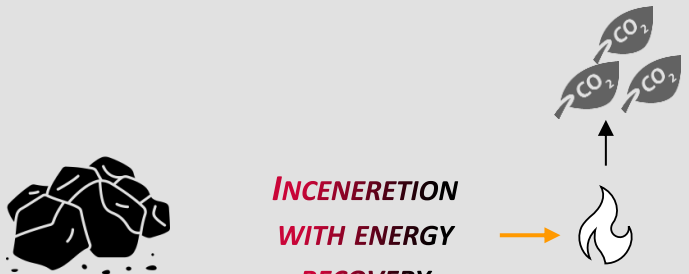
Examples of char uses and differences compared bio char



WO2022144440

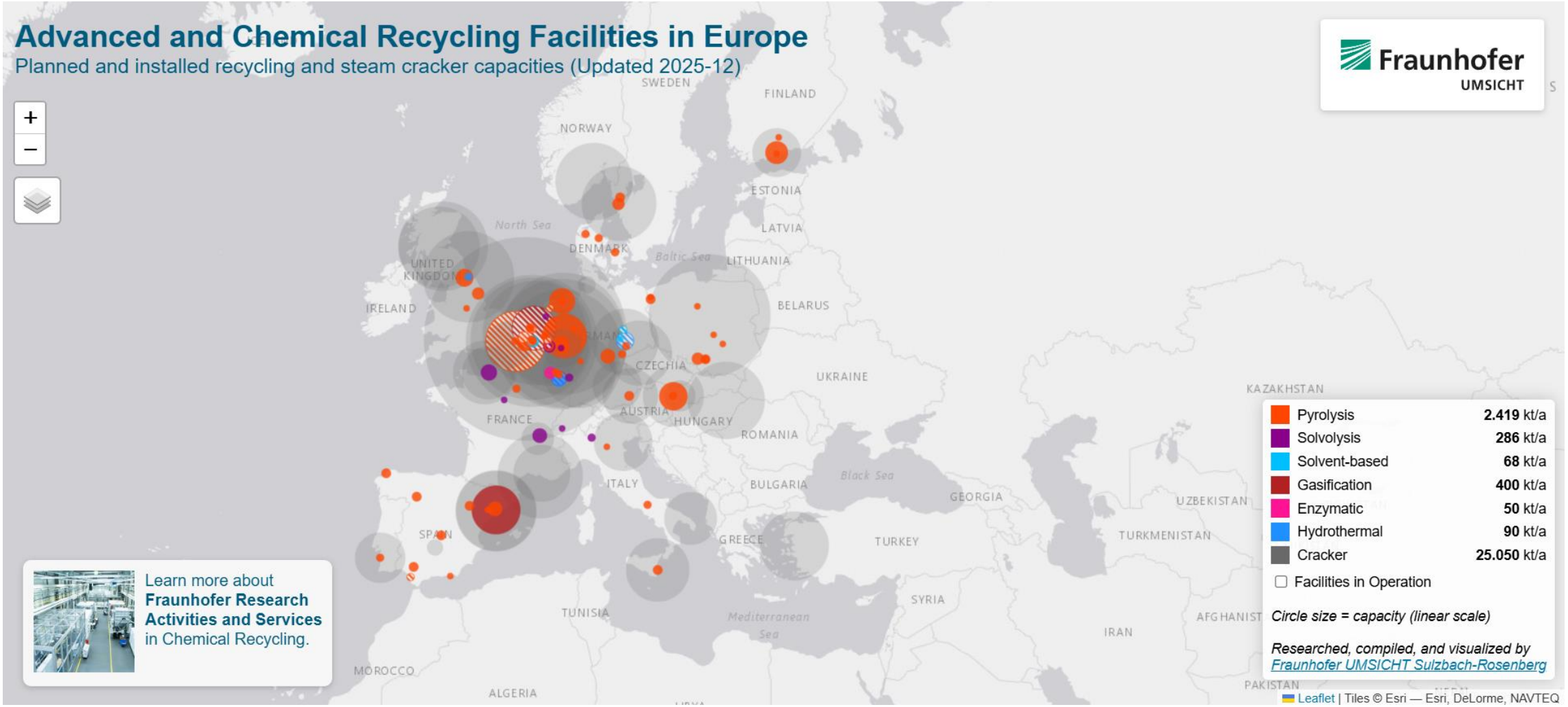


PROBABILY WASTE



THE **CHAR** FROM PLASTICS'S PYROLISIS HAS VARIABLE COMPOSITION AND PRESENCE OF INORGANIC COMPOUNDS (ABOUT 50 %) LIKE: CALCIUM CARBONATE, SILICON AND TITANIUM OXIDE, ALUMINUM ETC.

Chemical Recycling: Planned investments in Europe



https://websites.fraunhofer.de/suro1/crmap/chemrec_map_interactive_Online_Alt_Map.html

Università Ca'Foscari Venezia
Dipartimento di Scienze Molecolari e Nanosistemi

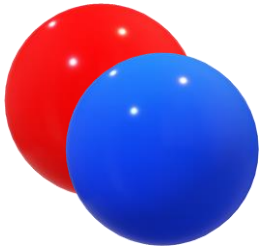
How was born the collaboration between Versalis and Ca' Foscari University

10/09/21 Forte Marghera (VE)
Lunch before of GIC best doctoral thesis award ceremony

The Boudouard's Reaction

Boudouard, Octave-Léopold
???
(1872-1923)

$$CO_2 + C \leftrightarrow 2\,CO$$

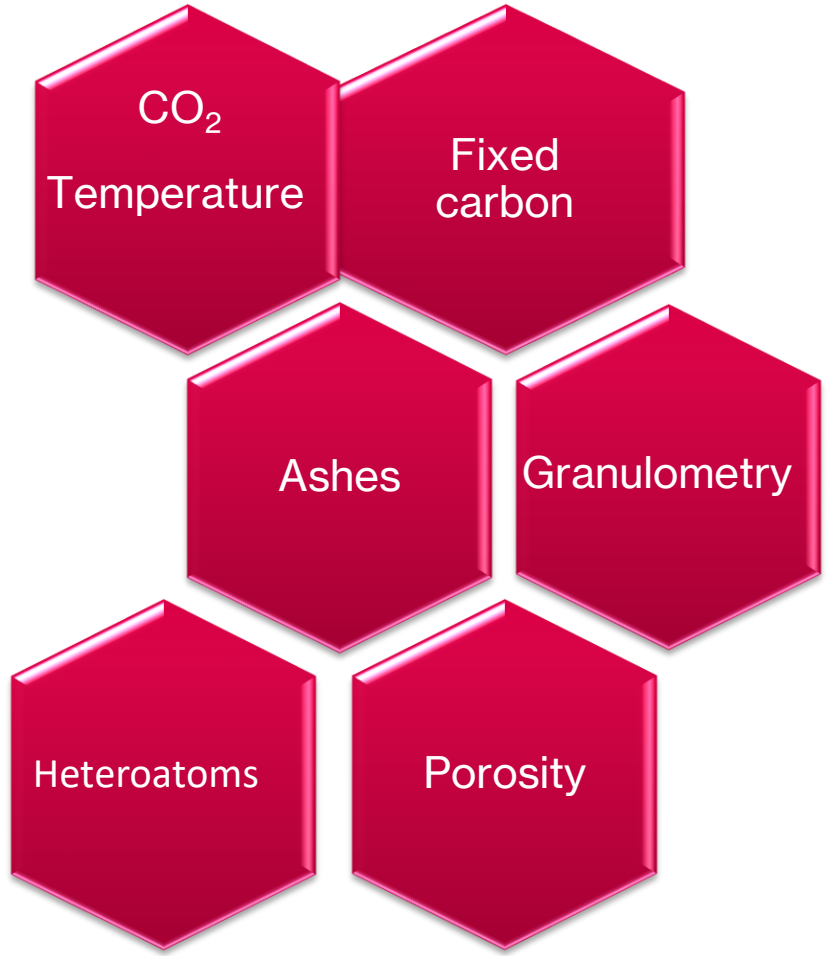


Università Ca'Foscari Venezia
Dipartimento di Scienze Molecolari e Nanosistemi

The Boudouard Reaction

Factors determining the reactivity of chars

$$CO_2 + C \rightleftharpoons 2\ CO$$



Patent

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
04 July 2024 (04.07.2024)

WIPO | PCT

(10) International Publication Number
WO 2024/141843 A1

(51) International Patent Classification:
C10J 3/62 (2006.01) *C01B 32/40* (2017.01)

(21) International Application Number:
PCT/IB2023/062661

(22) International Filing Date:
14 December 2023 (14.12.2023)

(25) Filing Language: Italian

(26) Publication Language: English

(30) Priority Data:
102022000026886 27 December 2022 (27.12.2022) IT

(71) Applicant: **VERSALIS S.P.A.** [IT/IT]; Piazza Boldrini, 1, 20097 San Donato Milanese (MI) (IT).

(72) Inventors: **VECCHINI, Nicola**; Via Giuseppe Taliercio, 14, 46100 Mantova (MN) (IT). **GALEOTTI, Armando**; Via Giuseppe Taliercio, 14, 46100 Mantova (MN) (IT). **GRADELLA, Cecilia**; Via Giuseppe Taliercio, 14, 46100 Mantova (MN) (IT). **SIGNORETTO, Michela**; Via Torino, 155, 30172 Venezia (VE) (IT). **LONGO, Lilia**; Via Torino, 155, 30172 Venezia (VE) (IT).

(74) Agent: **BOTTERO, Carlo**; c/o BARZANO' & ZANARDO MILANO S.p.A., Via Borgonuovo, 10, 20121 Milan (IT).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO,

(54) **Title:** PROCESS FOR TREATING CHAR FROM RECYCLED PLASTICS

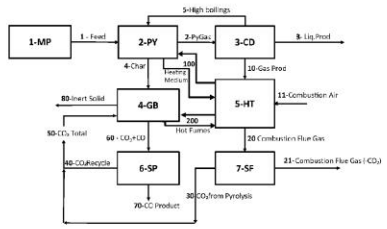


Fig. 1

(57) **Abstract:** A process for recovering the carbon contained in a char (solid carbonaceous residue) from a pyrolysis of mixed plastic waste or secondary raw material obtained from the recycling and/or treatment of plastic wastes is described, said process comprising the following steps: (A) heating said char in a gasification reactor and in the presence of carbon dioxide to reach a given temperature comprised in a range lower than 950°C and higher than 600°C, preferably lower than or equal to 850°C; (B) continue heating said char in the aforementioned temperature range, preferably in the range from 750 °C to 850 °C, in the presence of CO_2, for a given residence time of said char in said reactor producing an outflow gas stream (effluent) comprising CO in addition to unreacted CO_2, and possibly H_2, (C) sending at least a part of the gas stream (effluent) leaving the reactor

[Continued on next page]

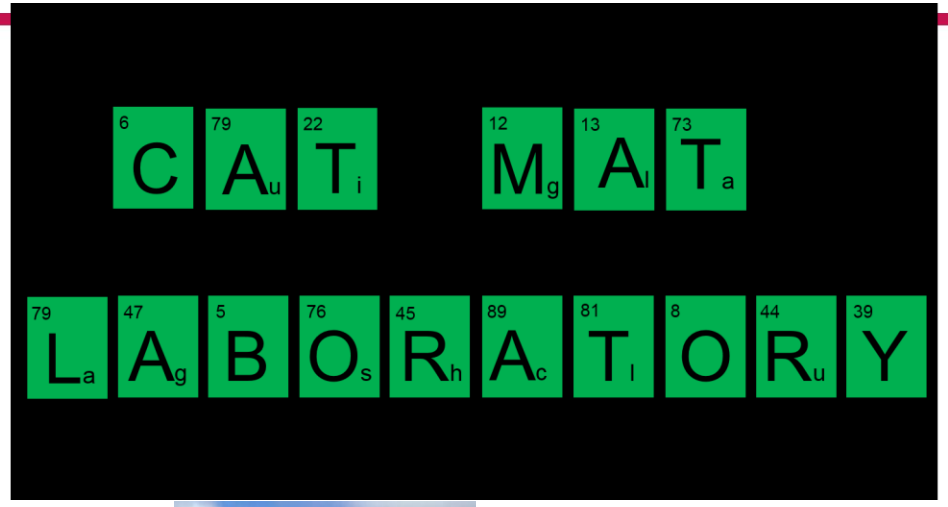
WO 2024/141843 A1

WO2024141843A1 PROCESS FOR TREATING CHAR FROM RECYCLED PLASTICS

Università Ca'Foscari Venezia
Dipartimento di Scienze Molecolari e Nanosistemi

Acknowledgement

www.unive.it



Lilia Longo

Nicola Vecchini
Armando Galeotti
Cecilia Gradella

versalis
CHEMISTRY BY PEOPLE FOR PEOPLE