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Processing of vegetable shells for solid carburizers production to achieve case hardening of a low carbon steel

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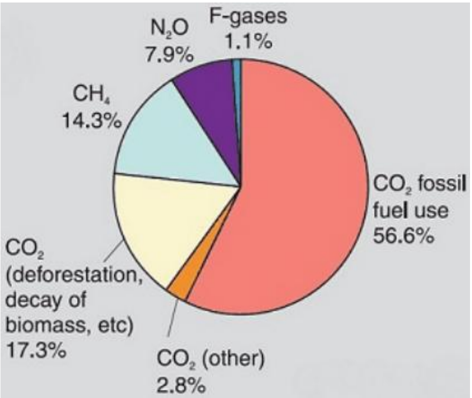
CONTEXT AND ISSUES

Canarium Schweinfurthii (CS)



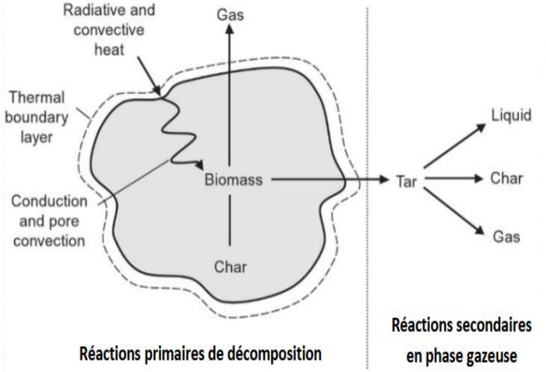
Annual breakdown of grenhouse gas (GES) in 2004

Damaged mechanical system parts

CARBON POTENTIAL :

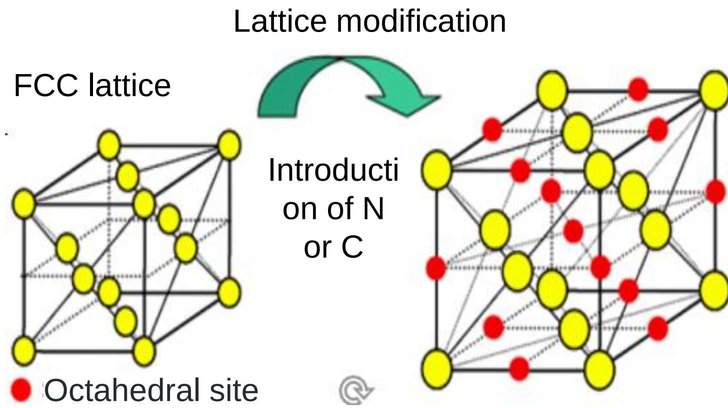
51,99% (Garba et al., 2023)

PRODUCTION : 1000t per season in Western Cameroun (Njoukam et al, 2002)



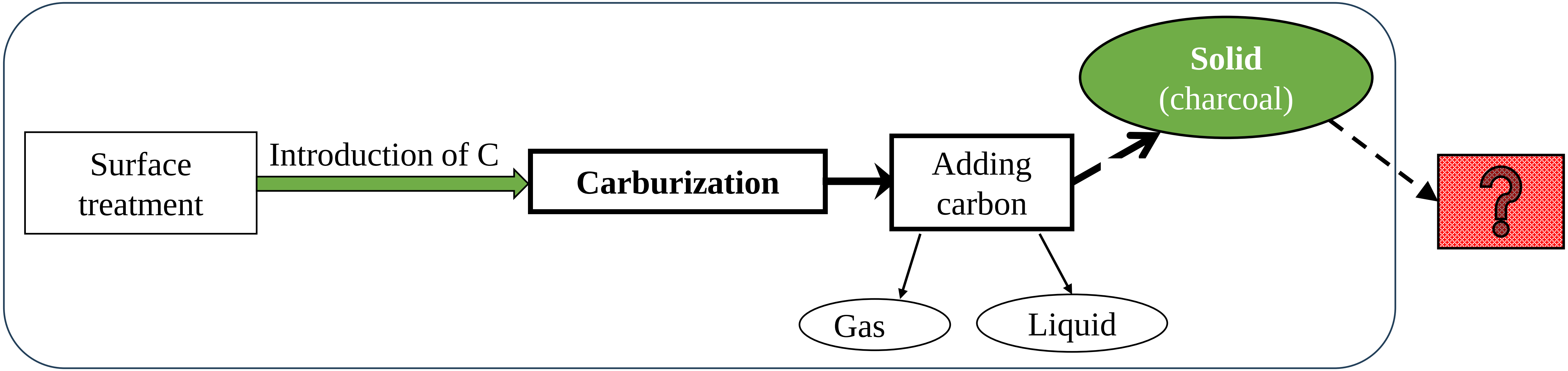
Thermal decomposition of biomass (Sami Z., 2017)

Hard caol (%C>75)



Lattice modification (T. LESAGE, 2019)

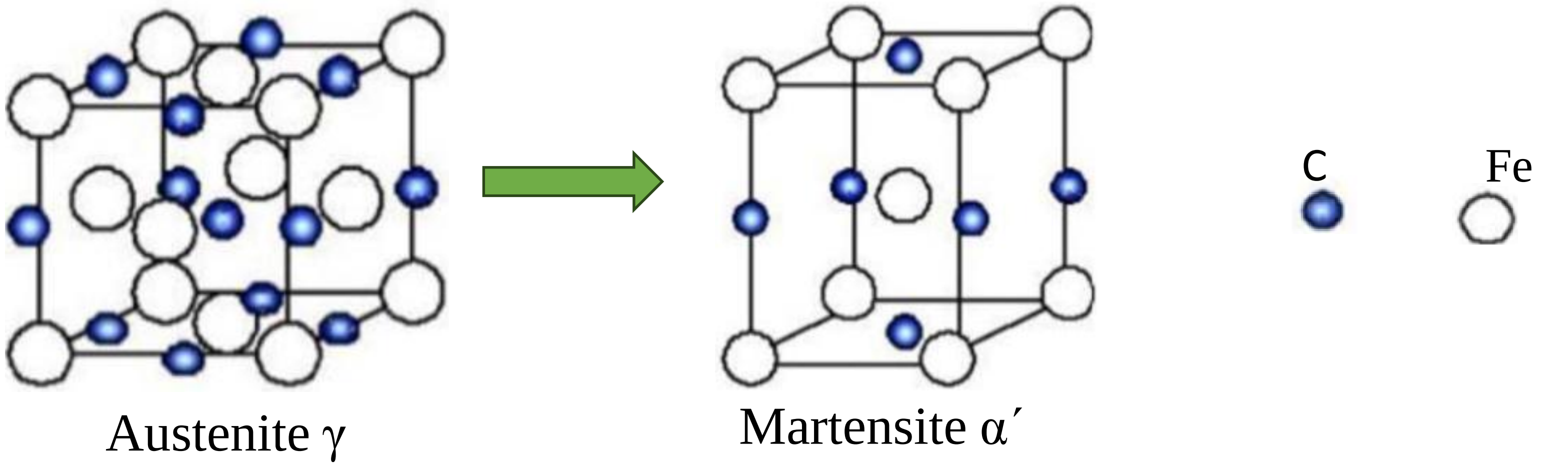
CONTEXT AND ISSUES



How can the characteristics of low carbon steels be improved by carburizing using these high carbon CS shells?

OBJECTIVES

- Enriching the surface layers of mechanical parts with carbon by using bio-carburizers from the shells of Canarium Schweinfurthii (CS) through a carburizing treatment



- Carry out and characterize bio-carburizers (yield, microstructure, Ultimate analysis, ...)
- Case hardening of streel and characterize carburized substrate (microstructure, hardness)

BACKGROWND

Case hardening

Carbon content improved
Reduce volatile mater

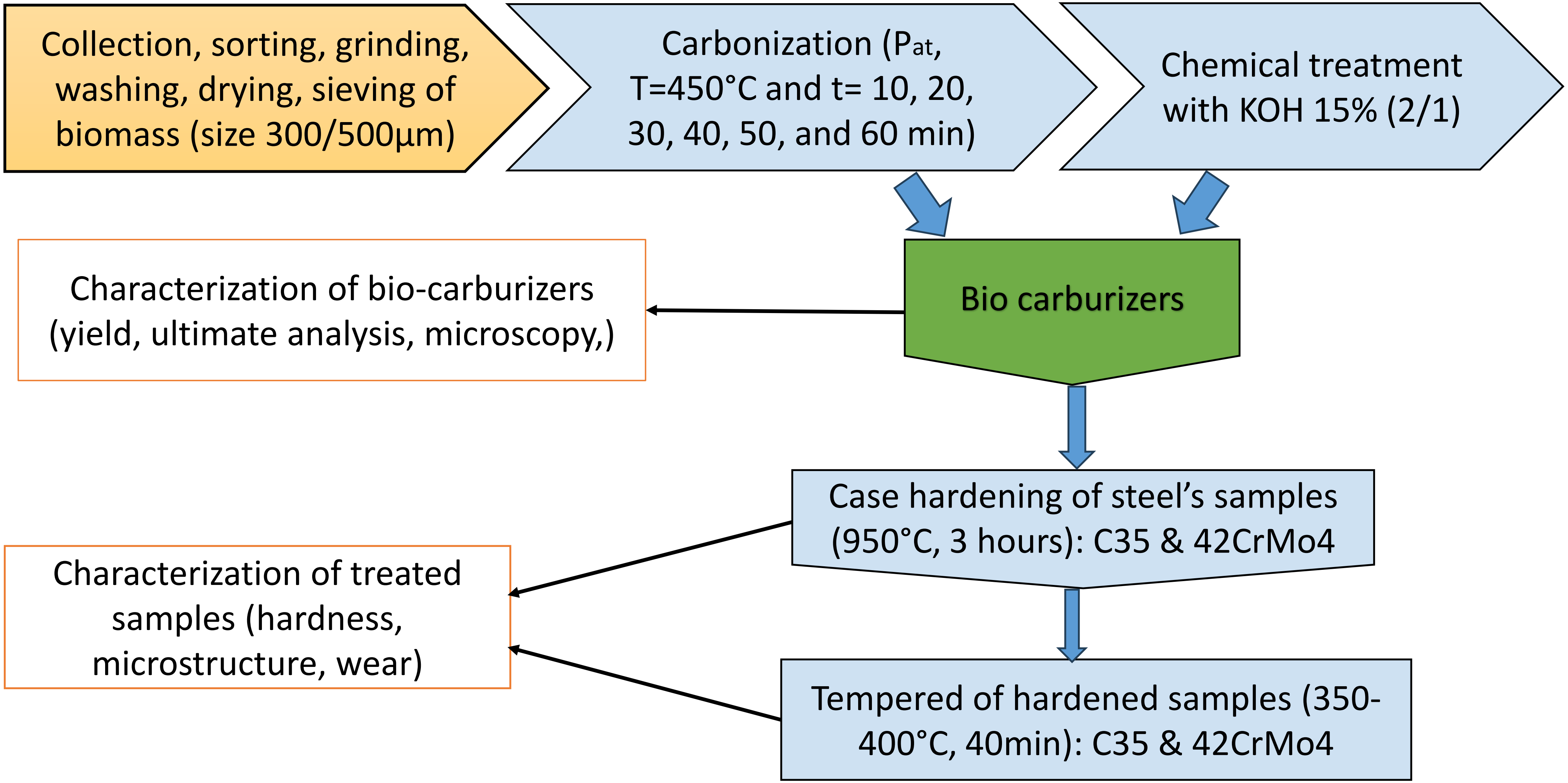
- Carbonisation (Chen et al, 2021)
- Chemical treatment of Coal (Alayont et al, 2022; Samba, 2024)

Carburizer

Animal's bone	**Leaves**	**Coal**	**Vegetable (cores) shells**
(Oyetunji and Adeosun, 2012)	(Isadare and al, 2018)	(Elzanaty, 2014)	(Umunakwe, 2017; Oluwafemi and al, 2015

MATERIALS, METHODS AND RESULTS

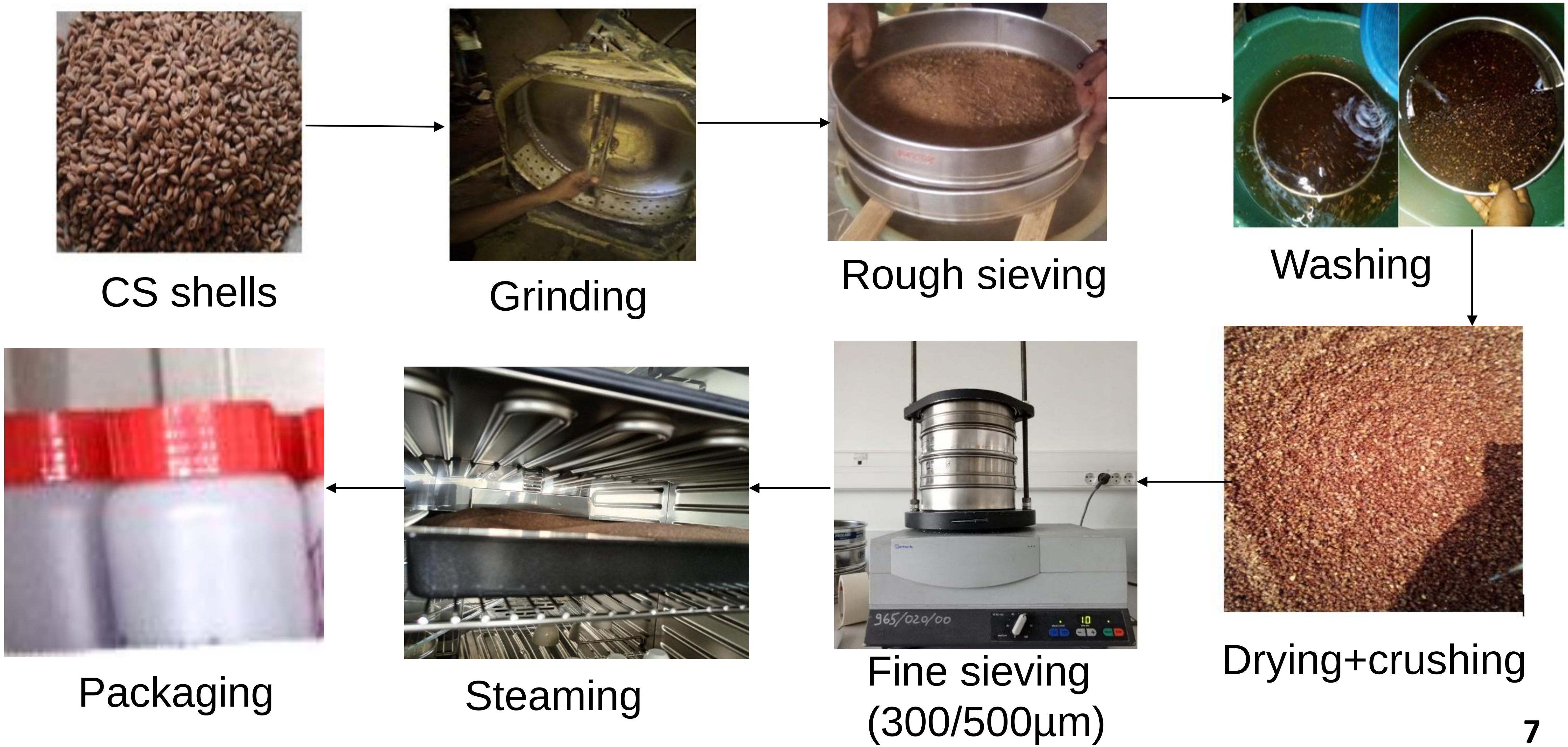
Flow chart



MATERIALS, METHODS AND RESULTS

- **CS shells collection and pretreatment**

Objective: prepare and pack the shells



MATERIALS, METHODS AND RESULTS

➢ Thermal treatment of shells

Weighing

Carbonization at 450°C

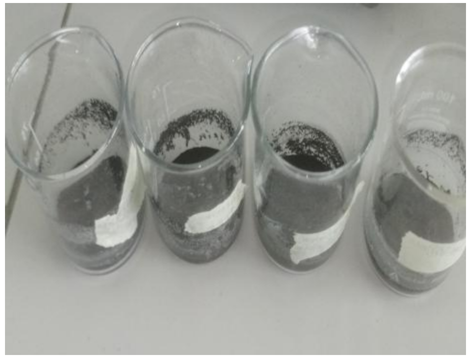
Cooling

➢ Chemical tratment of carbonized's shells

+

15% KOH solution addition

→

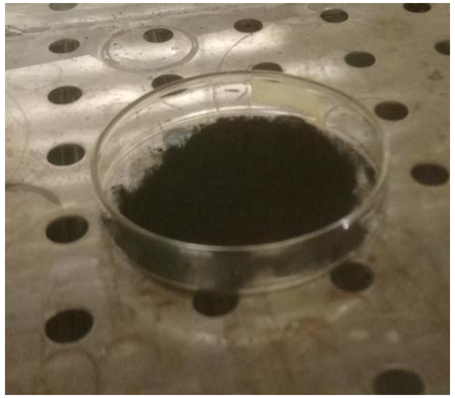


Steaming at 105°C for washing

↓

Neutral test

←



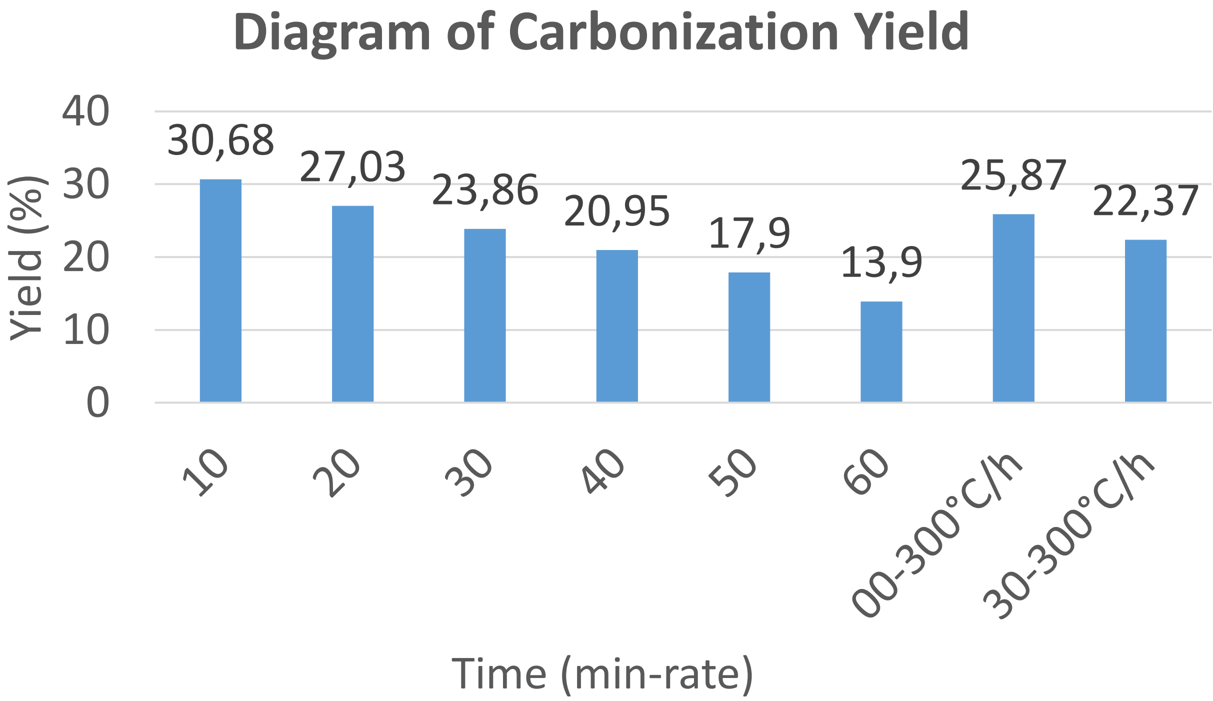
Chemical treated bio-carburizer

MATERIALS, METHODS AND RESULTS

❑Characterization of bio-carburizers

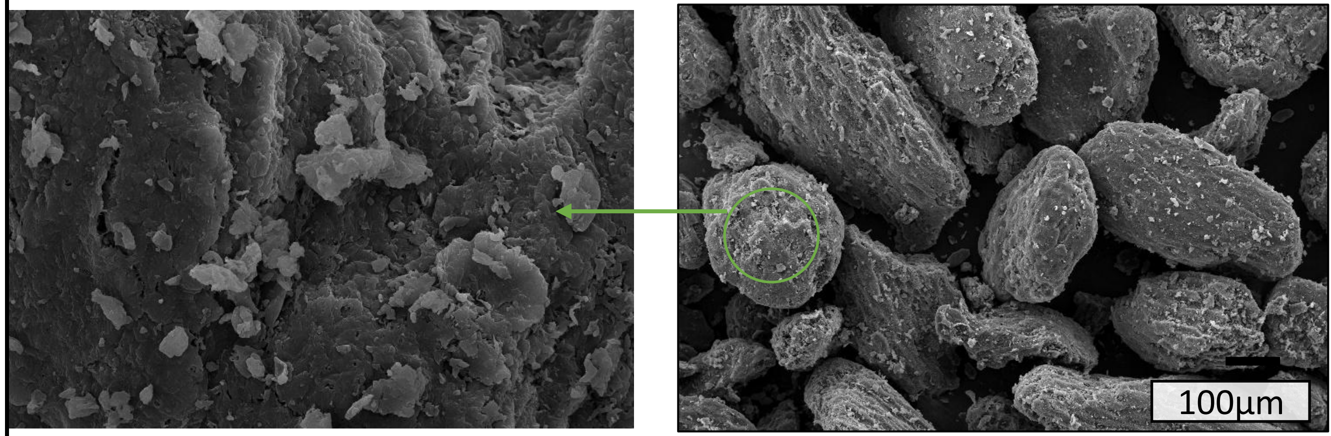
➢Carbonization yield

$$\textbf{Yield (\%)} = \frac{final\ mass}{initial\ mass} \times 100 \quad \textbf{(1)}$$

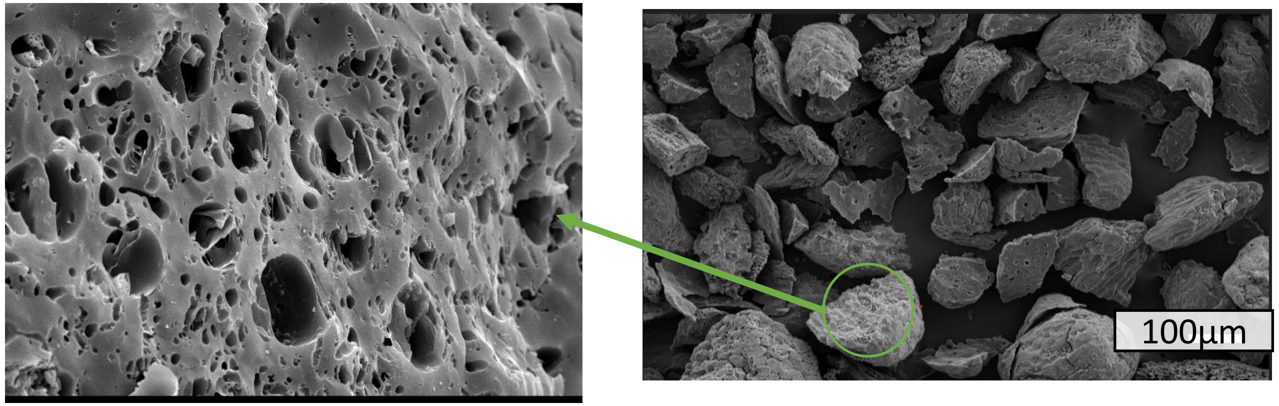


↗ Charcoal at the same temperature (N. Boukaous, 2021)

➢SEM characterization



Low porosity of carbonized bio-carburizers



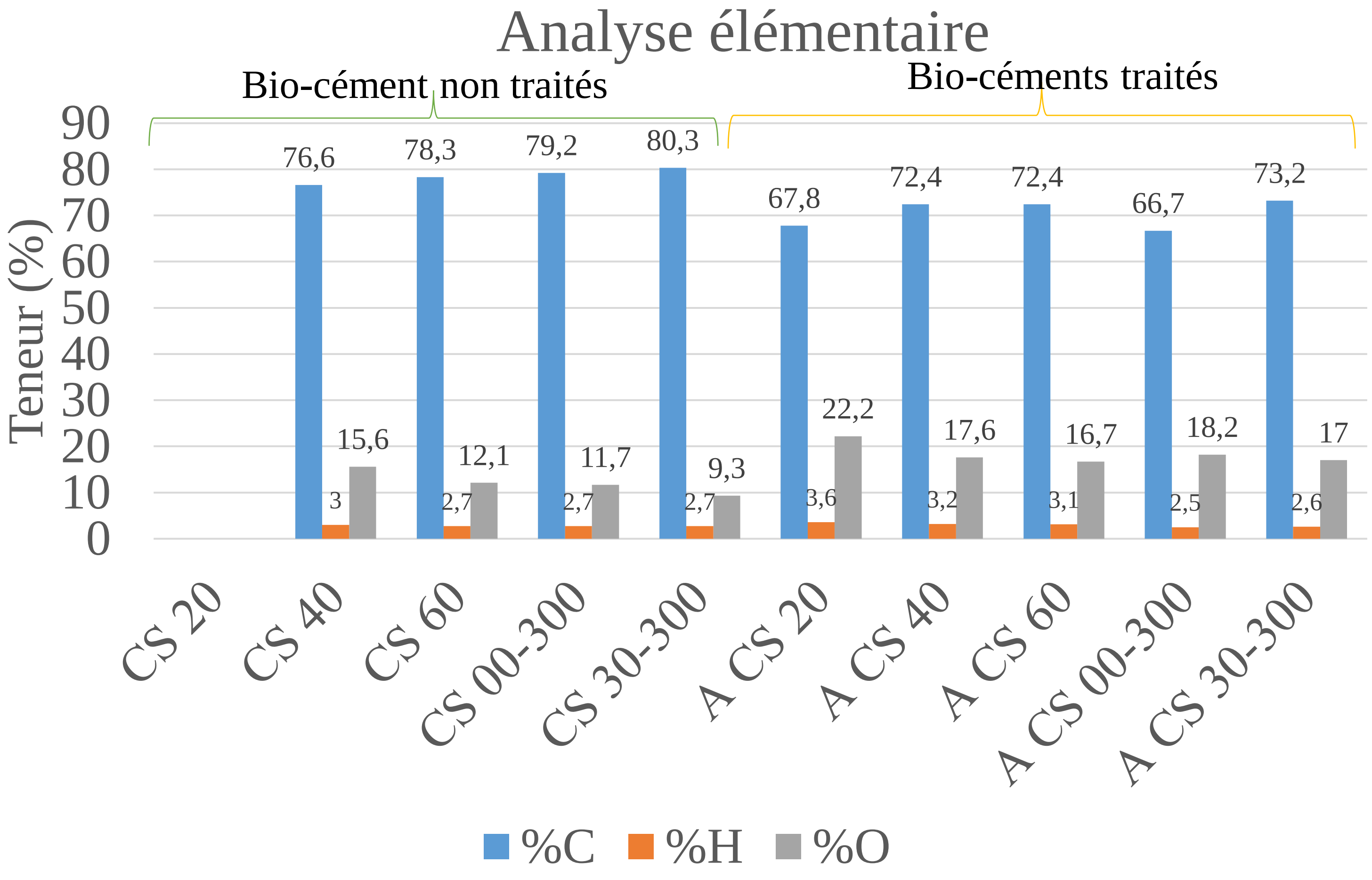
Higher porosity of chemical treated bio-carburizers

MATERIALS, METHODS AND RESULTS

❑Characterization of bio-carburizers

➢Ultimate analysis

Objective: Determine the C, O and H content in selected bio-carburizers



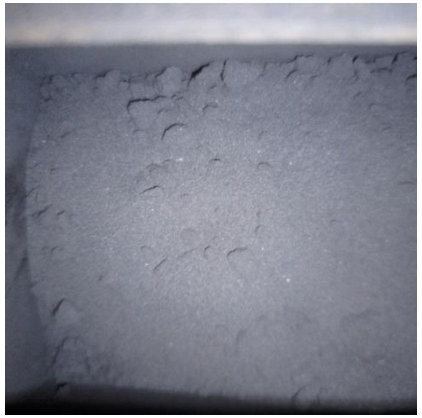
	%C	%H	%O	Author
Biochar from Dynamotive Corporation	83,07	3,76	9,6	(Azargohar and Dalai, 2006)
Hydrochar from Camellia oleifera shells	49.77-70.68	4.46-5.72	17.35-43.54	(Chen et al., 2021)
Biochar from sunflower hulls	70.8	1.2	21.3	(Samba, 2024)

MATERIALS, METHODS AND RESULTS

- **Case hardening (Carburizing) (**950°C Elzanaty, 2014; Umunakwe et al, 2017**)**

<u>Objective</u>: Improve the properties of low carbon steel

<u>Samples used</u>: low carbon steel **C35, 42CrMo4**



Substrate covered by carburizer

Box covered with clay

Box placed in the muffle furnace at 950°C for 3 hours

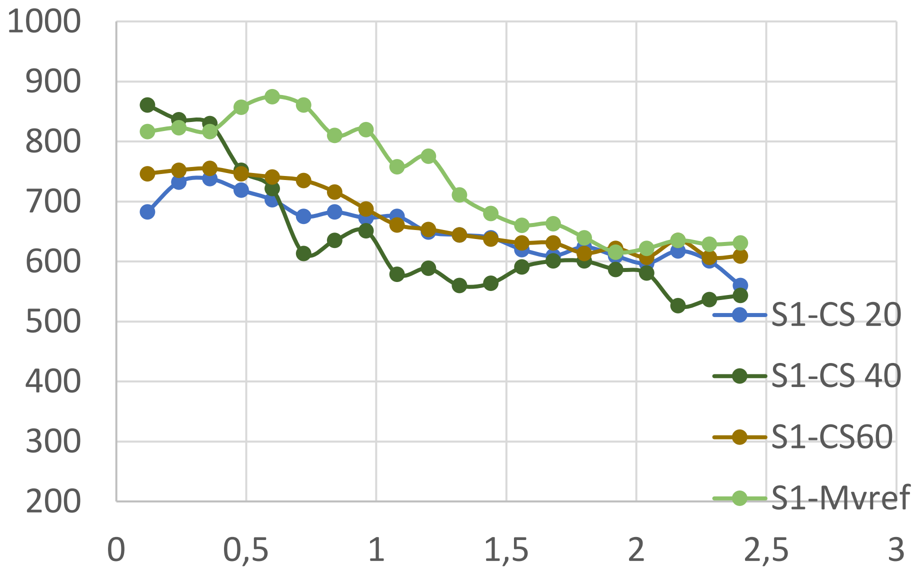
Box removed at the end of time

Samples quenched in the water

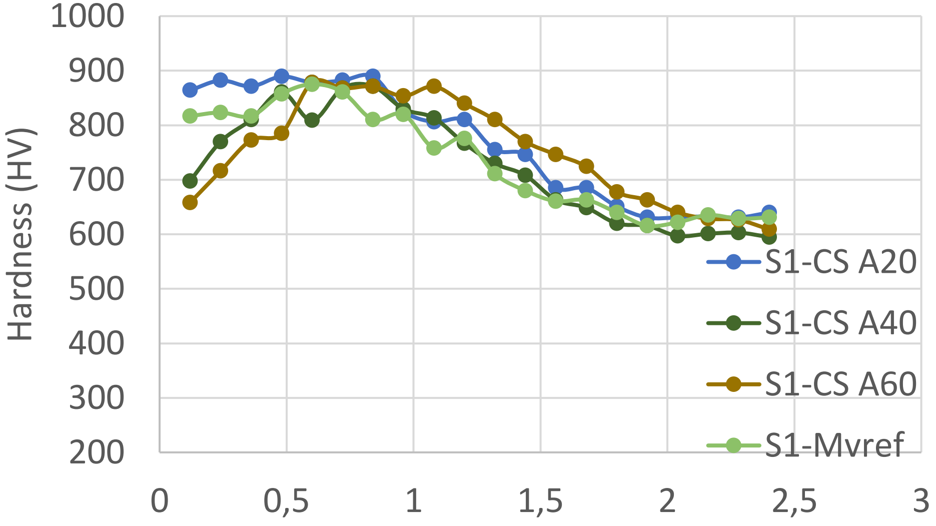
MATERIALS, METHODS AND RESULTS

➢ Charactarization of carburized subtrate

- **Hardness profiles of quenched samples C35 (254HV)**

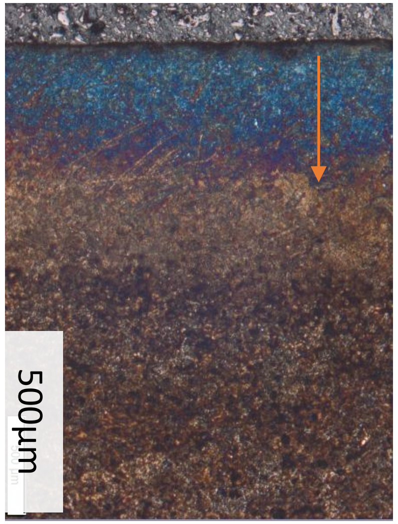


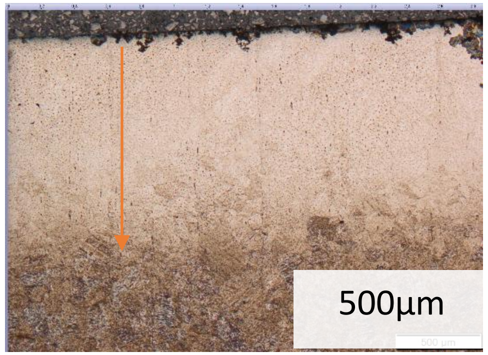
With chemical treated bio-carburizer



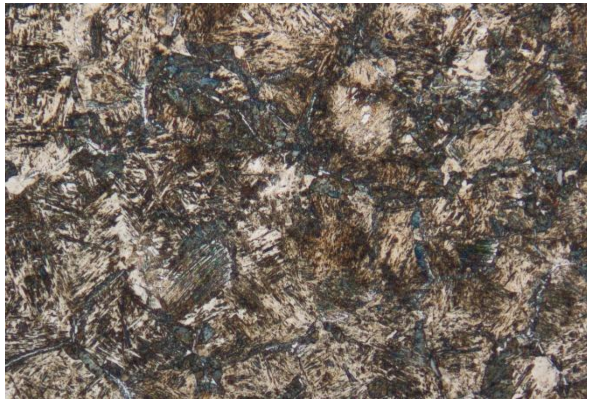
- **Optical microscopy**

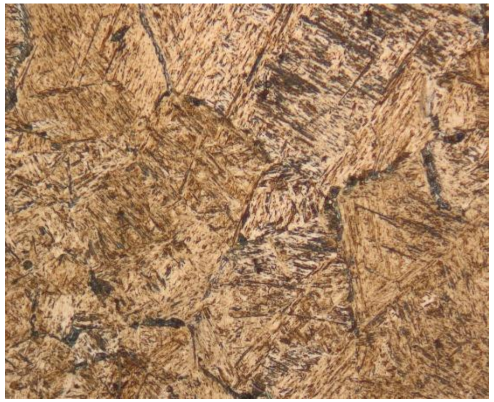
Surface layer





Core





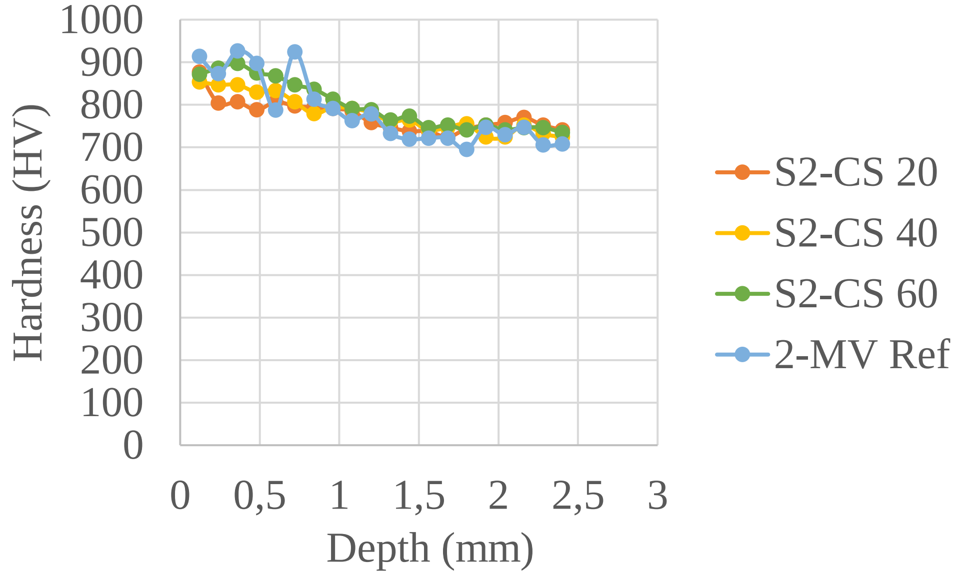
Untreated bio-carburizer(60min) Martensite-residual austenite-carbide

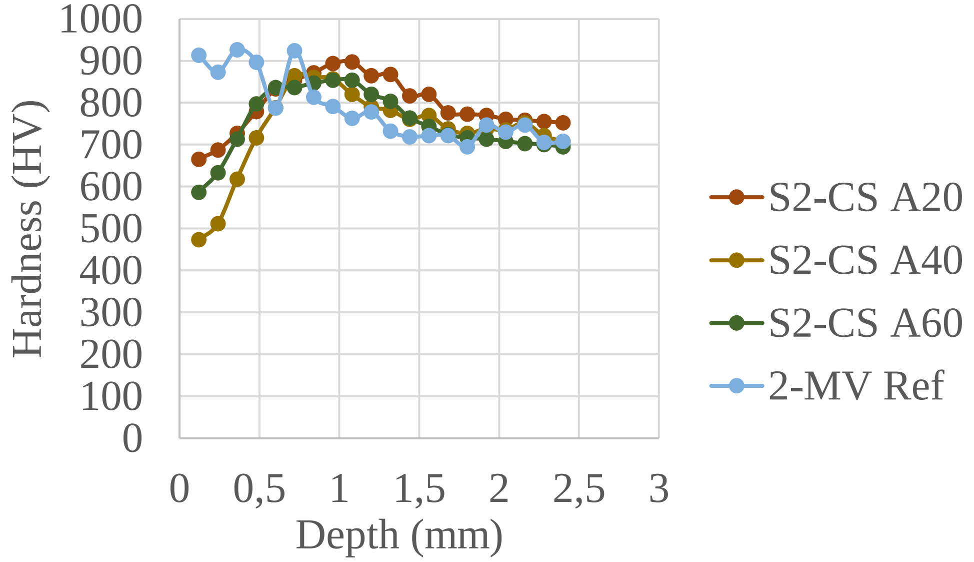
KOH treated bio carburizer (60min) Martensite-retained austenite

MATERIALS, METHODS AND RESULTS

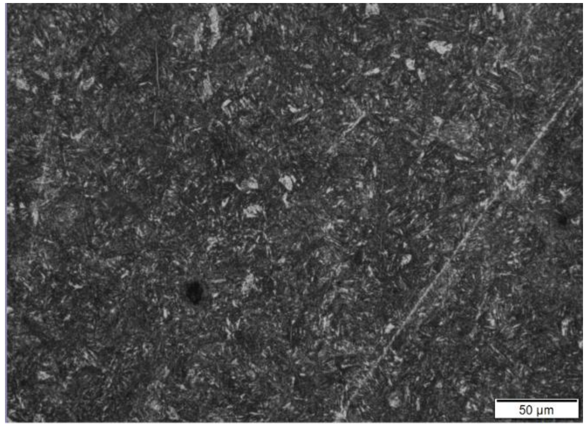
➢ Charactarization of carburized subtrate

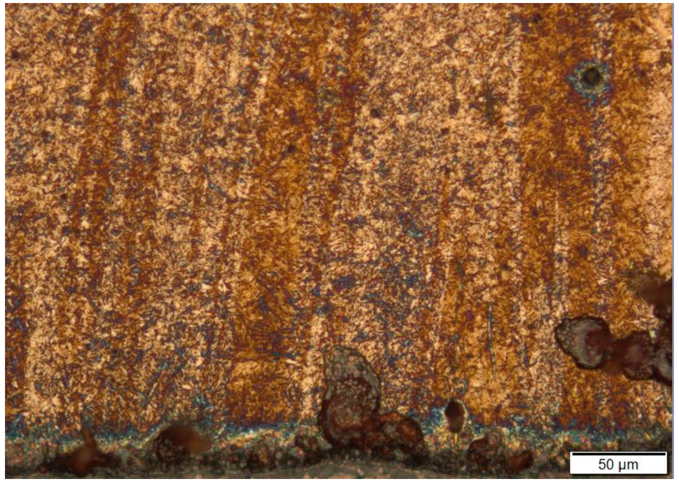
- **Hardness profiles of quenched samples 42CrMo4 (355HV))**



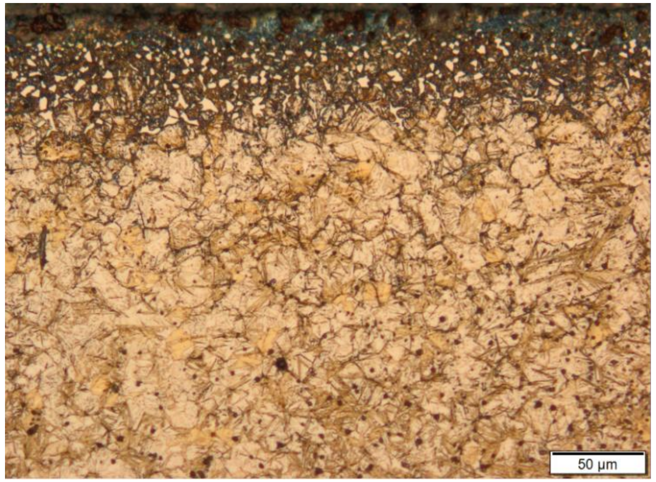


- **Optical microscopy**





Thermal treated bio-carburizer (60min)

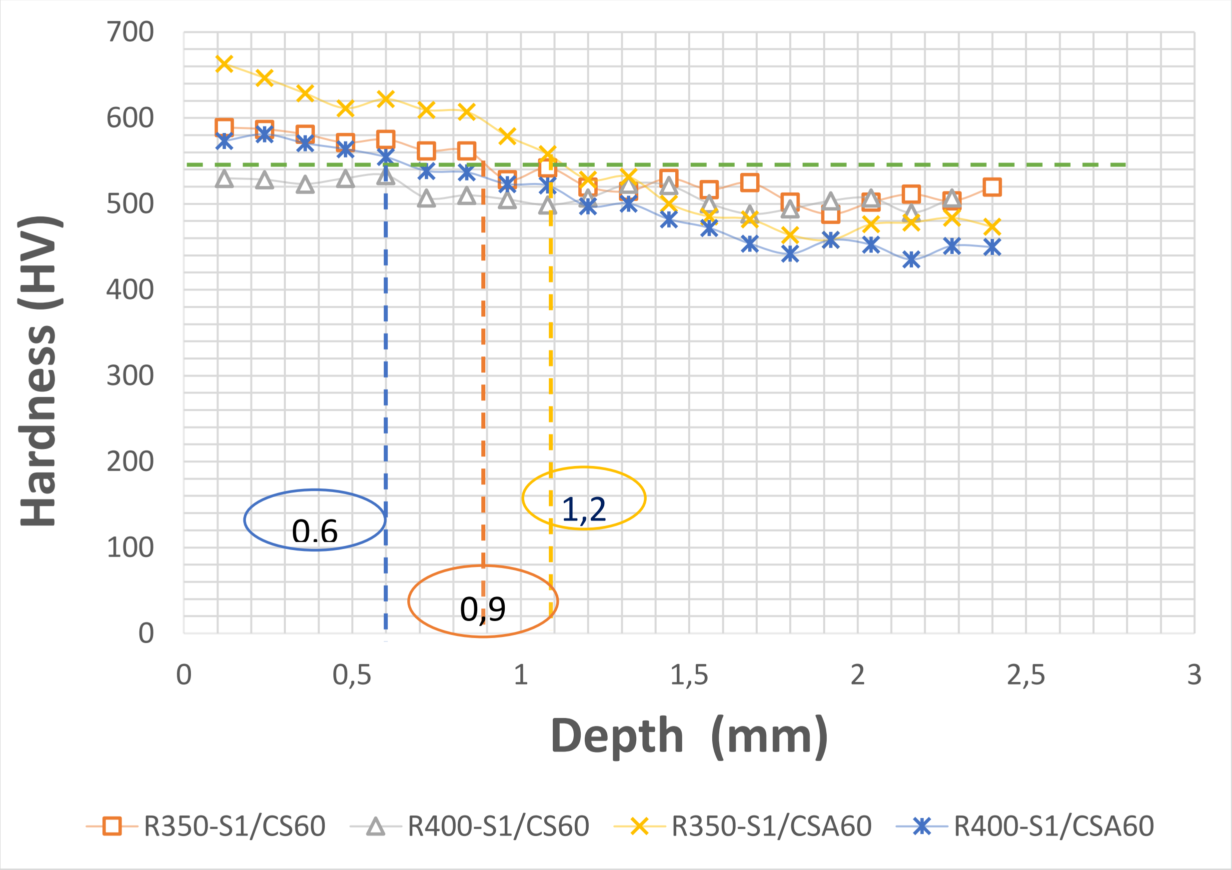


Chemical trated bio-carburizer: carbides, retained austenite

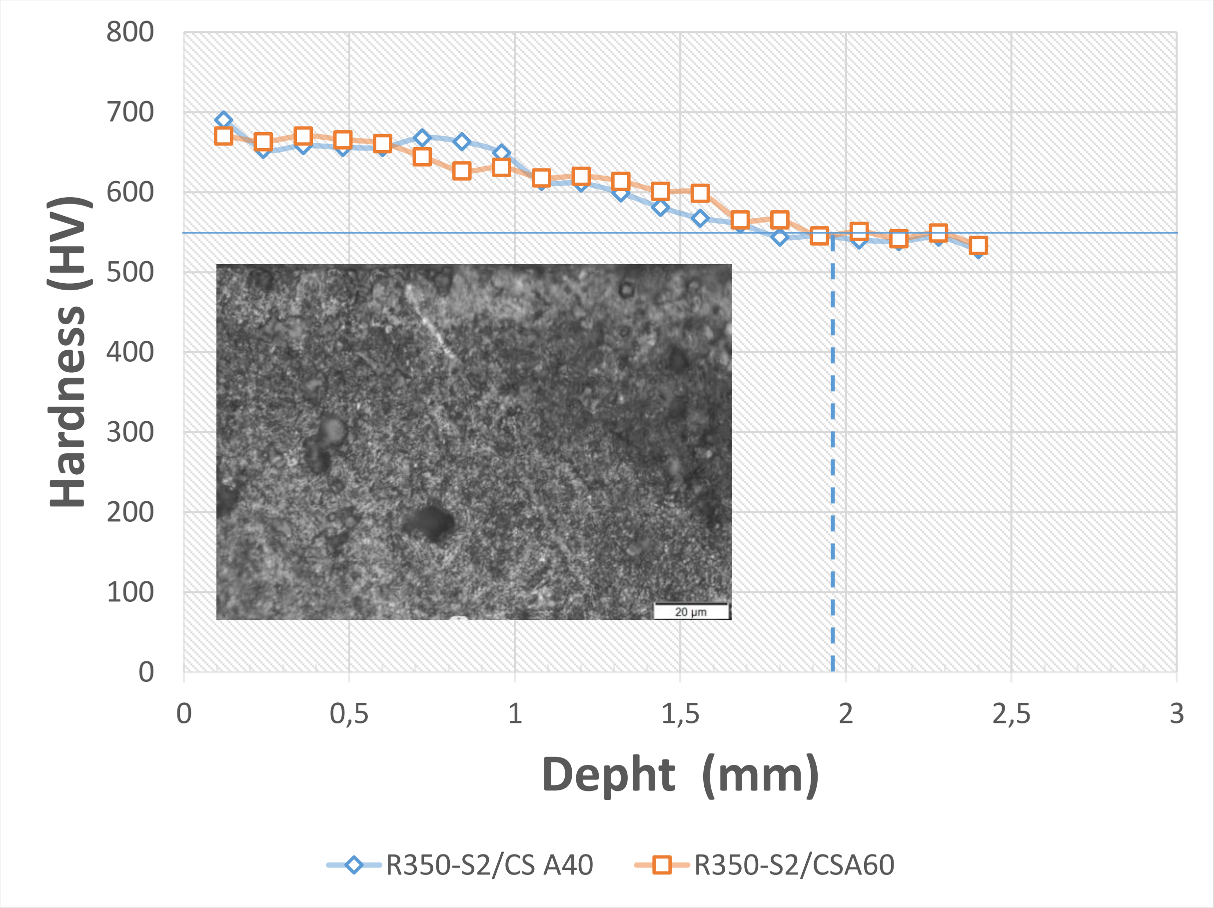
MATERIALS, METHODS AND RESULTS

- **Tempering treatment**

  - **Case hardening depth (CHD) C35**



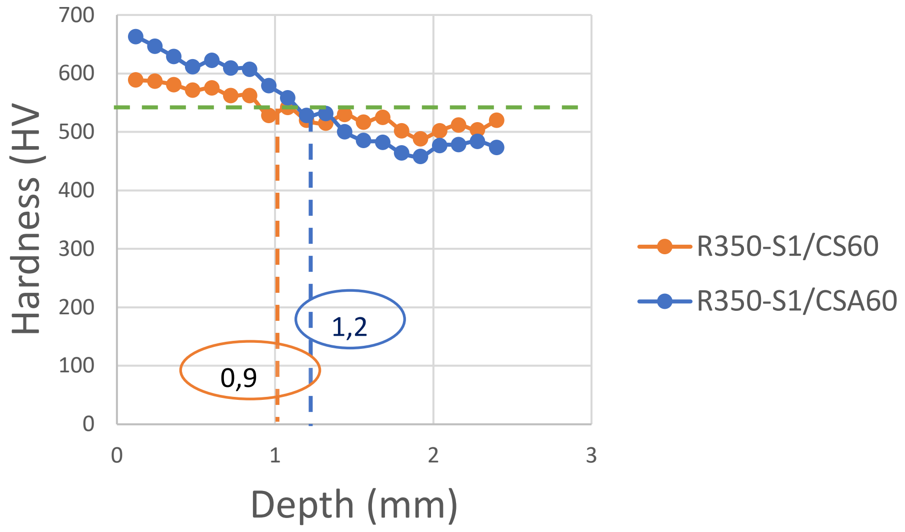
  - **Case hardening depth (CHD) 42CrMo4**

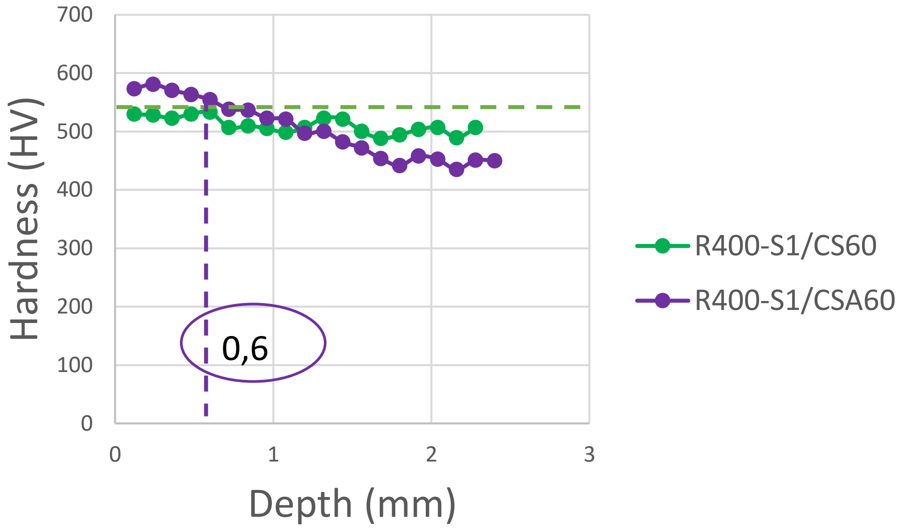


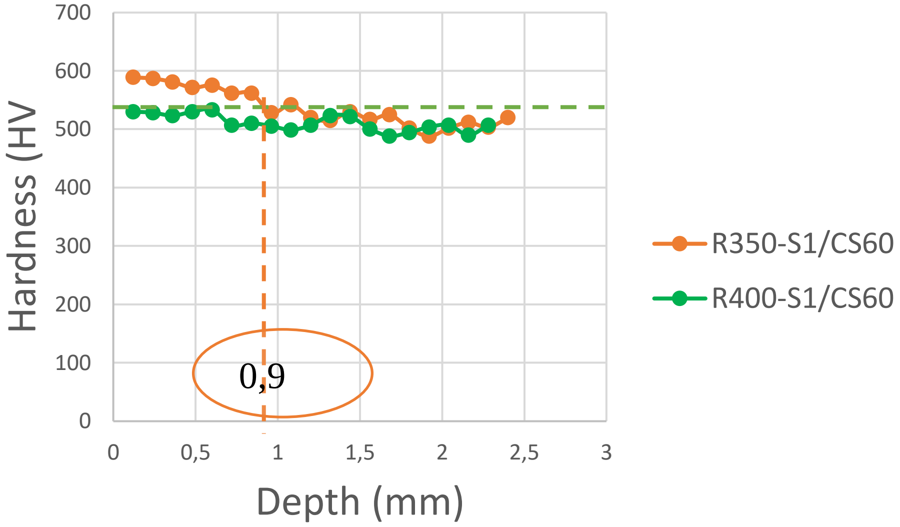
MATERIALS, METHODS AND RESULTS

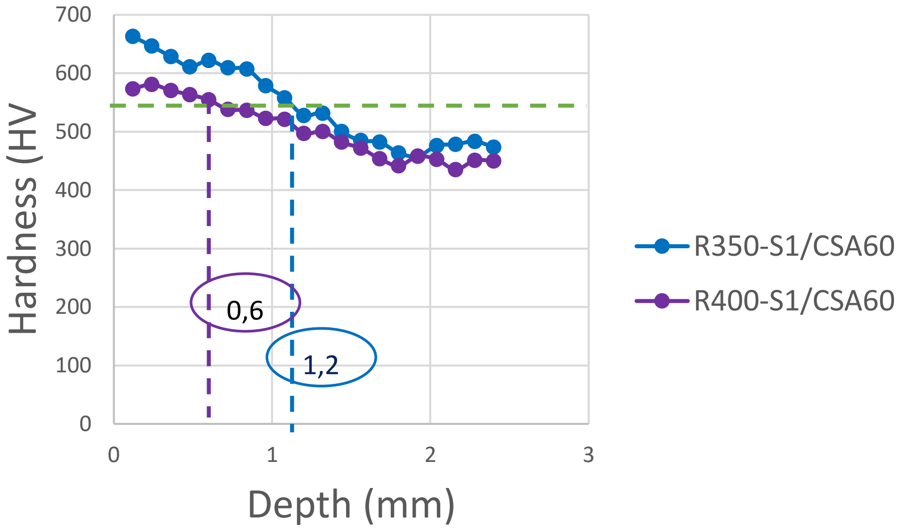
- **Influence of tempering treatment temperature and biocarbirizer on case hardeness depht**

Tempering at 350 and 400°C









CONCLUSION

Carbonization yield and Ultimate analys

- Mass loss increases with carbonization time
- Carbonization increases the carbon content of bio-carburizers
- Chemical treatment decreases de carbon content

Microscopy

- The chemical treatment allows to obtain a bio-cement with more microporosity, just as porosity increases with carbonization time

Microstructural analysis

-The carburizing treatment undergone by C35 and 42CrMo4 steel changes the microstructure

-The microstructure of the steel sample depends on the processing conditions undergone by the bio-carburizer used

-The presence of residual oxide and austenite a thickness depends on the bio carburizer used

Hardness profile

-Bio-carburizers improve the mechanical characteristics of steel,

-The depth of carburization varies depending on the treatment undergone by the bio-carburizer

-Hardness is higher for substrates carburizing with KOH treated carburizers and the depth can reach 2mm

-The low surface hardness is due to the presence of residual austenite and oxides on quenched samples

-Tempering converts the retain austenite on the surface

PERSPECTIVES

- Wear behavior assessment
- Study the diffusion phenomena

ACKNOWLEDGEMENTS

THANKS FOR YOUR KIND ATTENTION

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