



EXPLOITATION OF CANARIUM SCHWEINFURTHII CORE SHELLS AS CARBON SOURCE FOR CASE HARDENING OF STEELS

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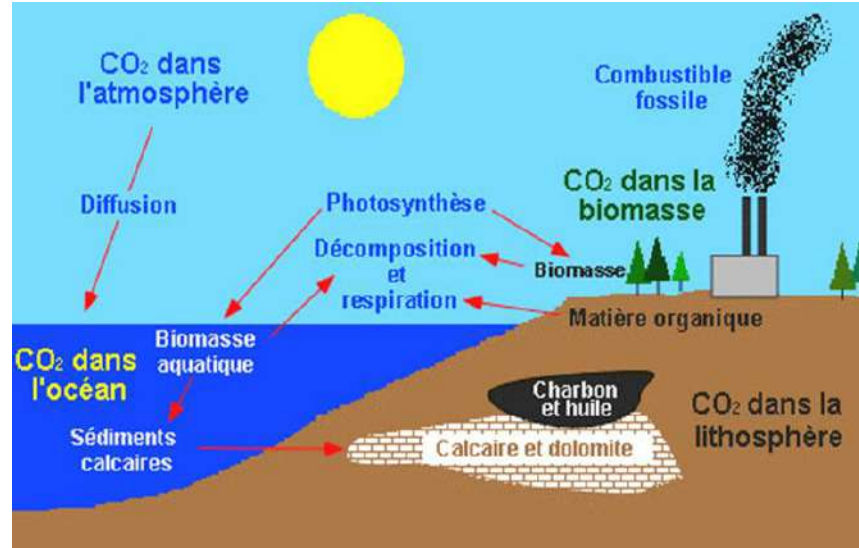
CONTEXT AND ISSUES



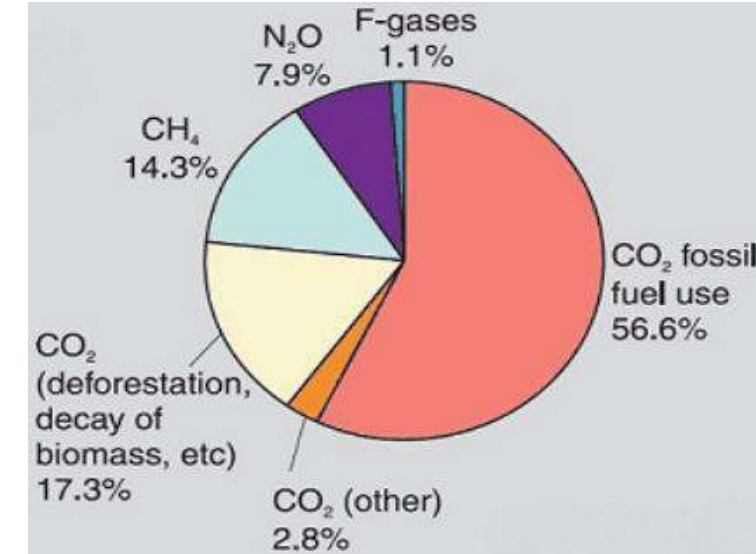
Canarium Schweinfurthii core shell

CARBON POTENTIAL OF SOME PLANT SHELLS

- Palm nut shells : 49,1-54,2% (A. Diedhiou et al., 2014)
- Coconut shells : 50 % (Ernesto de la Torre Chauvin, 2015)
- Core shells of Canarium Schweinfurthii (CS): **51,99%** (Garba et al., 2023)



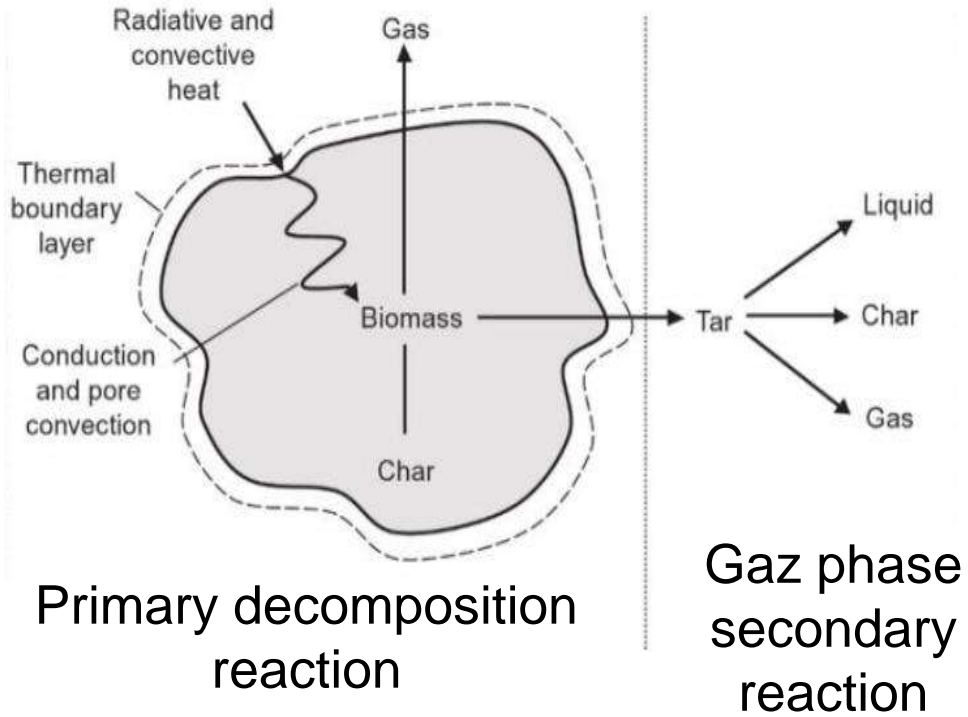
Consequences of neglected plant waste in nature



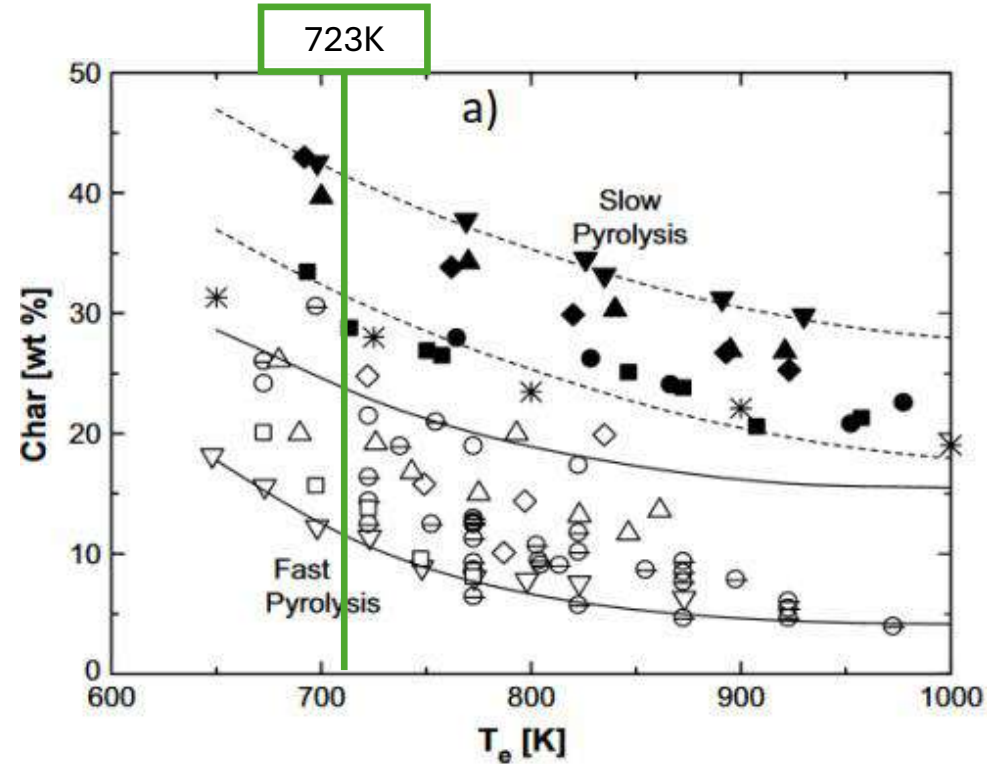
Annual distribution of greenhouse gas (GHG) emissions in 2004

CONTEXT AND ISSUES

Coal from biomass (carbonization)



Biomass pyrolysis (Basu, 2013;
Sami Zellagui, 2017)



Coal yield as a function of
temperature (Di Blasi, 2009)



Coal

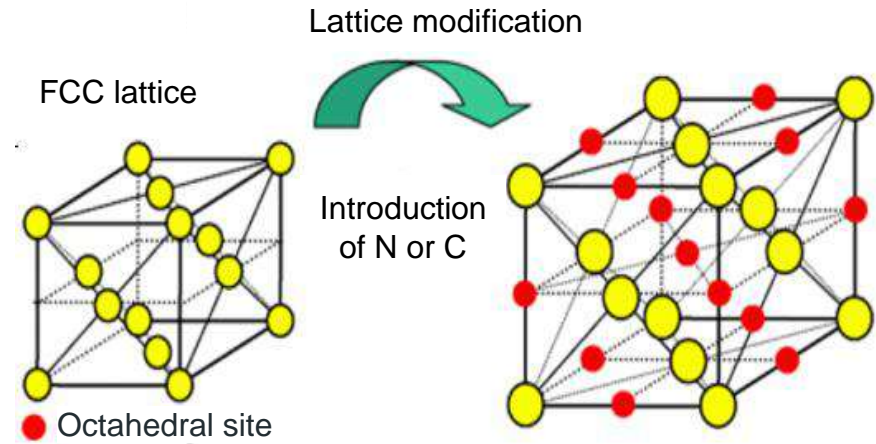
CONTEXT AND ISSUES



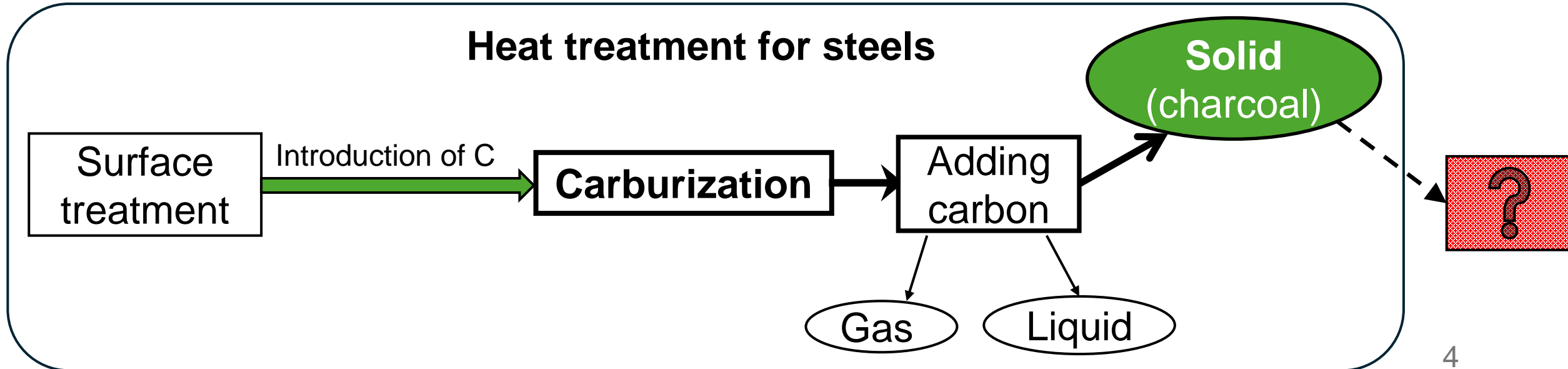
Clutch friction plate



Damaged brake



Change of the lattice after insertion of carbon or nitrogen in octahedral sites (T. LESAGE, 2019)

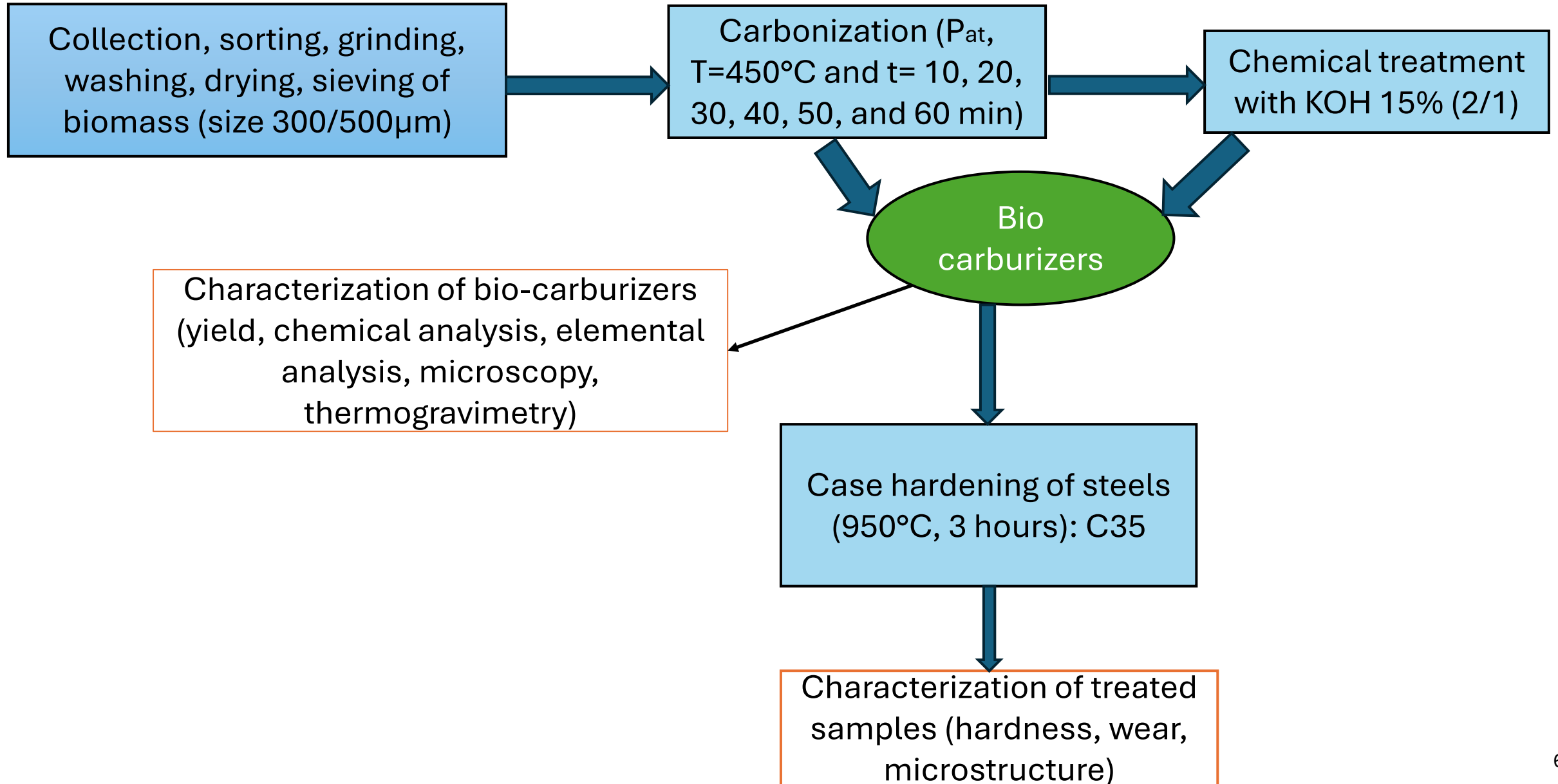


RESEARCH QUESTION

What is the contribution of bio-carburizer made from *Canarium Schweinfurthii* on the mechanical characteristics (hardness) and microstructural properties of the heat treated steels ?

MATERIALS, METHODS AND RESULTS

Step diagram



MATERIALS, METHODS AND RESULTS

➤ Shell collection and pretreatment

Objective: prepare and pack the shells



Canarium core shells



Grinding



Sieving 1



Washing



Drying+crushing



Fine sieving
(300/500 μ m)



Steaming



Packaging

MATERIALS, METHODS AND RESULTS

➤ Carbonization process

Objective: Produce bio-carburizers and evaluate the carbonization's yield



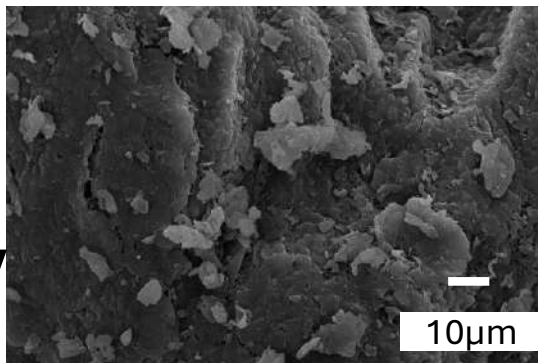
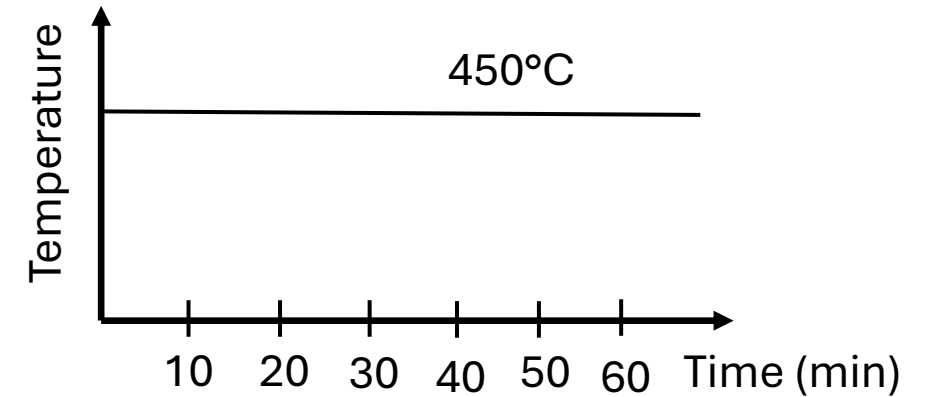
Weighing



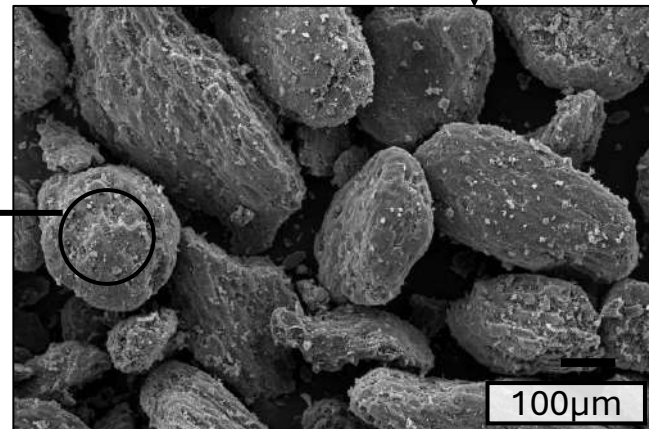
Carbonization
(P_{at})



Cooling



Low porosity

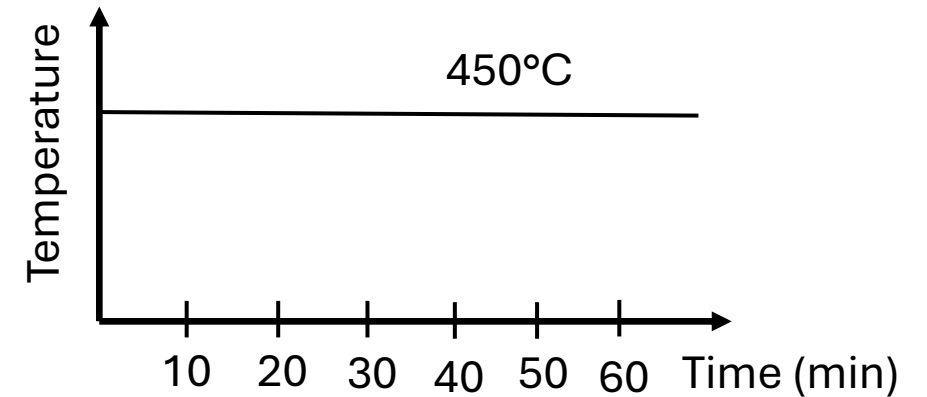
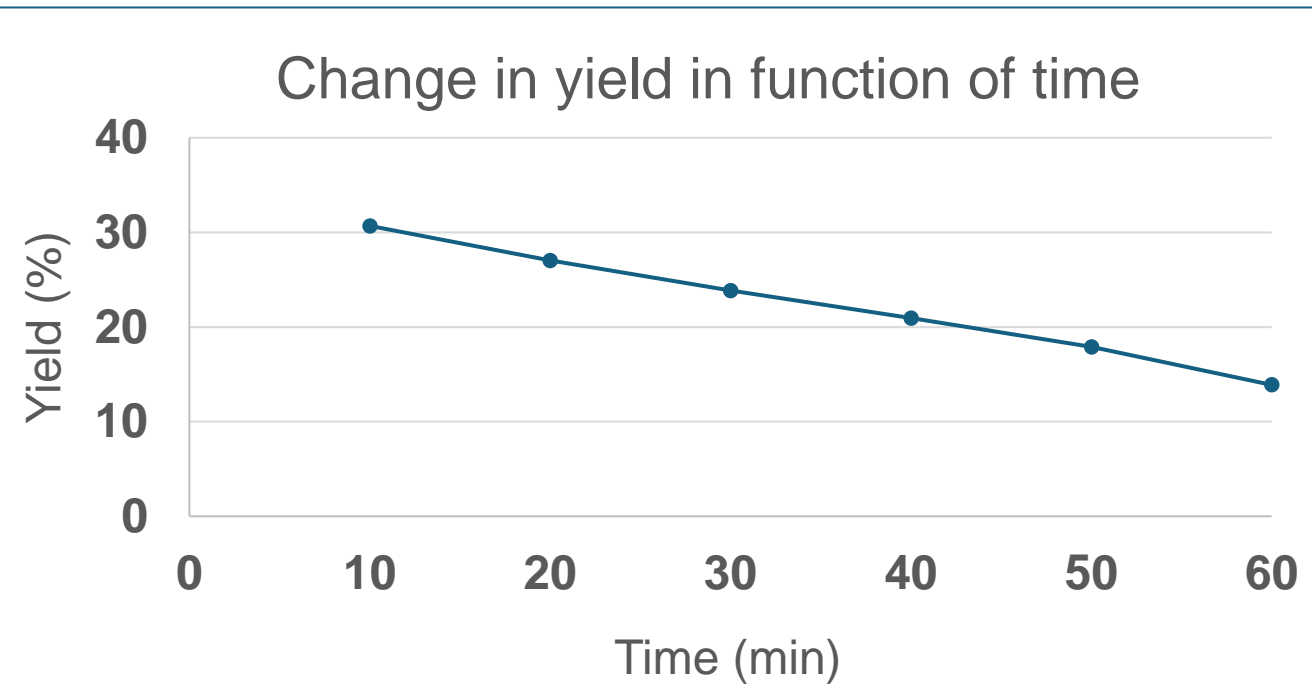


$$\text{Yield (\%)} = \frac{\text{mass}_{\text{final}}}{\text{mass}_{\text{initial}}} \times 100$$

MATERIALS, METHODS AND RESULTS

Objective: Produce bio-carburizers and evaluate the carbonization's yield

➤ Carbonization yield



- ❑ The results are similar (<33%) to those obtain by Linares-Salano, 1980; Daud, 2001 (palm kernel shell)
- ❑ The yield is higher (>10%) than that of charcoal (10%) at the same temperature (N. Boukaous, 2021)

MATERIALS, METHODS AND RESULTS

➤ Chemical treatment

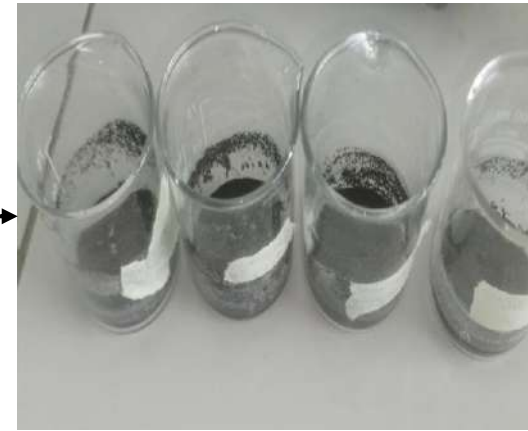
Objective: Increase the carbon content and porosity of bio-carburizer (Ajayi, 2009)



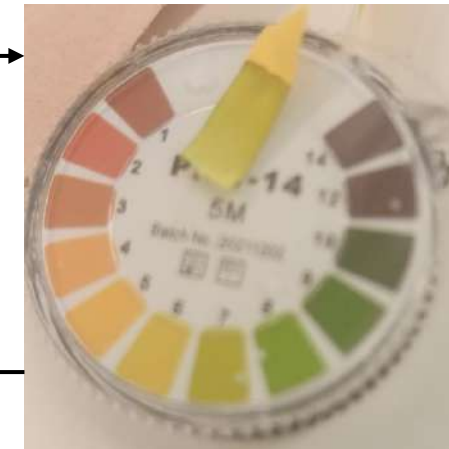
15% KOH solution



Bio-carburizer mixed with solution (2/1)



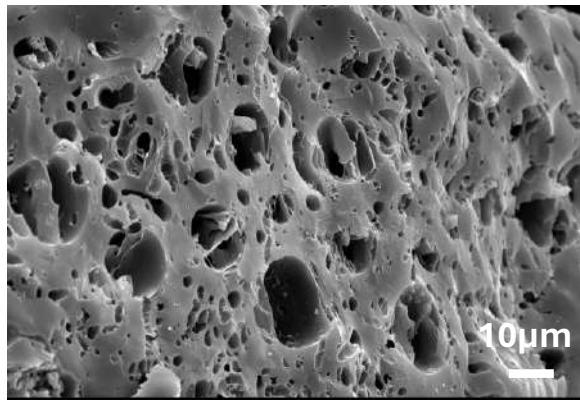
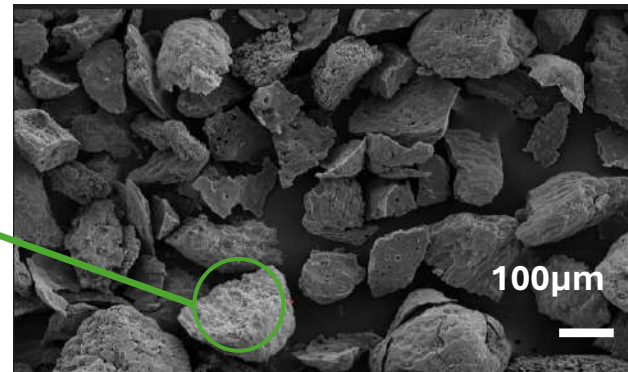
Steaming at 105°C (12h) for washing



Neutral test



Neutral bio-carburizer drying at 105°C (24h)



High porosity

MATERIALS, METHODS AND RESULTS

➤ **Thermochemical carburizing** (950°C Elzanaty, 2014; Umunakwe et al, 2017)

Objective: Enrich in carbon the surface layer of low-carbon steel

Samples used: a low carbon steel **C35**



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

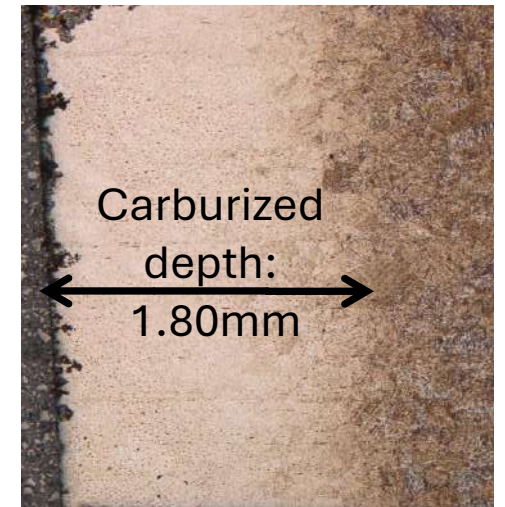
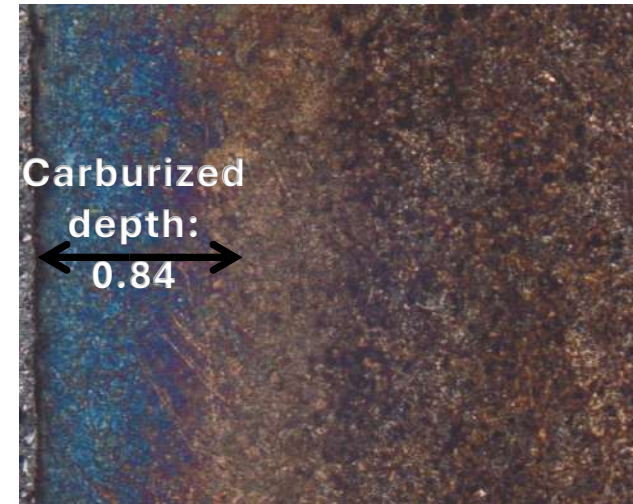
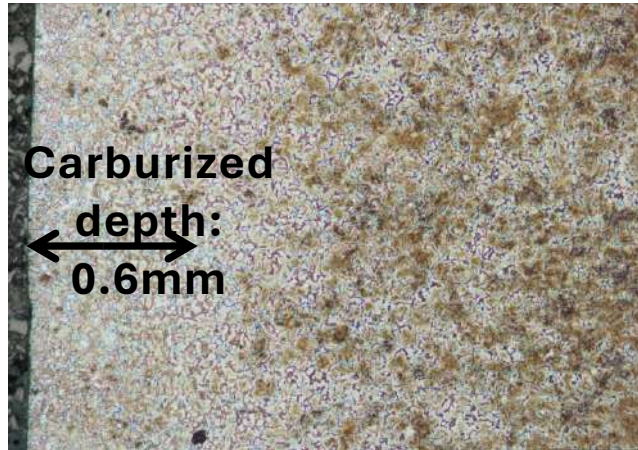


Samples quenched in the water

MATERIALS, METHODS AND RESULTS

➤ Optical microscopy: microstructural characterization

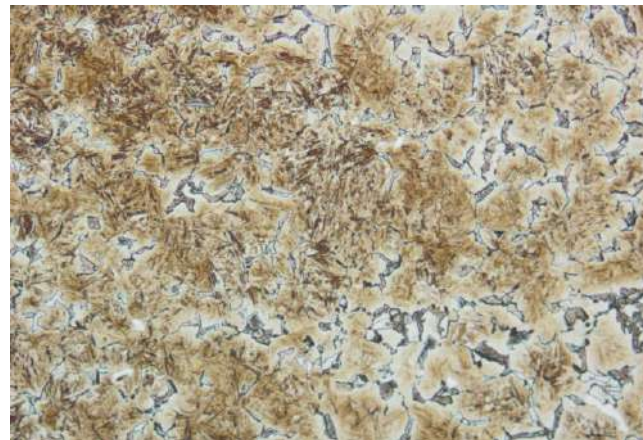
Superficial layer:



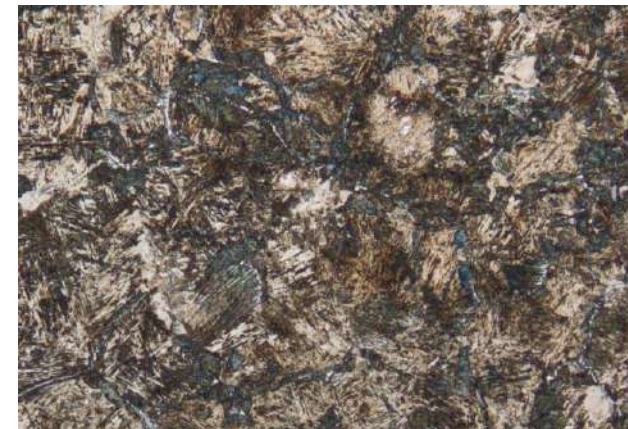
Core:



Untreated substrate
Ferrite-pearlite structure



Raw shell
Martensite+ferrite+pearlite
+residual austenite



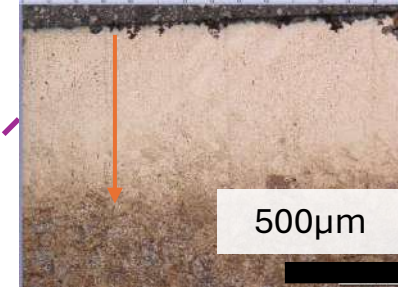
Untreated bio-carburizer(60min)
Martensite-residual austenite-carbide



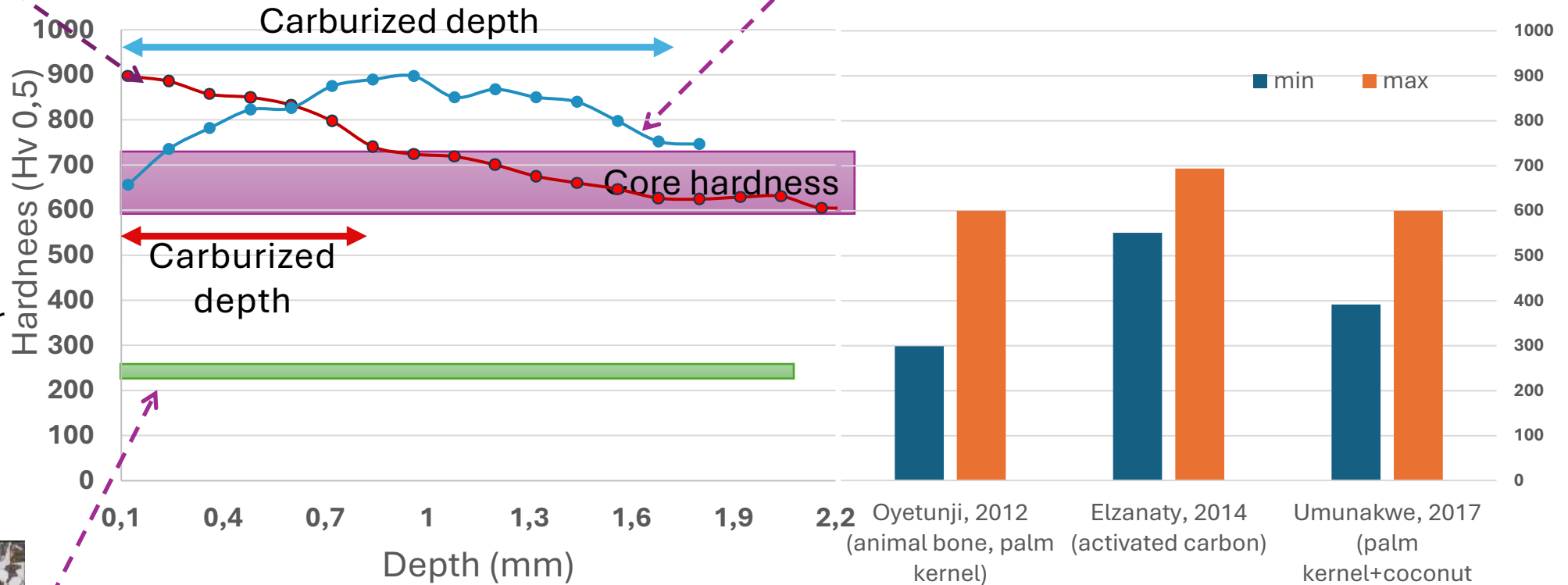
KOH treated bio-carburizer (60min)
Martensite-retained austenite

MATERIALS, METHODS AND RESULTS

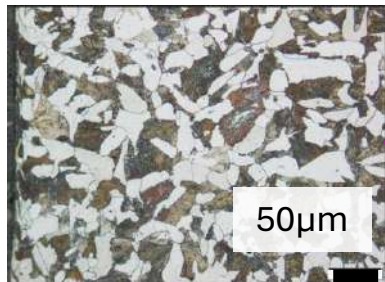
➤ Mechanical characterization: Vickers microhardness profiles



Treated bio carburizer
(Carbonization time:
60min)



Untreated bio-carburizer
(Carbonization time:
60min)



Untreated substrate

CONCLUSION

Carbonization
yield



- ✓ Yield decreases with carbonization time

Optical
microscopy

- ✓ Carburization depth depends on the bio-carburizers used

Hardness
(HV)

- ✓ Bio-carburizers produced from *Canarium Schweinfurthii* increase the mechanical properties (hardness) of steels
- ✓ Treated bio-carburizers give steels a higher hardness than untreated ones, this is justified by the higher specific surface area of the bio-carburizer

PERSPECTIVES

- Evaluate the carbon content of treated and untreated bio-carburizers
- Study the influence of case-hardening time
- Submit substrate to a tempering process
- Evaluate the wear resistance

ACKNOWLEDGEMENTS

The logo for ARES, featuring the word "ARES" in a bold, blue, sans-serif font.

ACADÉMIE
DE RECHERCHE ET
D'ENSEIGNEMENT
SUPÉRIEUR

The logo for PACO DEL, with "PACO" in red and "DEL" in blue, both in a large, bold, sans-serif font.

Partenariat
Coopération
Développement

The logo for M.M.S., featuring the letters "M.M.S." in a stylized font with a blue and green color scheme, and the text "Metallic Materials Science" below it.The logo for GRE, featuring a stylized flame in yellow and orange above the letters "GRE" in a bold, blue, sans-serif font.The logo for the University of Douala, featuring a circular arrangement of black and green dots, a palm tree, and the text "UNIVERSITE DE DOUALA" and "Laboratoire de Mécanique et de Matériaux Adaptés" around the perimeter, with "LAMINA" in green at the bottom.

THANK YOU FOR YOUR KEEN

ATTENTION

REFERENCES

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