Dr. UMBERTO CANCELLI

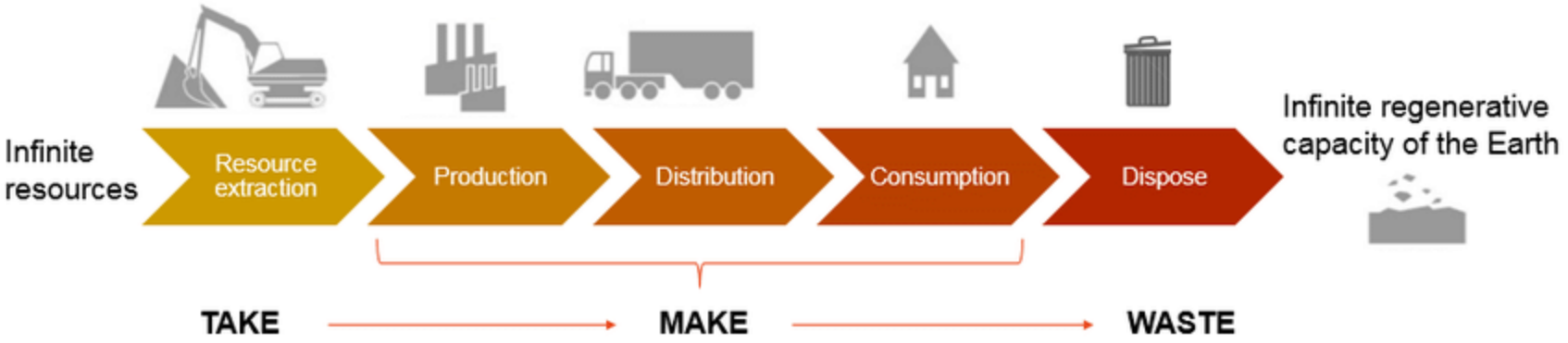
CIRCULAR ECONOMY STRATEGIES FOR MANAGEMENT AND VALORISATION OF SOME BY-PRODUCTS OF THE WINE INDUSTRY

Dept. of Life Sciences University of Modena and Reggio Emilia, Italy
Doctorate School in Agri-Food Sciences, Technologies and Bio-Technologies

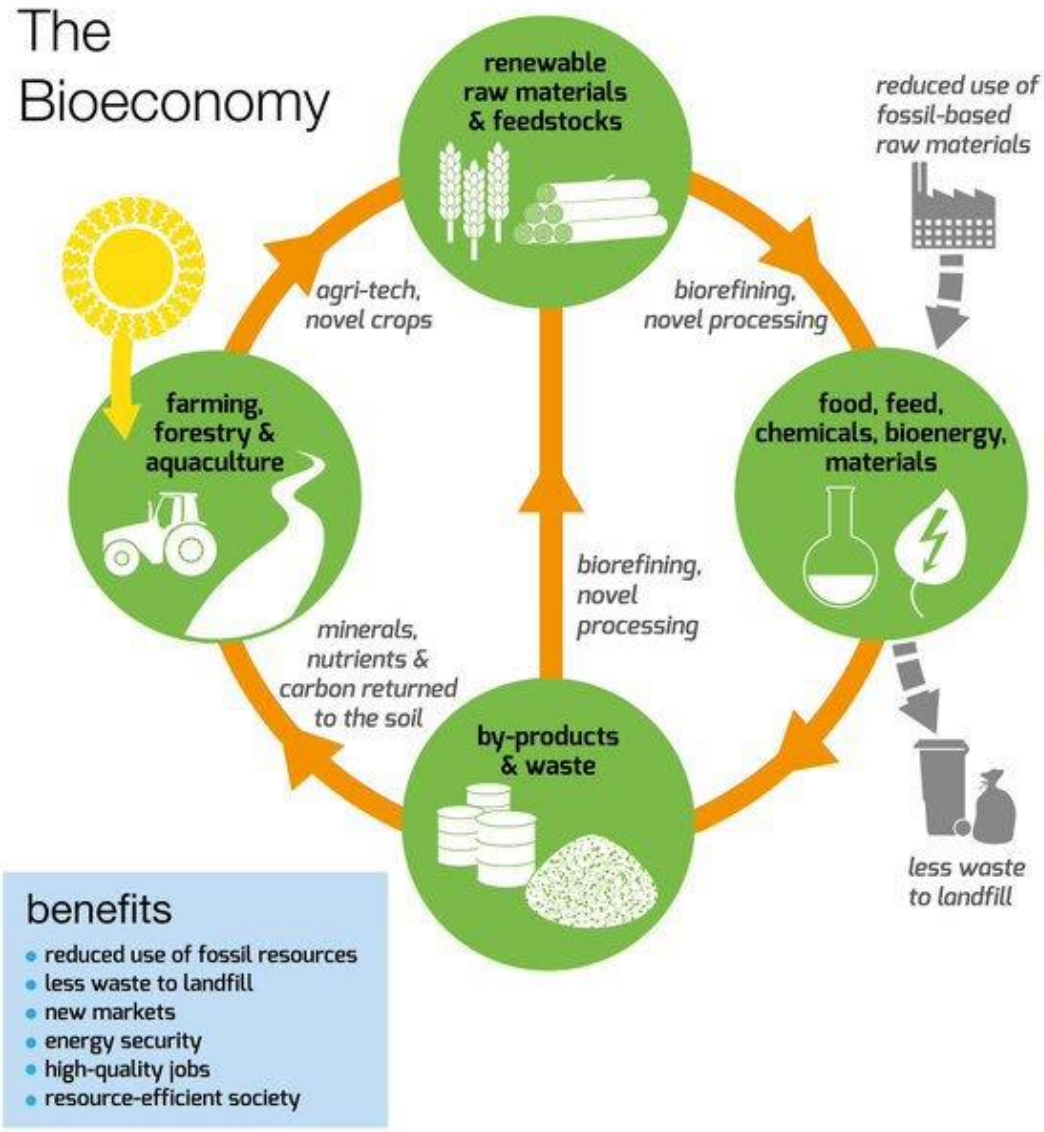
Tutors: prof. Andrea Antonelli and dr. Giuseppe Montevecchi

CIRCULAR ECONOMY

LINEAR ECONOMY

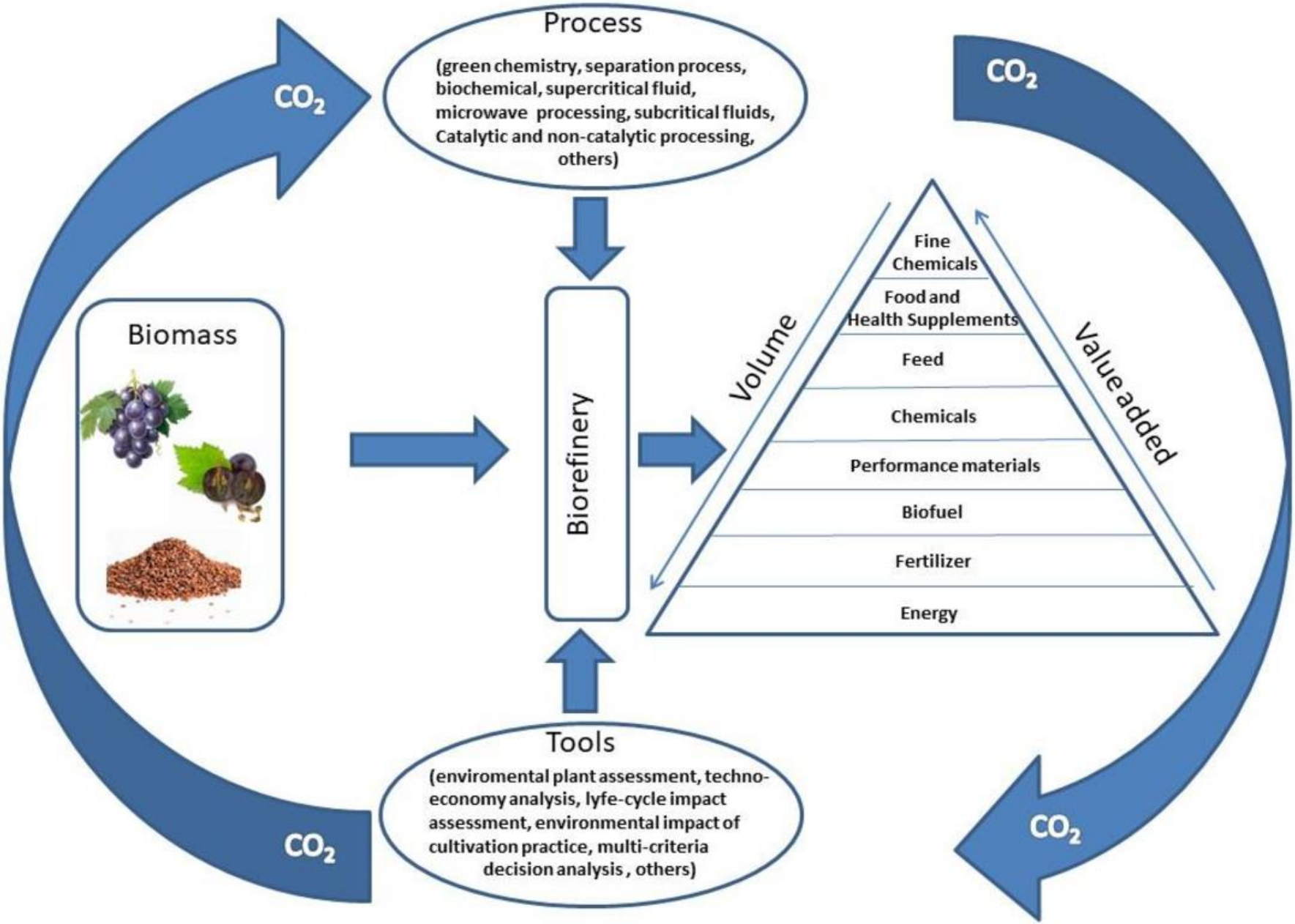


CIRCULAR BIO-ECONOMY FOR THE FOOD SUPPLY CHAIN WASTE AND BIOMASS SOURCES



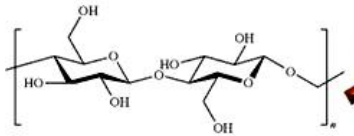
IMPORTANCE OF THE CIRCULAR BIO-BASED ECONOMY IN SUSTAINABLE DEVELOPMENT OBJECTIVES 2030

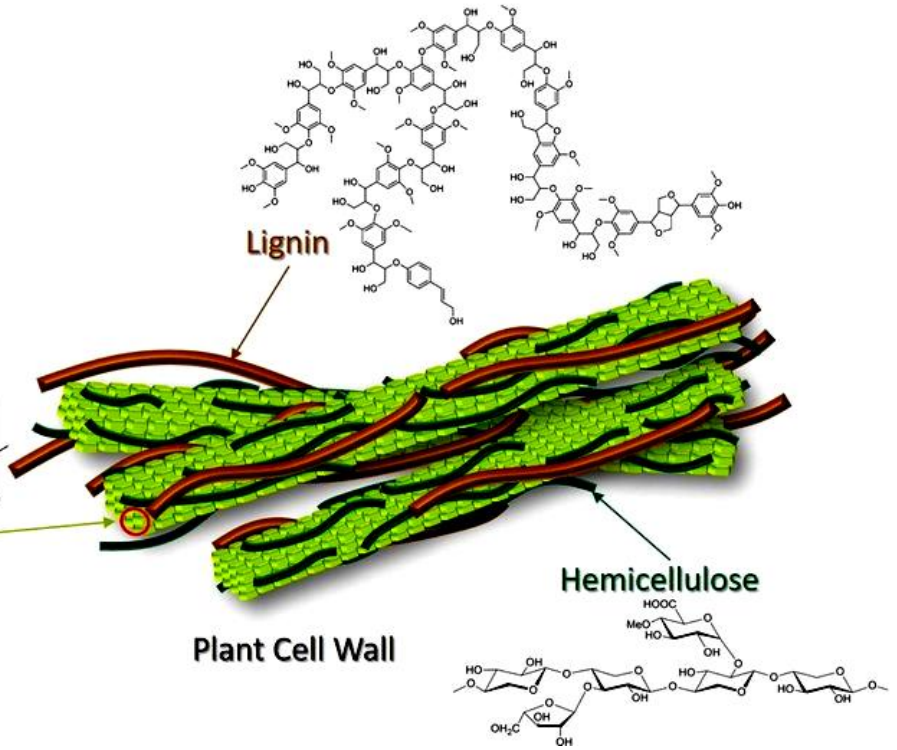
CIRCULAR BIO-ECONOMY APPLIED TO WINE INDUSTRY



VALORISATION OF GRAPE STALKS

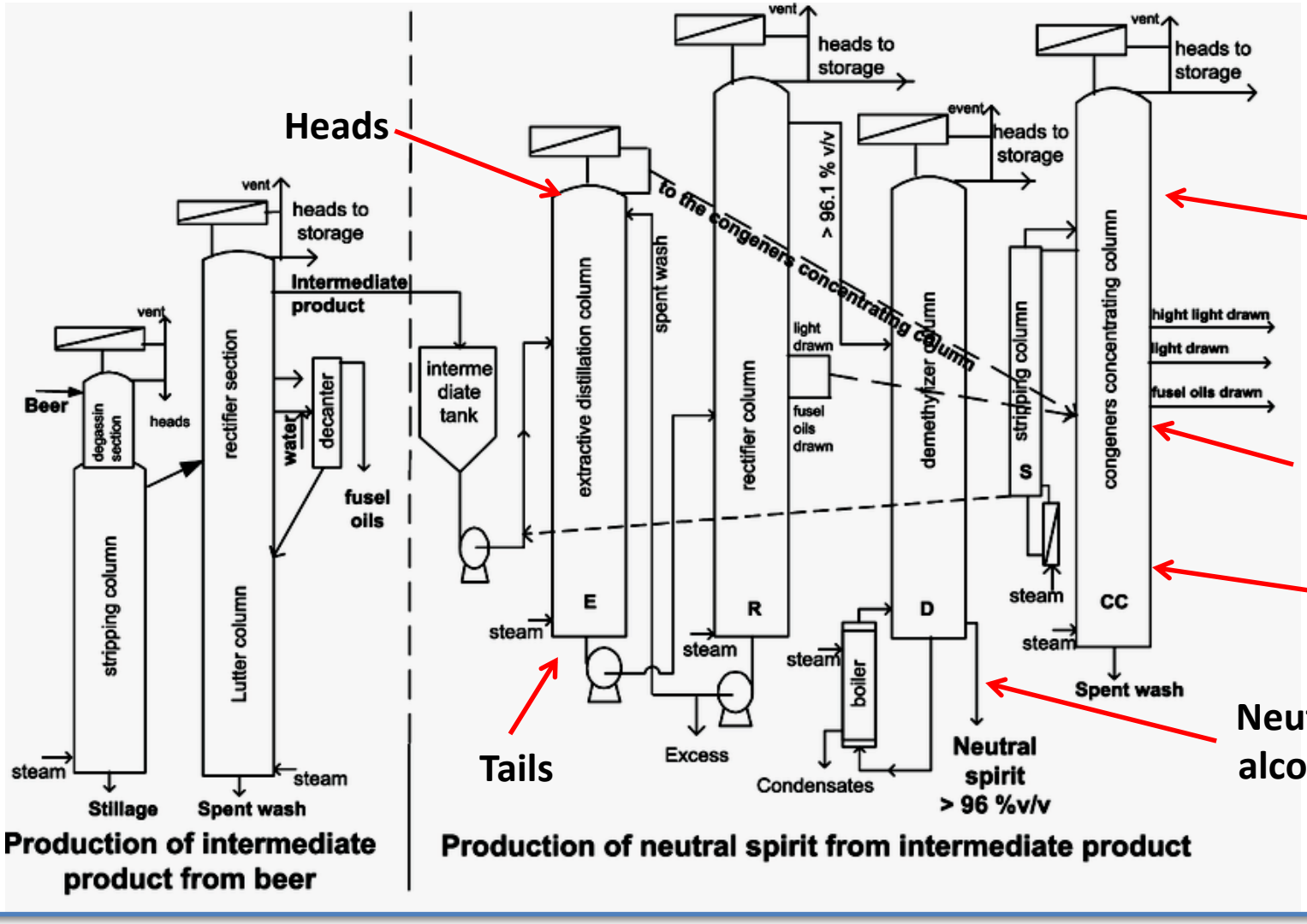
Molecular structure of the lignocellulosic biomass in the grape stalks





Lignocellulosic biomass as source of biopolymers: cellulose, hemi-cellulose and lignin

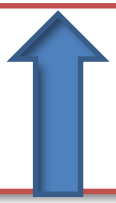
VALORISATION OF ALCOHOLIC DISTILLATION FRACTIONS



Distillation plant for the production of neutral alcohol (red arrows indicate the withdrawal points)

VALORISATION OF GRAPE STALK POWDER

FILLER FOR THE REALIZATION OF BIO-COMPOSITES



GRAPE STALK POWDER

ELECTROSTATIC SEPARATION IN TWO STEPS

EXTRACTION WITH: 1) WATER AND 2) H_2SO_4 sol. 2%
ON 9 FRACTIONS OF GRAPE STALK POWDER AND HPLC ANALYSIS

VALORISATION OF BY-PRODUCTS OF DISTILLATION

HEADS AND TAILS OF ALCOHOLIC DISTILLATION

GC-MS ANALYSIS OF PROFILING COMPOUNDS

USE OF THE ALCOHOLIC DISTILLATION FRACTIONS IN THE EXPERIMENTS WITH A DIRECT METHANOL FUEL CELL (DMFC)

SAMPLE PREPARATION OF THE GRAPE STALKS

1° STEP

Drying of the grape stalks at 65 °C

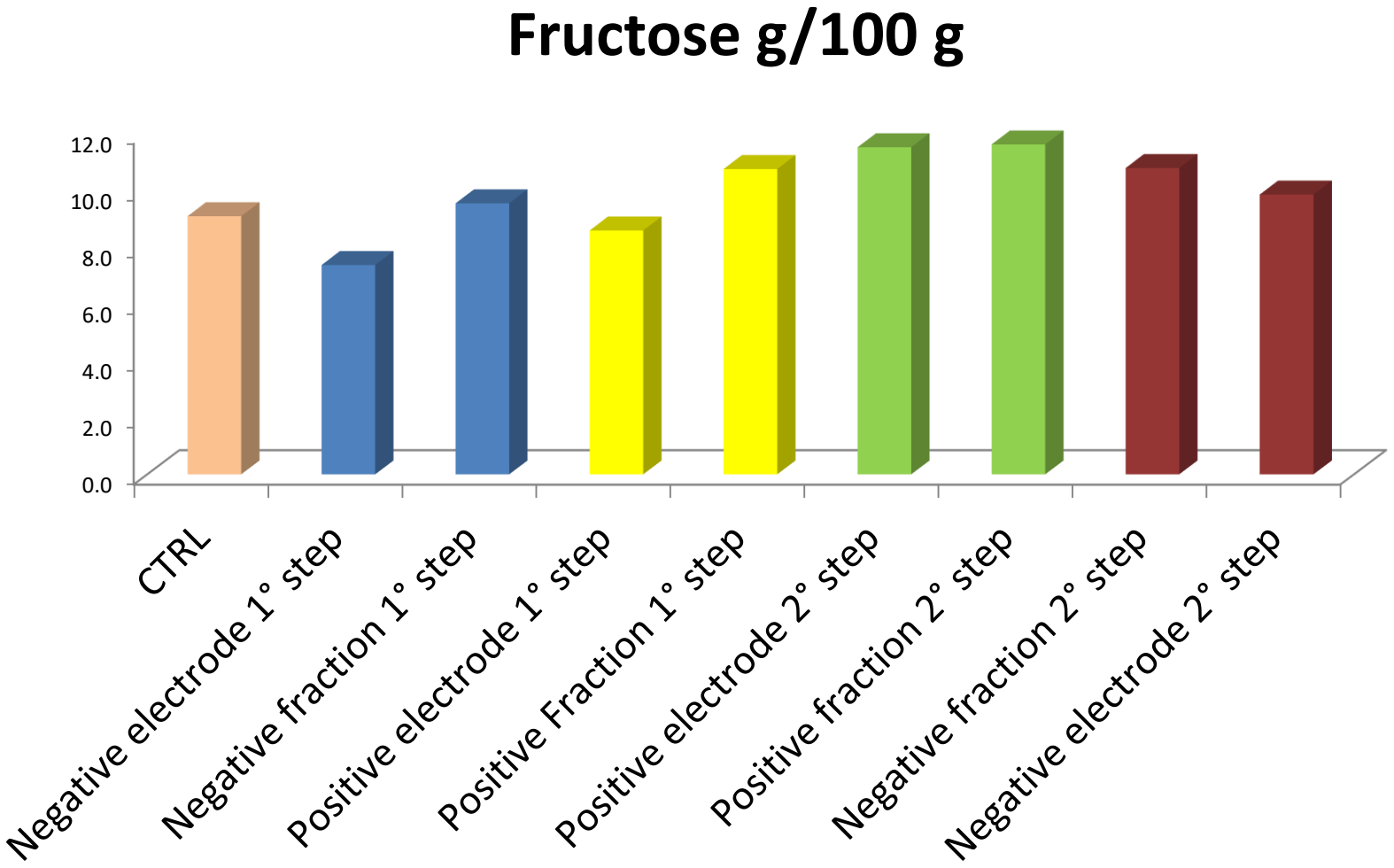
2° STEP

Milling of the dried material and separation of the powder into 4 granulometric classes

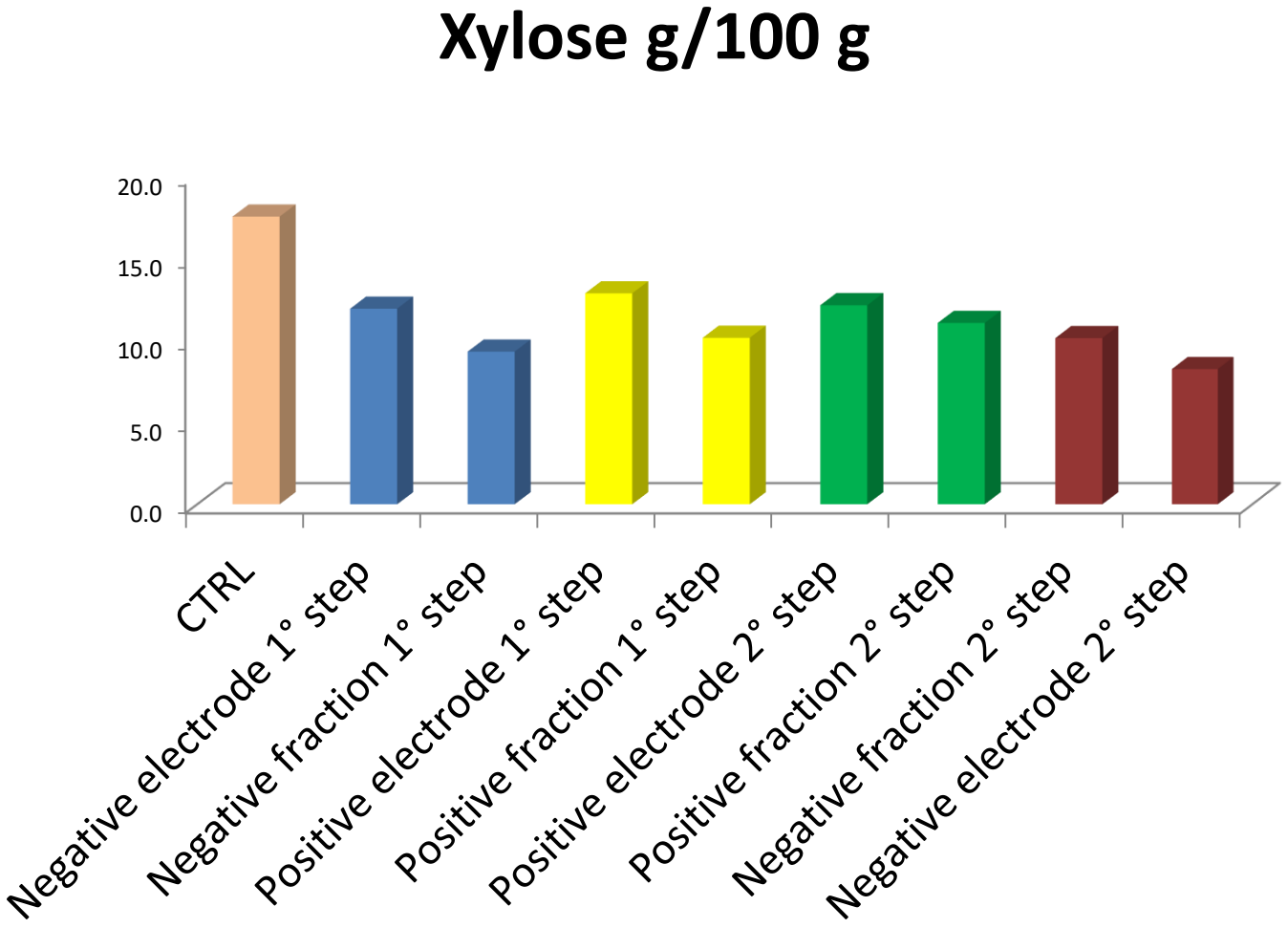
ELECTROSTATIC SEPARATION OF GRAPE STALK POWDER IN TWO STEPS

HPLC ANALYSIS OF THE 9 FRACTIONS

HPLC ANALYSIS OF THE 9 FRACTIONS



HPLC ANALYSIS OF THE 9 FRACTIONS



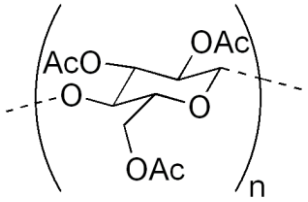
BIO-COMPOSITE MATERIALS

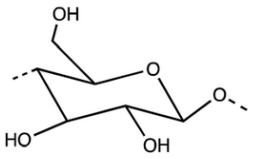
FRACTION WITH PARTICLE SIZE 63÷212 µm

CHEMICAL DERIVATIZATION OF THE POWDER

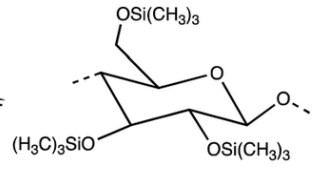
ACETYLATION

SILYLATION



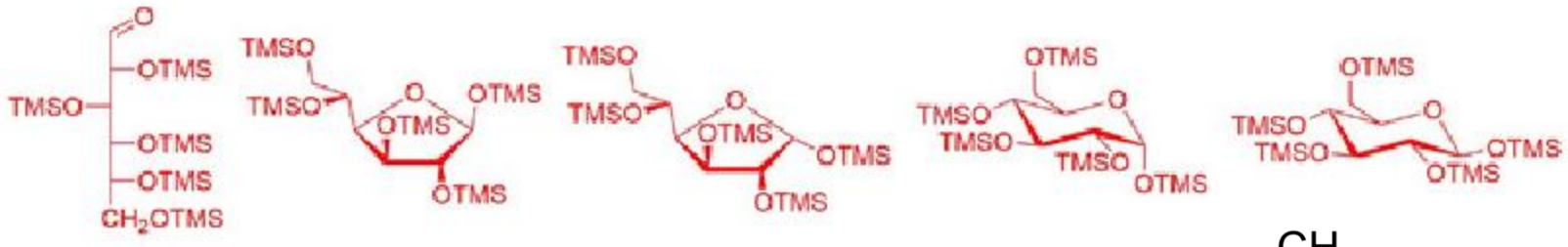


Cellulose



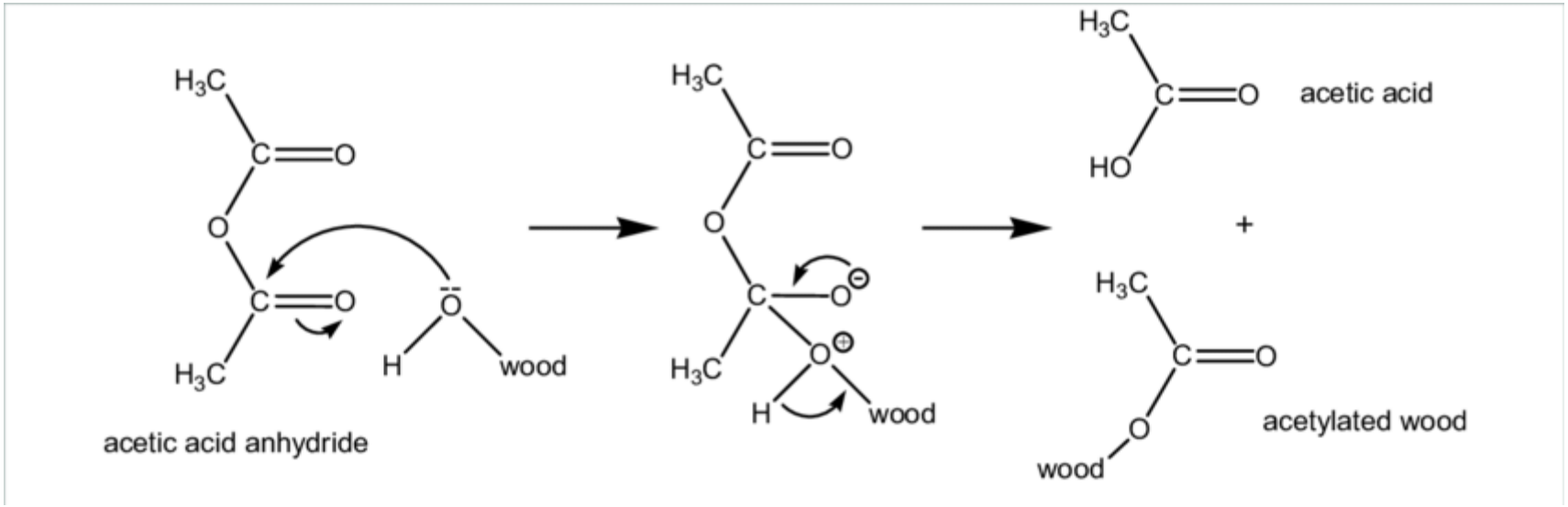
Trimethylsilyl cellulose (TMSC)

MECHANISM OF REACTIONS

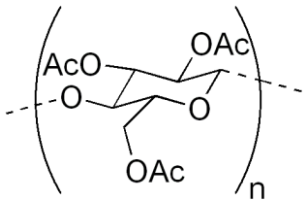


SILYLATION

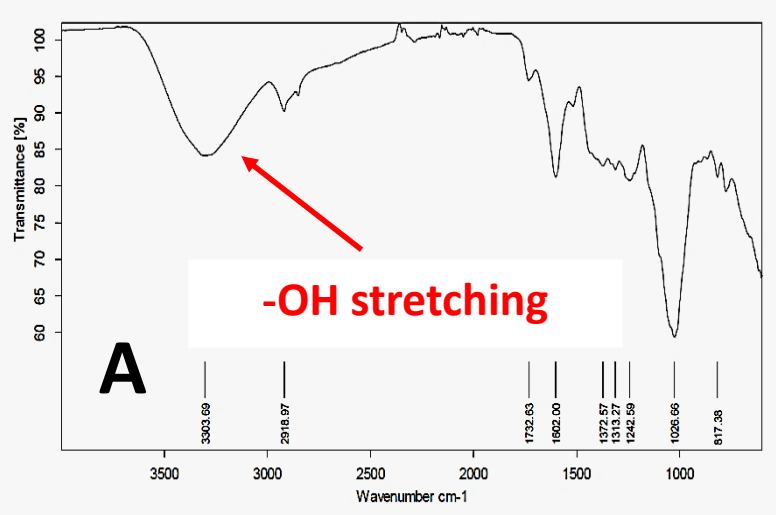
TMS = $-Si(CH_3)_3$

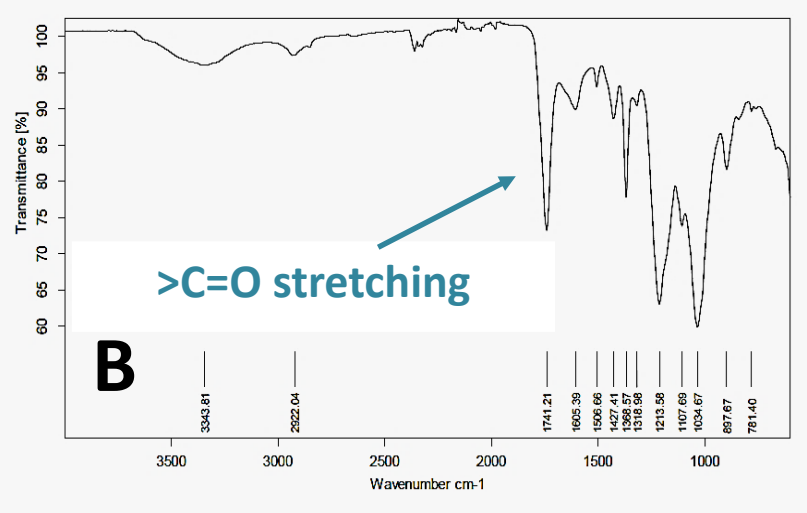


ACETYLATION

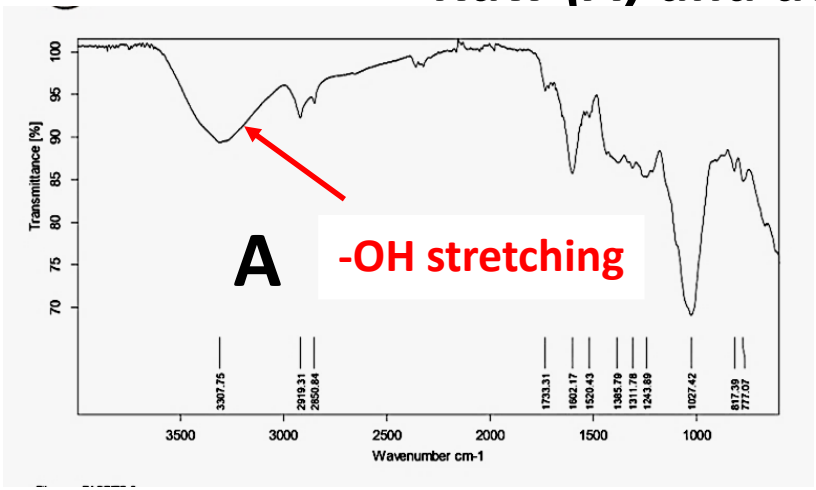


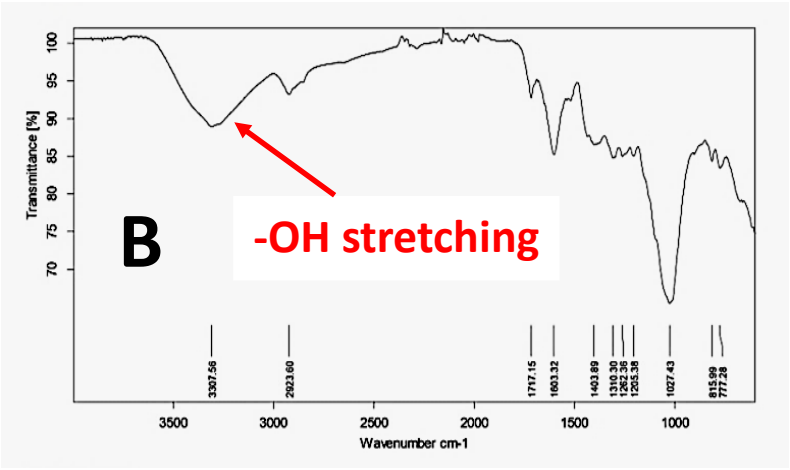
STRUCTURAL ANALYSIS OF THE MODIFIED GRAPE STALK POWDER WITH FT-IR SPECTROSCOPY





Raw (A) and acetylated (B) materials





Raw (A) and silylated (B) materials

TESTS FOR THE REALIZATION OF BIO-COMPOSITES WITH POLYBUTYLENE SUCCINATE (PBS)

GRAPE STALK
CONTROL

Phr 10

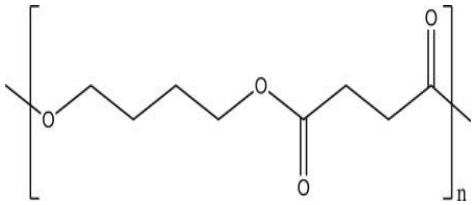
ACETYLATED
GRAPE STALK

Phr 10

SILYLATED
GRAPE STALK

SILYLATED
GRAPE STALK
in situ

Phr 10



POLYBUTYLENE
SUCCINATE (PBS)

POLYMER

REALIZATION OF BIO-COMPOSITES

EXTRUSION PROCESS OF MIXED MATERIALS

GRANULATION

INJECTION MOULDING

MECHANICAL ANALYSIS OF BIO-COMPOSITES

Characterization of Young's Module **E**, Tensile Stress **s**, and Elongation at break **e**

	E [MPa]	s [MPa]	e [%]
PBS	623	32.4	472
10 GS	713	25.7	168
10 GS silylated	710	25.9	153
10 GS acetylated	**717**	26.1	274
10 GS silylated *in situ*	629	30.3	354

Better performance obtained with acetylated grape stalk than the pure polymer by increasing (+15%) of the stiffness Young's module E

DISTILLATION LEFTOVERS

HEADS

TAILS

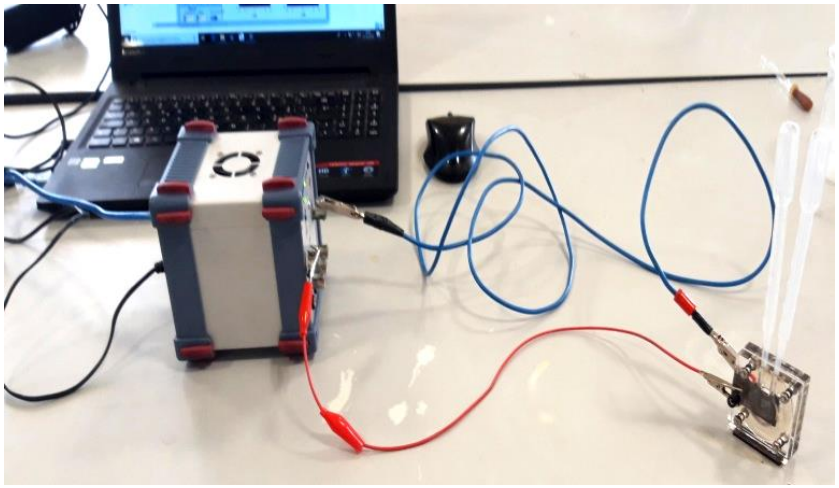
GC-MS ANALYSIS OF THE PROFILING VOLATILE COMPOUNDS

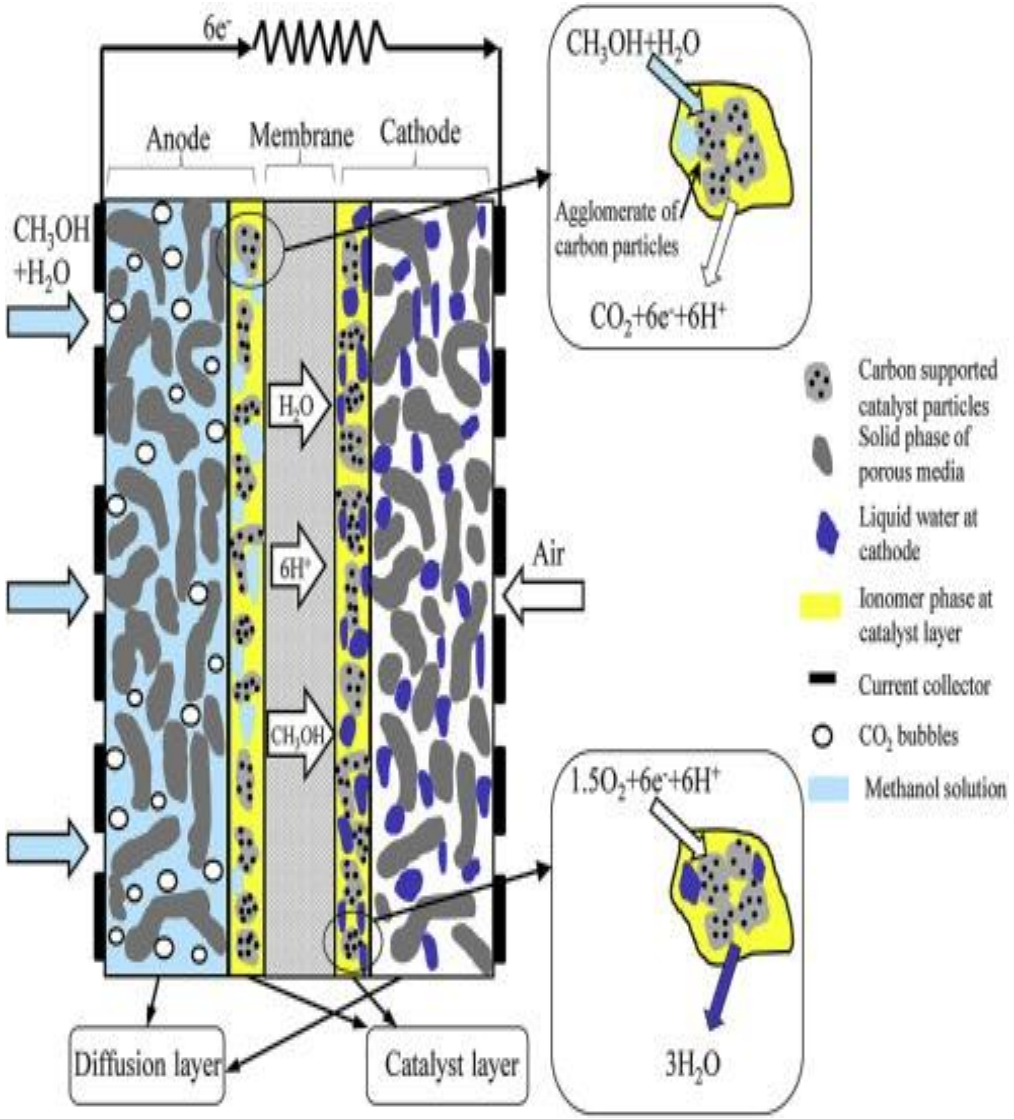
COMPOSITION OF THE DISTILLATION FRACTIONS

	HT grape pomace	DM	EP	HT Lees	Fusel oils	
					Upper phase	Lower phase
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ethyl acetate	7898	47	5908	7272	4070	1385
Methanol	38253	8337	518	4526	2025	2960
1-Propanol	3887	-	3559	6226	13420	5673
Isobutyl alcohol	1078	1.6	-	998	11264	2509
1-Butanol	26	-	48	182	3340	1025
1-Pentanol	-	-	4.6	0.00	1604	228
Isoamyl alcohol	149	8.4	995	735	73176	14229
Acetoin	1058	-	-	-	-	228
Alcohol by volume (%)	74.6	73.7	82	73	25	66

HT: heads and tails; DM: demethylation; EP: epuration

USE OF DISTILLATION FRACTIONS IN DIRECT METHANOL FUEL CELL (DMFC)

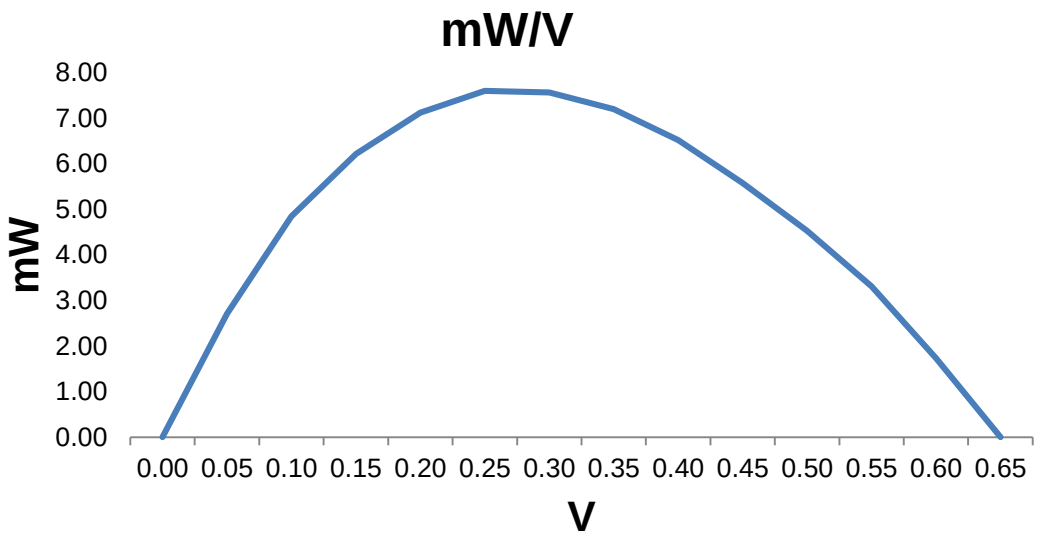




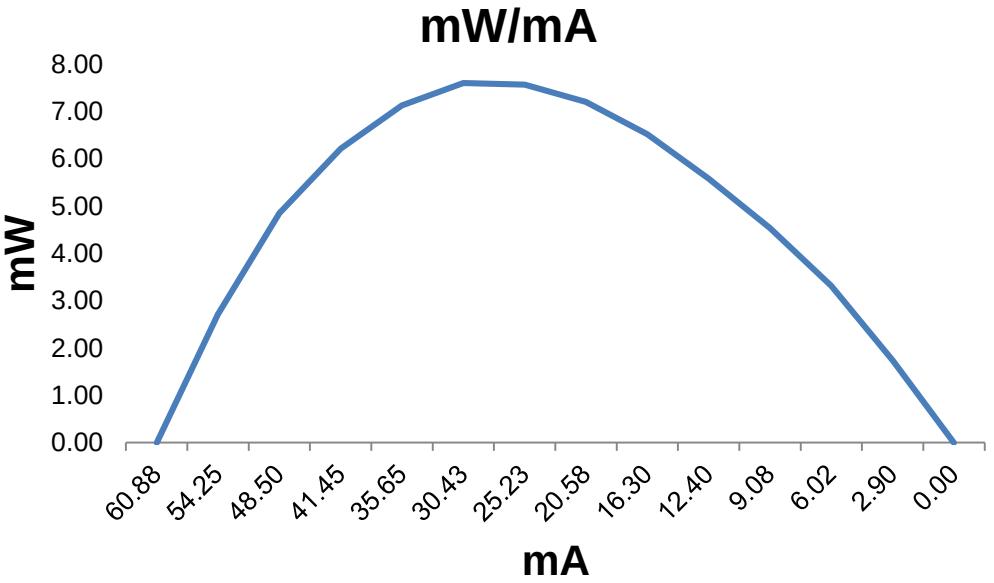
Structure and mechanism of DMFC

RESULTS OF THE ELECTROCHEMICAL MEASUREMENTS

Apparent power trend as a function of voltage



Apparent power trend as a function of electric current intensity



VARIATION OF THE COMPOSITION BETWEEN BEFORE AND AFTER FUEL CELL EXPERIMENTS

	HT grape pomace before fuel cell	HT grape pomace after fuel cell
	mg/L	mg/L
Ethyl acetate	25961	7844
Methanol	**84165**	**33968**
Ethanol	124736	69215
1-Propanol	9053	3346
2-Butanol	13986	5450
Acetic acid	2337	331784

HT: heads and tails

CONCLUSIONS

VALORISATION OF GRAPE STALKS

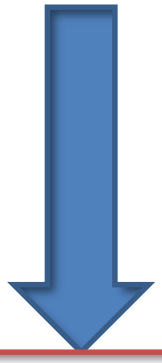
The ELECTROSTATIC SEPARATION method has yielded eight fractions that have been showing different composition

Since acid extraction has caused the formation of furans, which could be used as BUILDING BLOCKS in fine chemistry, electrochemical methods are being considered for their extensive production

The use of ACETYLATED GRAPE STALKS as FILLER could bring about a reduction in the cost of the polymer

CONCLUSIONS

HEADS AND TAILS OF DISTILLATION



These distillation leftovers showed proper concentrations of ethanol and methanol to be used as reducing agents in DIRECT METHANOL FUEL CELL

FUTURE PERSPECTIVES

ENHANCEMENT OF THE CIRCULAR ECONOMY APPROACH IN:

- THE WINE INDUSTRY, WITH STRONG IMPACT ON BIOMATERIALS AND ON RECOVERY OF BIO-MOLECULES

- THE FIELD OF FUEL CELL TECHNOLOGY

THANK YOU FOR YOUR ATTENTION