Microbial Cellulose Biosynthesis/Carbon Sources: an Inverse Gas Chromatography Study

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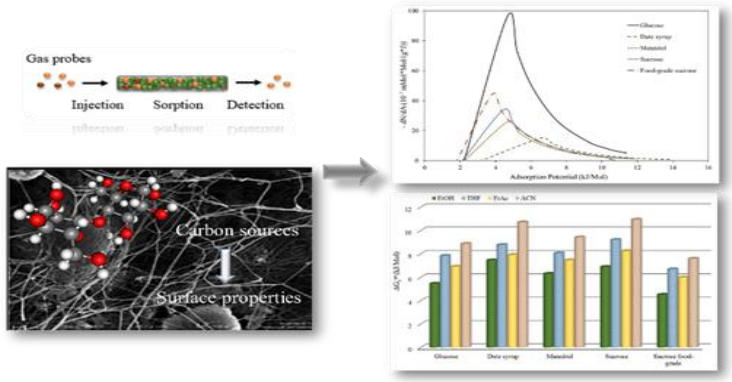
GRAPHICAL ABSTRACT



INTRODUCTION

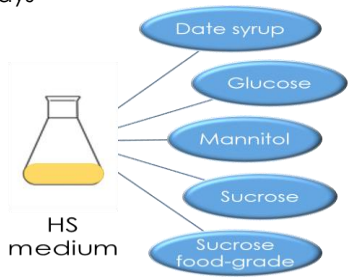
Microbial cellulose (MC) is a biotechnology product produced mainly from *Gluconacetobacter* sp. genus bacteria at the liquid/air interface. Despite the excellent self-evident MC properties, and in order to achieve specific applications, there is needed to change its properties. In the recent years, the use of industrial and agricultural by-products as alternative nutrients sources for MC production have been studied to achieve a "greener" MC production and reduce production costs. (Urbina et al, 2017, Tsouko, et al, 2015) The present study report a simple method for the surface properties modification by the alteration of the carbon sources in the MC biosynthesis process. Different MC biosynthesis conditions allows to obtain films with different properties. Date syrup, mannitol, sucrose and food-grade sucrose were the four carbon sources added in the MC biosynthesis beyond conventional source - glucose. The assessment of the changes and influence of these carbon sources in the surface properties of MC were investigated through Inverse Gas Chromatography (IGC).

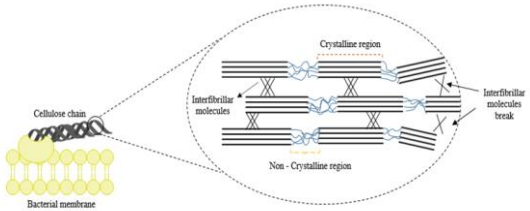
METHODS

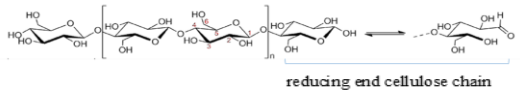
Conditions:

- 30 °C
- 7 days

Carbon sources:







RESULTS AND DISCUSSION

The alternative carbon sources change the MC particle morphology and there structure. The date syrup sources, rich in micro and macro-nutrients, give rise to MC with smaller surface area (S_{BET} = 4.04 m^2/g), turns the microporous MC membrane more hydrophobic (γ_s^d = 45.79 mJ/m^2) and with a more polar and basic character (36% more). By other hand, sucrose food-grade presented smaller MC production yield (37% less) and the obtained MC present more reticulation and crystalline structure (76.2 to 82.3%) with higher I_β/I_α ratio and a surface more dependent of the temperature. Thus, the use of alternative sources of carbon for the MC production it´s viable (yield increase 34%) and can be used to modify the MC surface properties.

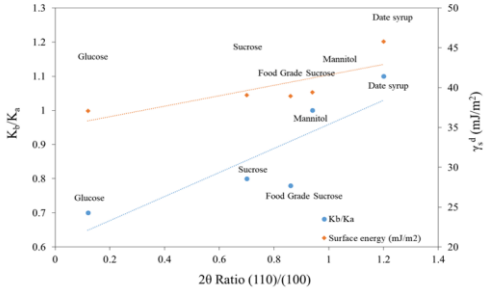


Figure 1. Relationship between the I_β/I_α ratio, and the γ_s^d and K_b/K_a ratio to bacterial cellulose produced using different carbon sources.

Table 1. IGC results obtained to the BC biosynthesis with different carbon sources, at 25 °C.

BC properties	Carbon source				
	Glucose	Date syrup	Mannitol	Sucrose	Sucrose food-grade
S_{BET} (m^2/g)	34.95 ± 1.05	4.04 ± 0.12	10.06 ± 0.30	8.36 ± 0.25	9.28 ± 0.28
n_m (mmol/g)	92.10 ± 2.76	10.65 ± 0.32	26.52 ± 0.80	22.04 ± 0.66	24.46 ± 0.73
γ_s^d (mJ/m^2)	37.08 ± 1.11	45.79 ± 1.37	39.07 ± 1.18	39.40 ± 1.17	38.94 ± 1.17
$\Delta\gamma_s^d/\Delta T$	-0.13	-0.70	-0.18	-0.34	-0.04
ΔG^{sp} (EtOH/THF)	0.70	0.85	0.78	0.75	0.67
K_a	0.10	0.10	0.10	0.10	0.09
K_b	0.07	0.11	0.08	0.10	0.07
K_b/K_a	0.70	1.10	0.80	1.00	0.78

S_{BET}: surface area; n_m: monolayer capacity; γ_s^d: dispersive component of surface free energy; K_a acid and K_b basic surface character; ΔG_s^{sp}: specific component of surface free energy.

CONCLUSION

Surface properties like, surface area, surface energy, porosity, roughness and acid-basic significantly change with the carbon source. The date syrup sources turns the microporous MC membrane more hydrophobic with a more basic character. By other hand, sucrose food-grade presented as being the source with the obtained MC present more reticulation, more crystalline, Kb/Ka and $\Delta\gamma_s^d/\Delta T$ smaller at the surface. Thus, the carbon source can be used as modeler of the MC surface properties.

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