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Workshop on Carbon-based Nanocomposites
Cutting-edge technology for multiple uses
November 21, 2018

Challenges in the production and characterization of polymeric nanocomposites based on two-dimensional fillers

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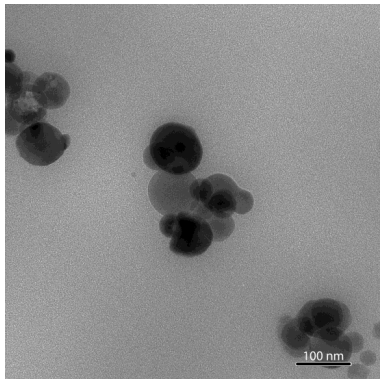
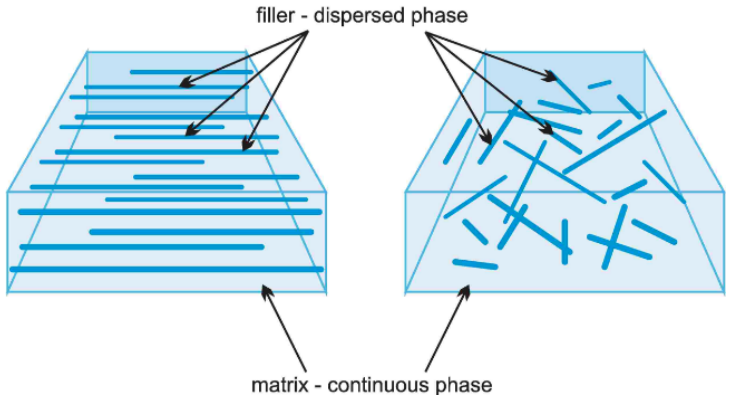
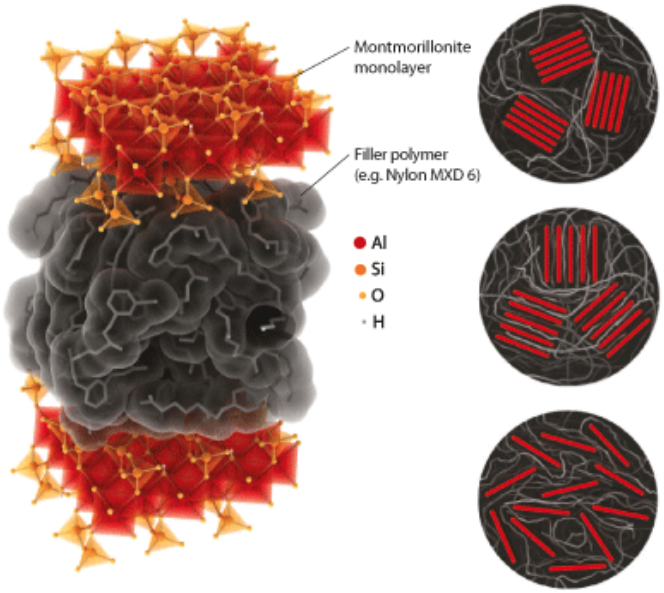
Traditional Fillers

- Content (%) ✓
- Compatibility with the matrix ✓
- Processing parameters ✓
- Simulation studies ✓
- Rheology of the nanocomposite ✓







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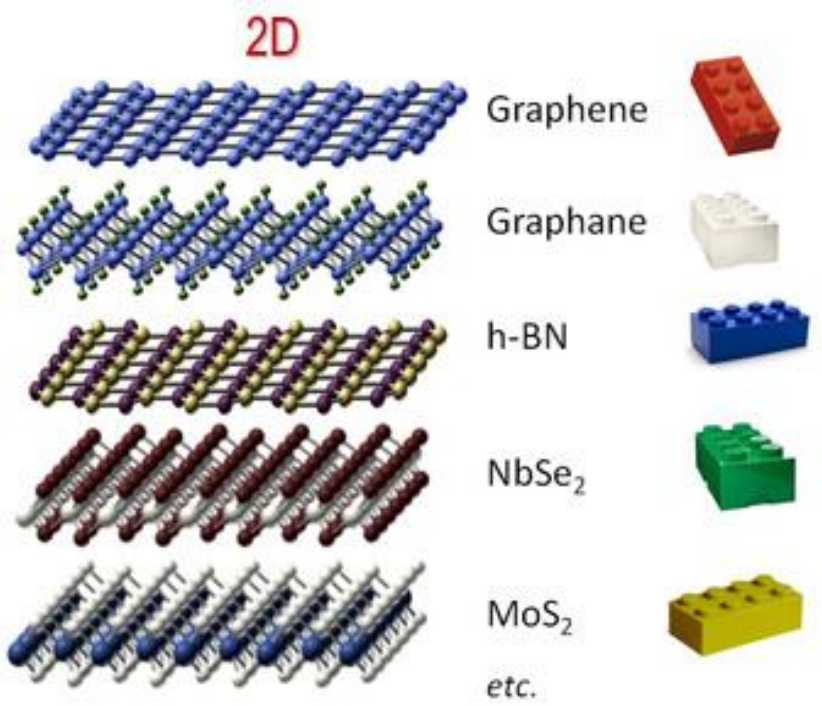
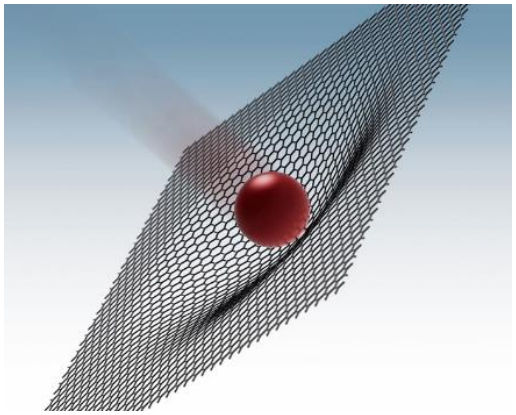
Two-dimensional materials



Why these 2D Materials are so good as fillers for polymers?



Elastic Modulus = 1 T Pa
Thermal conductivity = $3.10^3 – 5.10^3$ W/mK at room temperature
Electrical conductivity very high

Singular properties

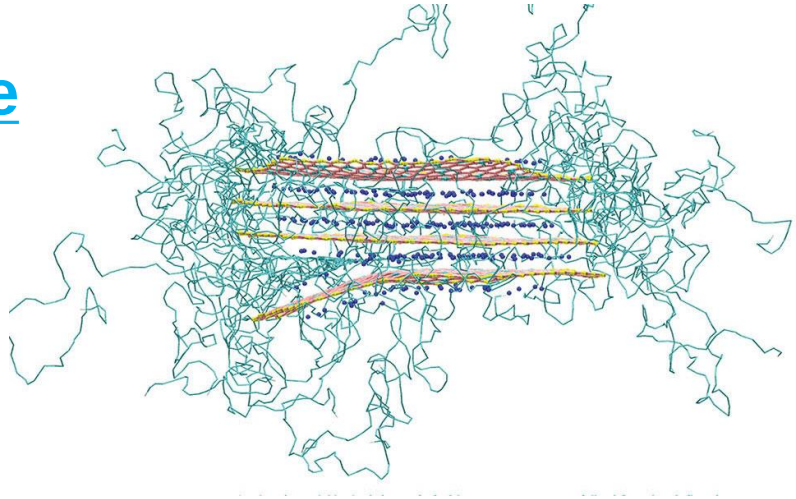
Surface area of graphene = 2700 m^2/g

Low content

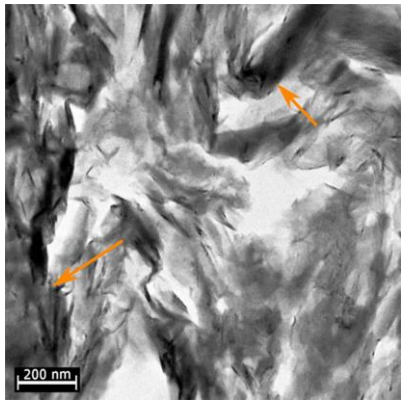
Challenges

Dilemma of two-dimensional materials

“High surface area”



“Filler agglomeration”



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Strategies

”Filler” + Polymer

(Melt mixing = Twin Screw extruder)

Exfoliation during the processing to obtain a polymer nanocomposite based on 2D material

Insertion of a pre-exfoliated material during the processing to obtain a polymer nanocomposite based on 2D material

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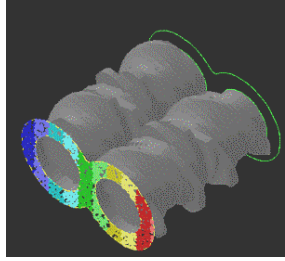
Our strategies



Solid-Solid Deposition

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https://doi.org/10.3144/expresspolymlett.2018.79

eXPRESS Polymer Letters

Novel improvement in processing of polymer nanocomposite based on 2D materials as fillers

P. A. R. Muñoz[1], C. F. P. de Oliveira[1], L. G. Amurin[1], C. L. C. Rodriguez[1], D. A. Nagaoka[1], M. I. B. Tavares[2], S. H. Domingues[1], R. J. E. Andrade[1], G. J. M. Fechine[1]*

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Liquid-Phase Feeding

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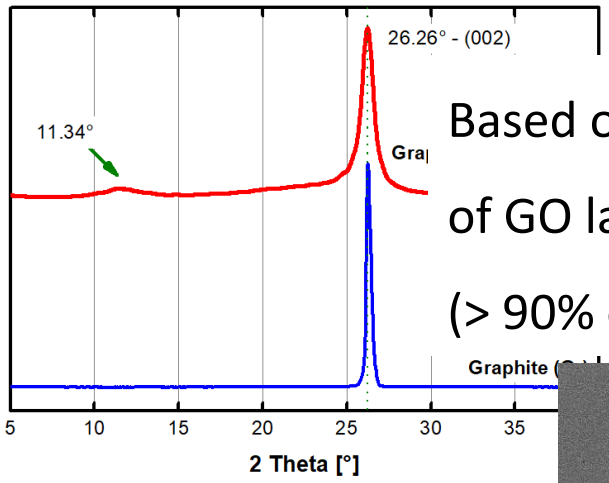
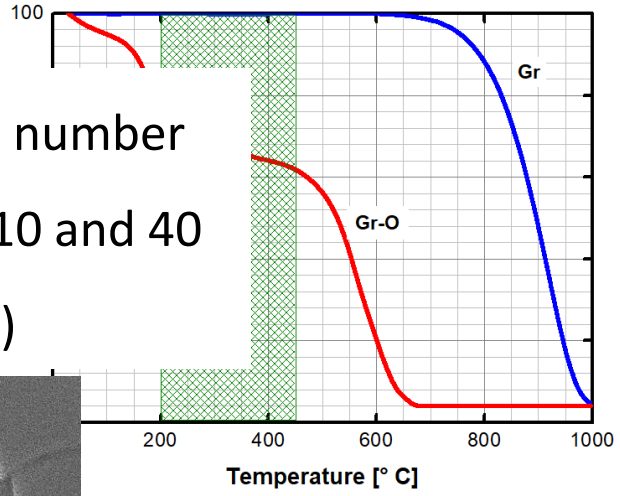
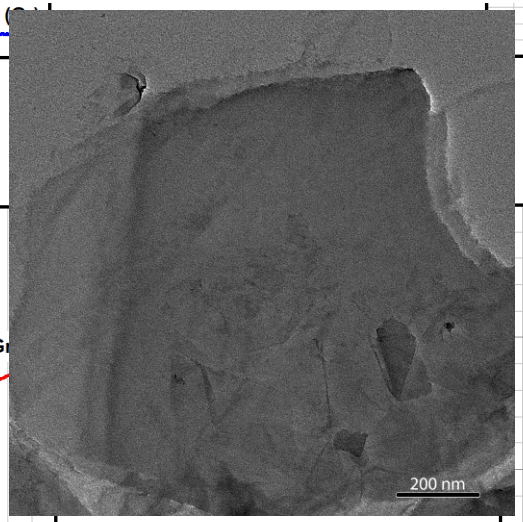
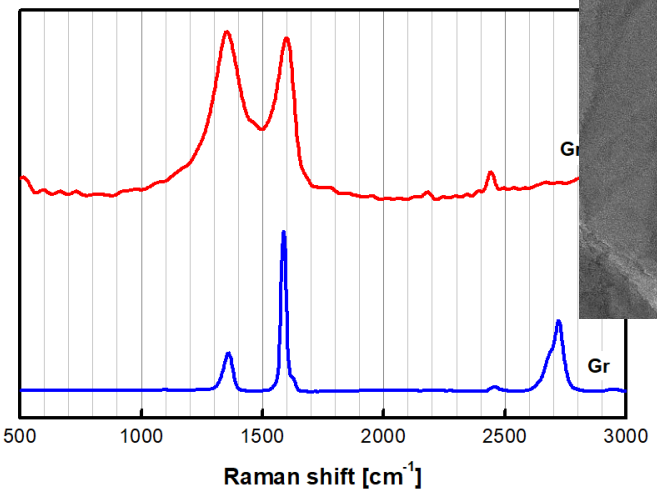
Graphite oxide (GrO) and multilayer graphene oxide (mGO)

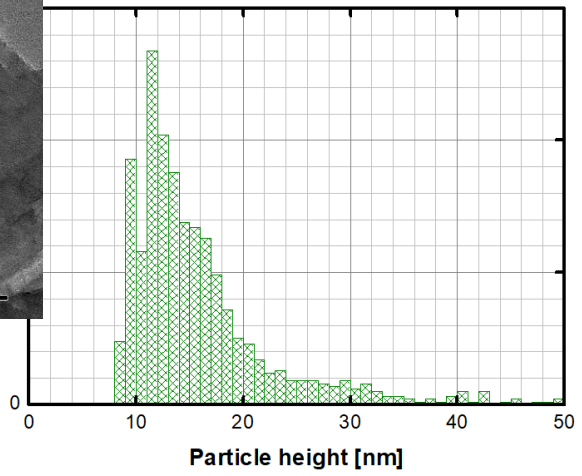


Based on these data, the number of GO layers is between 10 and 40 (> 90% of the population)









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Experimental Design

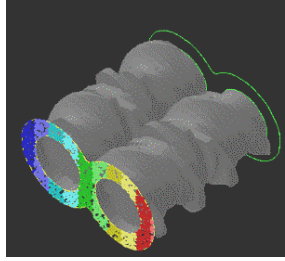

Table 1. Processing PS/GO composite experimental design.

Run	% GO	SV	% GO [wt%]	SV [rpm]
1	+	+	0.5	350
2	+	–	0.5	250
3	0	+	0.3	350
4	0	–	0.3	250
5	–	+	0.1	350
6	–	–	0.1	250

(+) upper variable level
(–) lower variable level.
(0) central point.

Table 4. Regression coefficients of response variables for the different nanocomposite manufacturing routes studied by ANOVA.

Model:	$S = a_0 + a_1(\%GO) + a_2(\%GO)^2 + a_3(SV) + a_4(SV)^2 + a_5(\%GO)(SV) + a_6(\%GO)^2(SV)$								
Sample	**Variable**	a_0	a_1	a_2	a_3	a_4	a_5	a_6	R^2
SSD	E [MPa]	3198.7	–56406.2	108187.5	4.1	–	163.3	–318.2	0.86933
	TS [MPa]	27.31640	–380549	–	0.05107	–	–	–0.04024	0.43576
	SBP [%]	1.1167661	–	–	0.000804	–	–	–0.002649	0.35466
LPF	E [MPa]	4665.2	–12944.1	27895.2	–	–	–	–15.7	0.85028
	TS [MPa]	60.1861	–	–	–0.0500	–	–	–	0.75152
	SBP [%]	2.794921	–	–	–0.004351	–	–0.001745	–	0.52037

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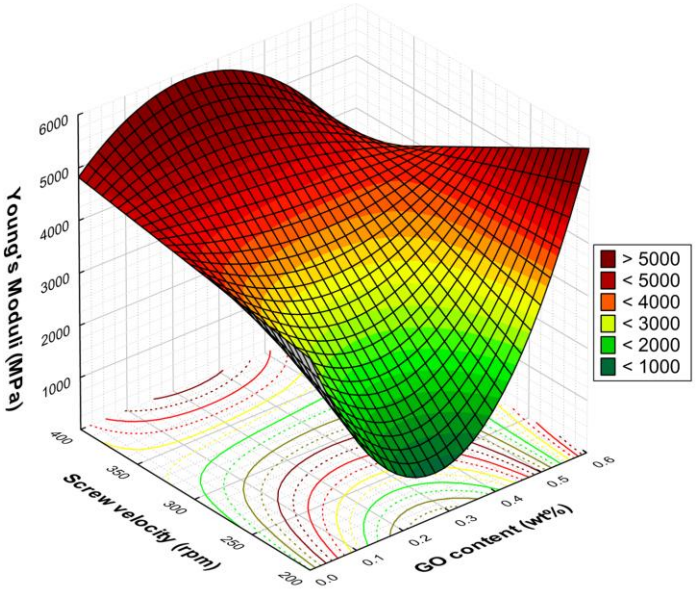
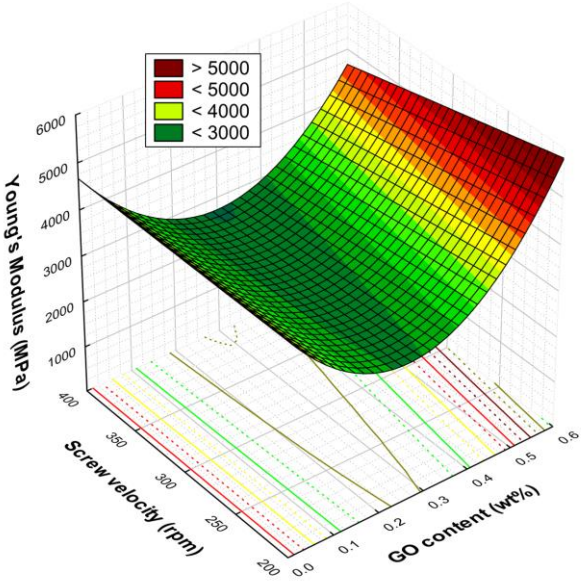
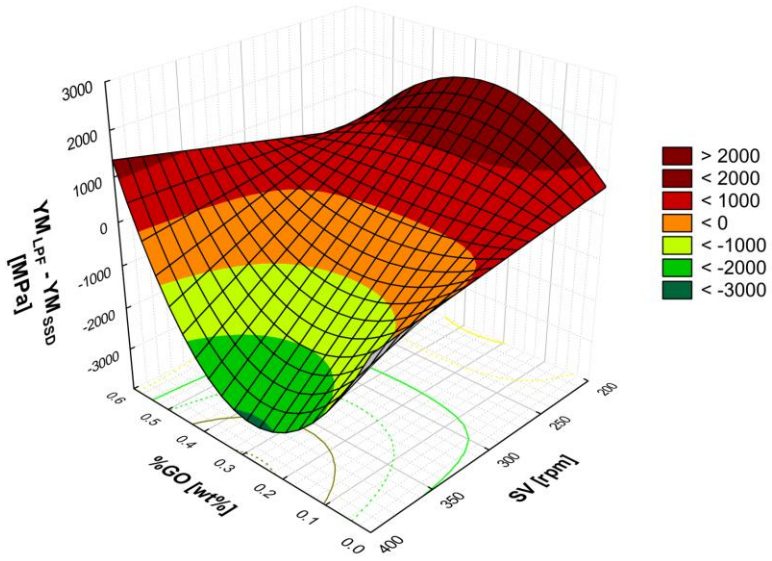
Mechanical Properties







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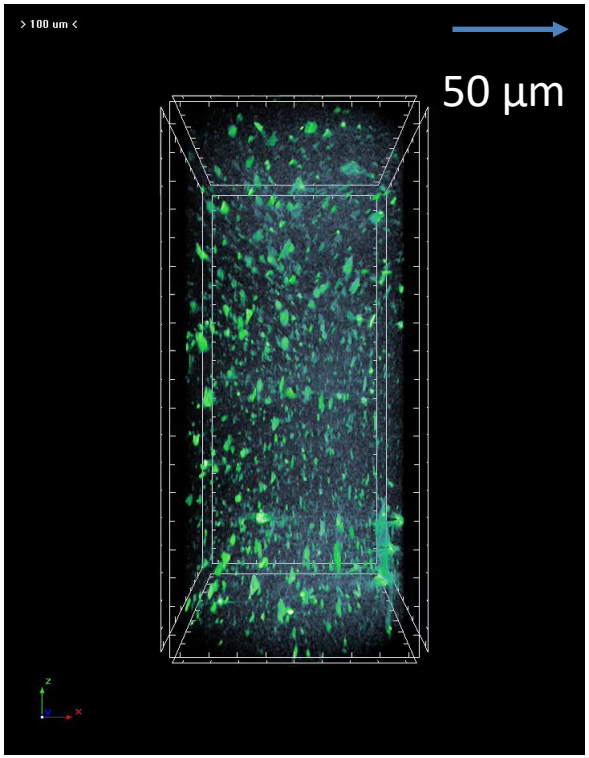
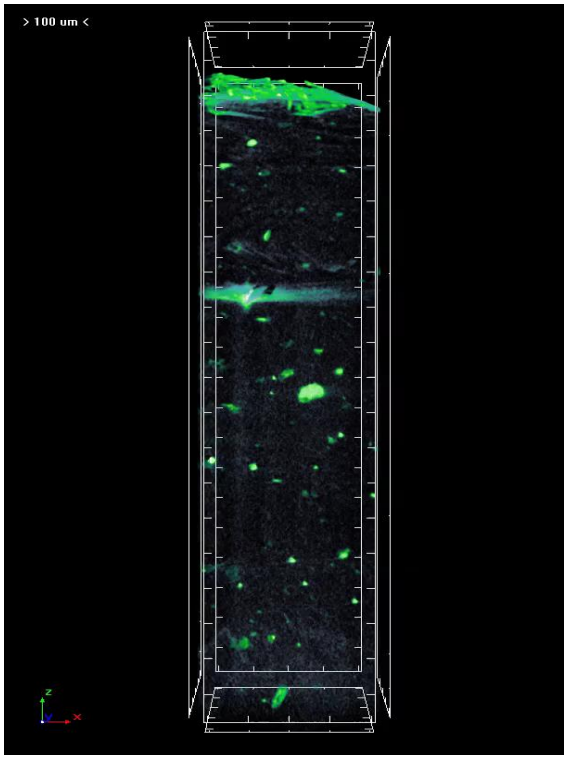
X-Ray Microtomography



LNNano

PS + mGO (0.5%) / 250 rpm



LNNano

PS + mGO (0.1%) / 350 rpm

Other systems

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PS + MoS_2

PP + mGO (photodegradation)

PCL + HA + mGO (Gabriela)

PLA + HA + mGO

TPU + mGO (Case University)

PBAT + mGO

In process…

PBAT + MoS_2

PP + hBN

UMWHDPE + mGO

LDPE + mGr

PS + MoS_2

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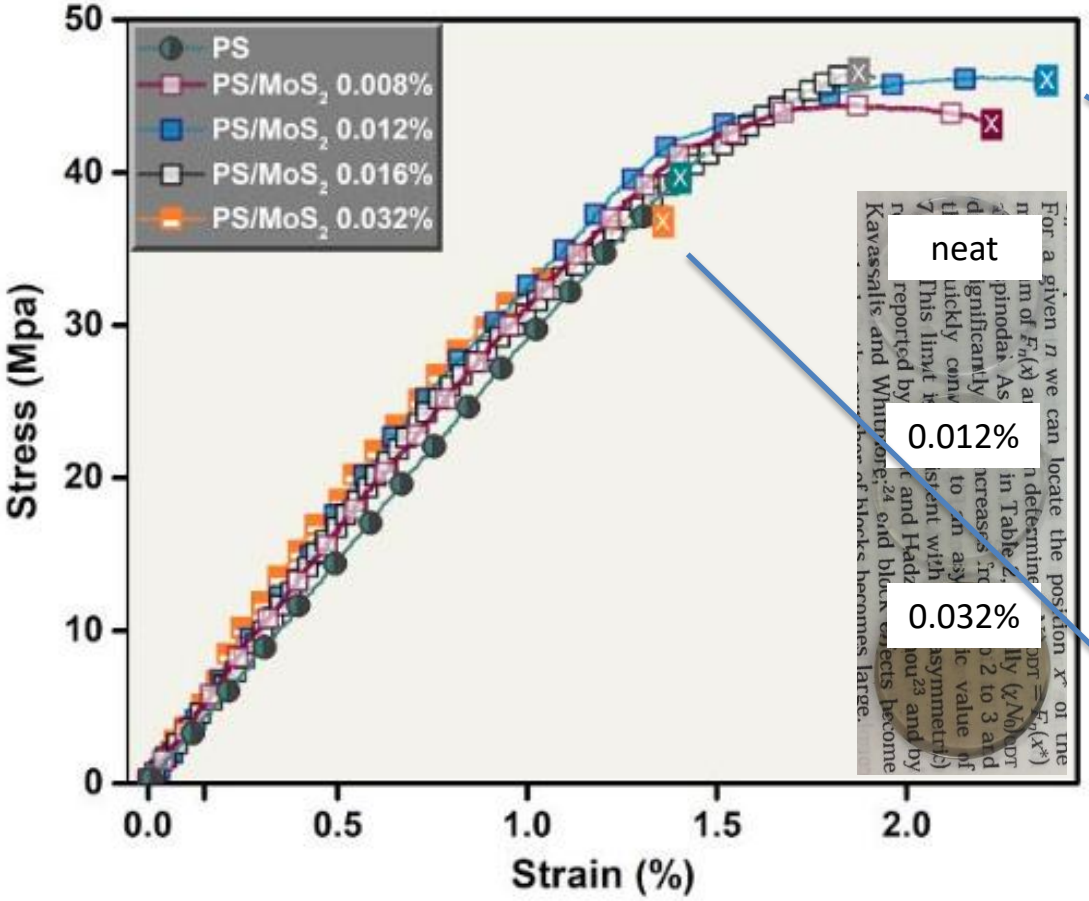
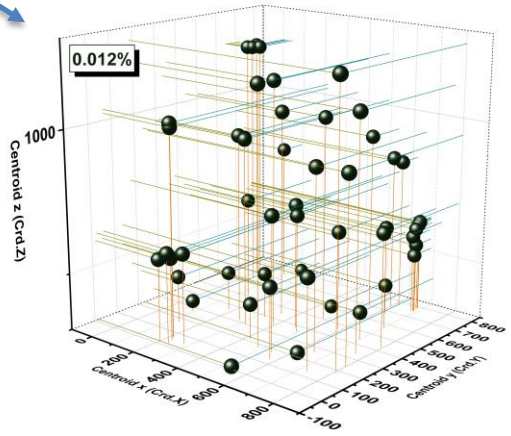


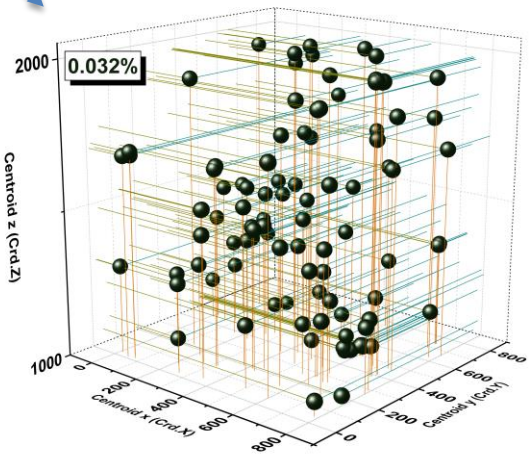
neat

0.012%

0.032%

24% (stress)
64% (strain)





PP + mGO

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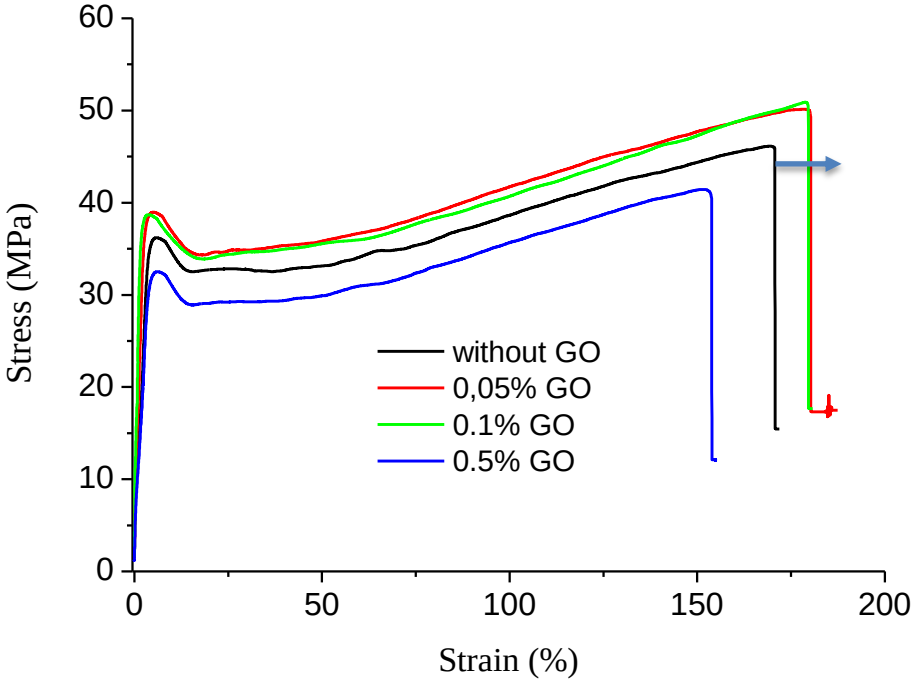

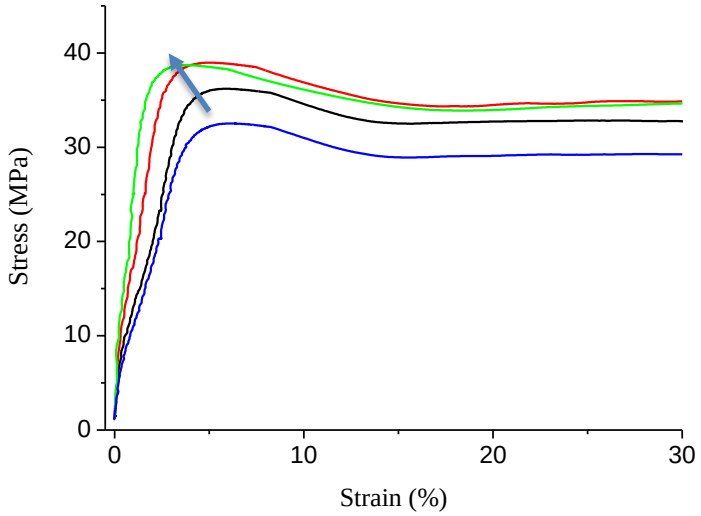

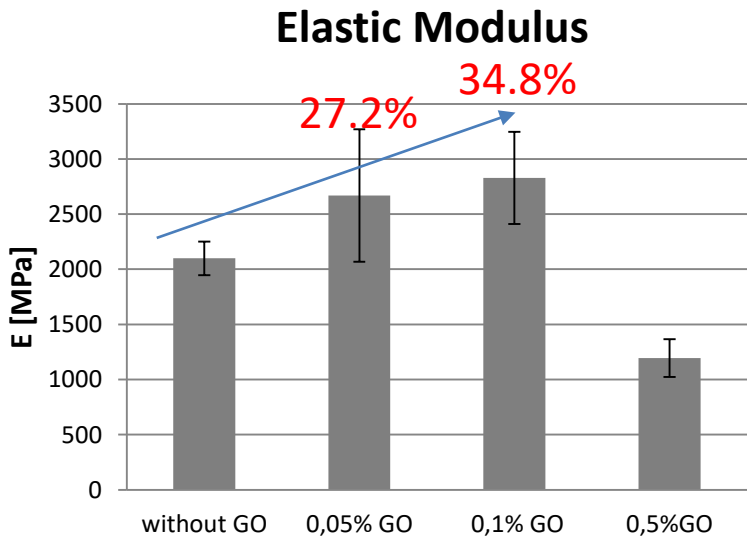

PCL + HA (20%) + mGO

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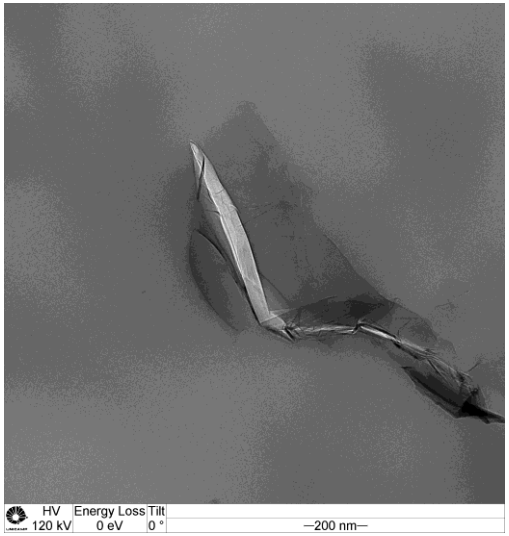
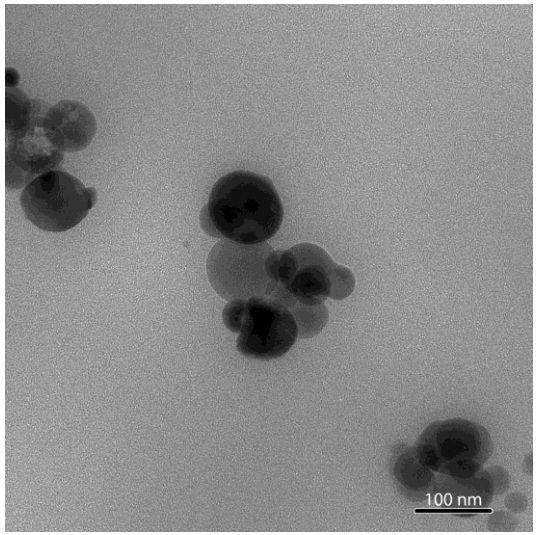
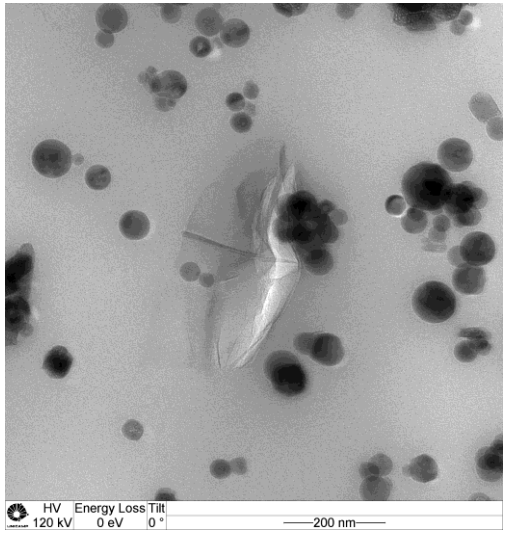
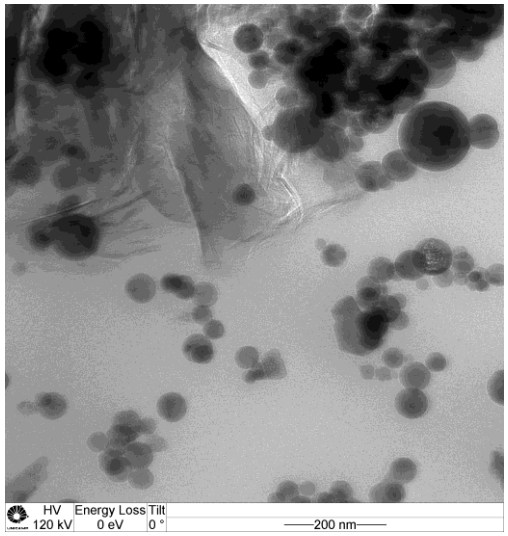


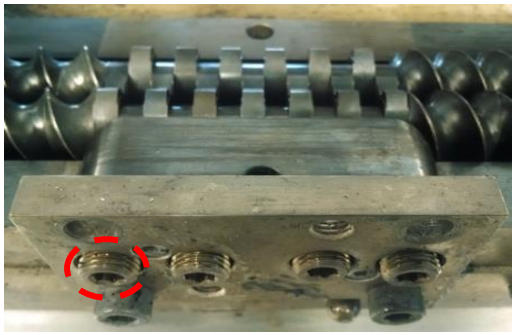




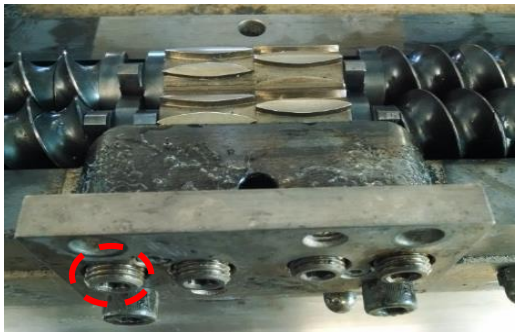


TPU + GO (0,25%)

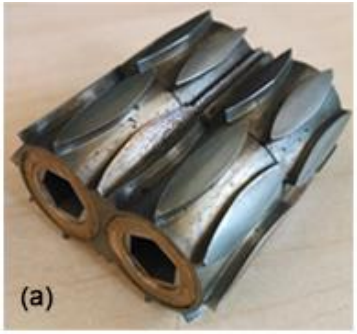
90° Kneading Block



Extensional Mixing Elements



L2

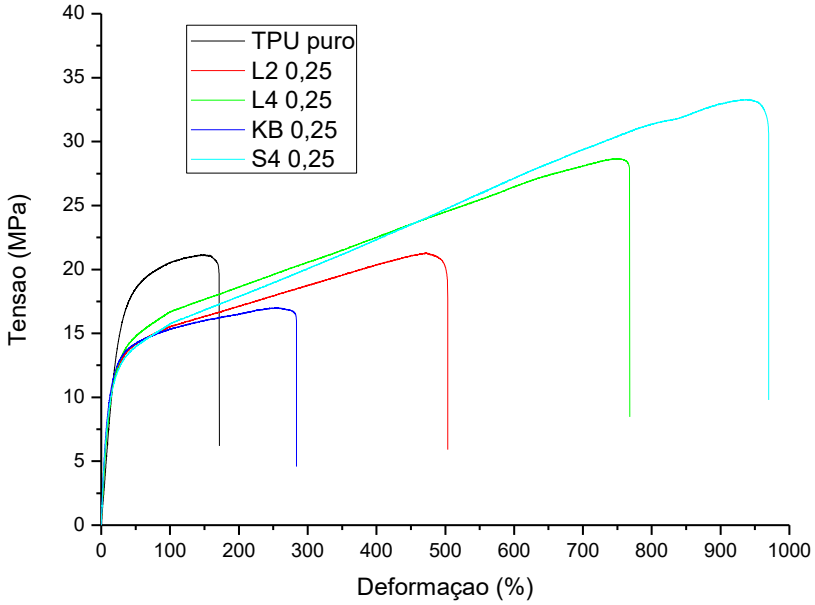


L4

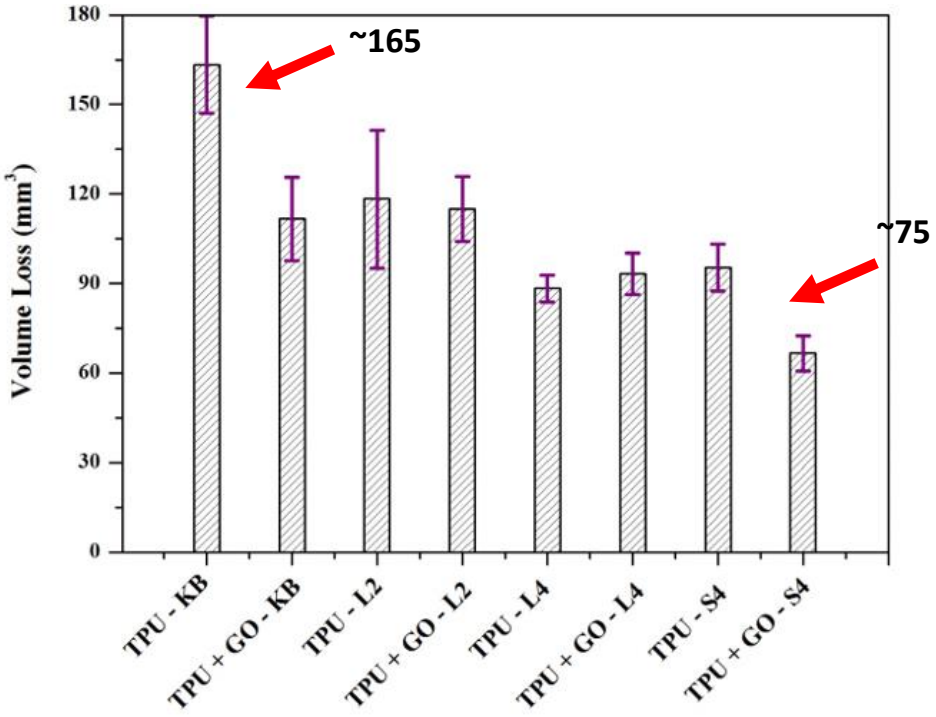
S4

TPU + GO (0,25%)

Mechanical Properties



Tribological Property



Surface Property

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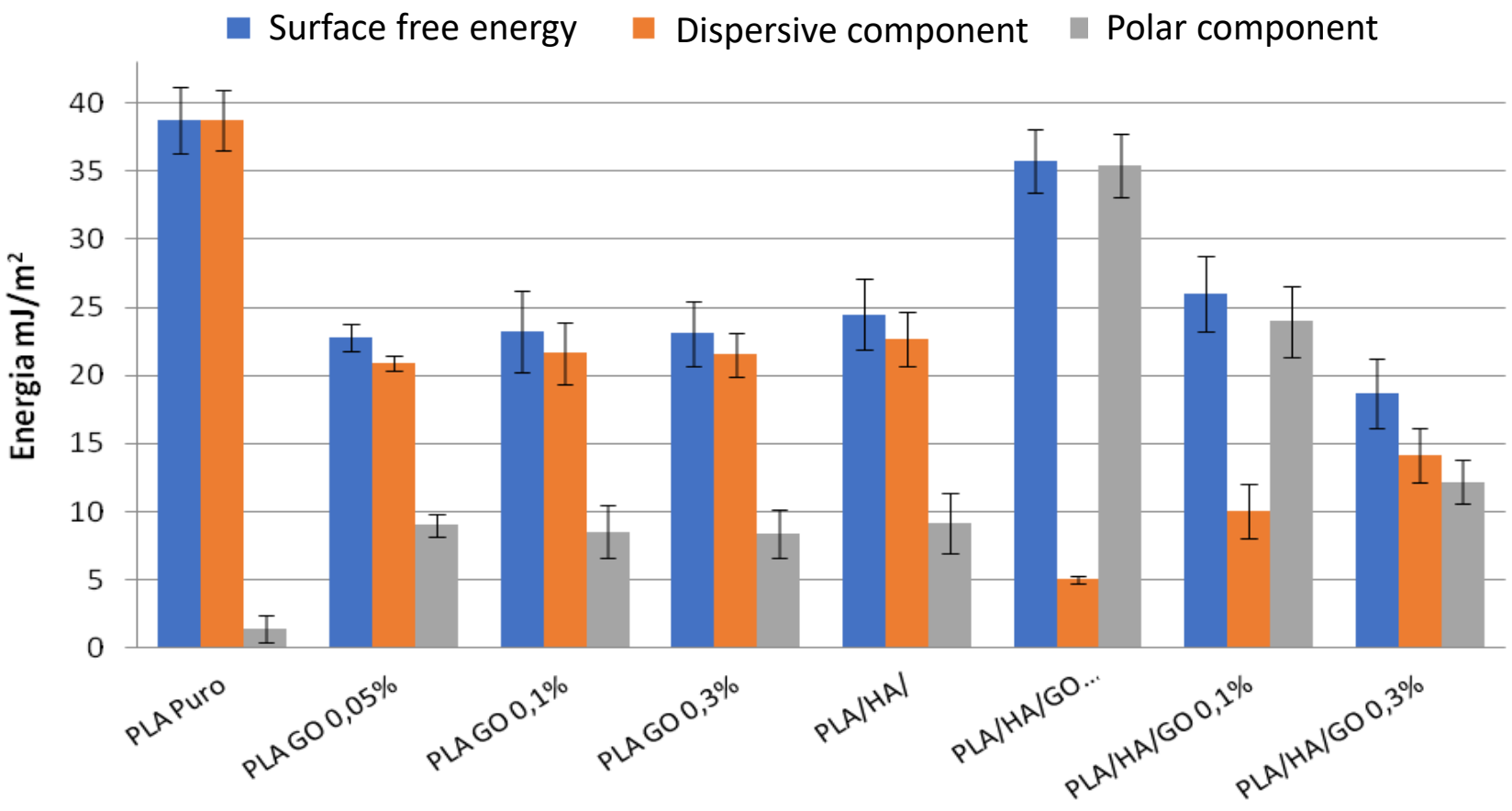
PLA + HA (20%) + mGO



Films

PBAT (Ecoflex) + GO

Neat PBAT	PBAT 0.05% GO	PBAT 0.10% GO	PBAT 0.30% GO	PBAT 0.50% GO

Gas permeability analyses are still in process (profa. Laura Hecker / UFCG)

About MackGraphe

(Graphene and Nanomaterials Research Center)

- MackGraphe began its activities in 2013 with funding (~US$ 20 millions) from the Mackenzie Presbyterian Institute; FAPESP and CNPq.
- Its headquarters building opened on 2 march 2016.
- 3 areas of interest: Photonics, Energy, Composite materials

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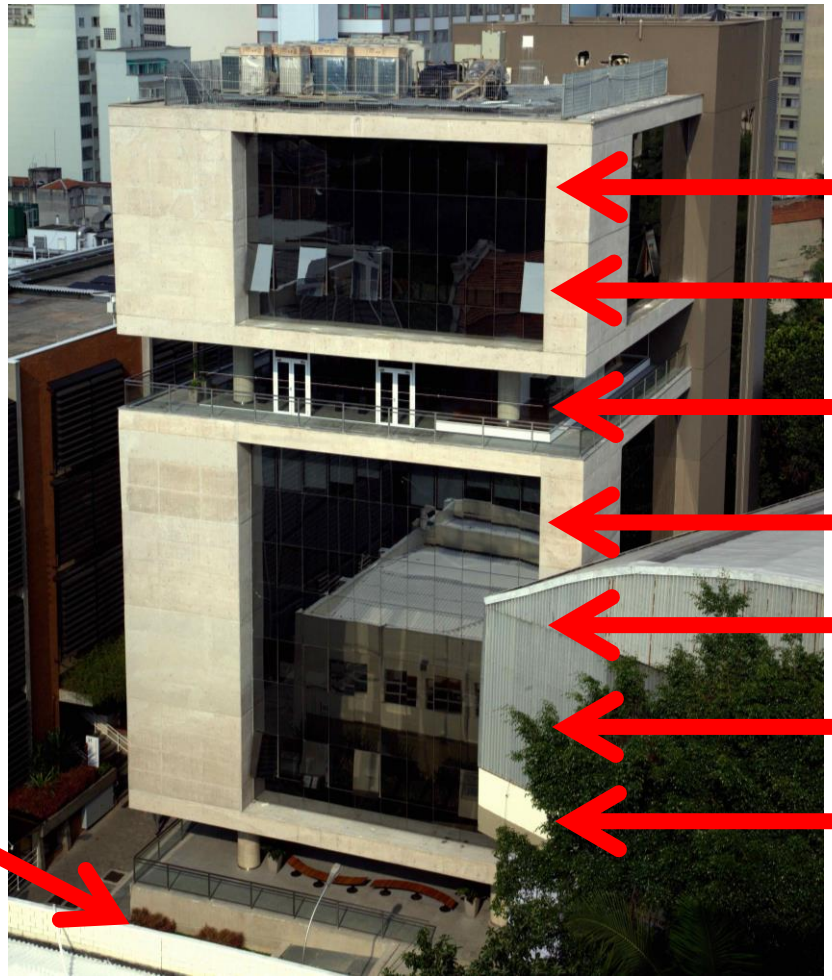

https://www.youtube.com/watch?v=0ivEFgbYRy0&t=12s

Research Group

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