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FOAM PERFORMANCE OF A NEW HMS-PP

01

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Why Produce Polypropylene Foam?

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- **Polypropylene Advantages:**
  - Performance properties:
    - Stiffness/ toughness balance
    - High service temperatures
    - Chemical resistance
  - Sustainability
    - Recyclable
    - Energy efficient processing
    - Low carbon footprint: density, CO_2 emission

Challenges for PP in Foam

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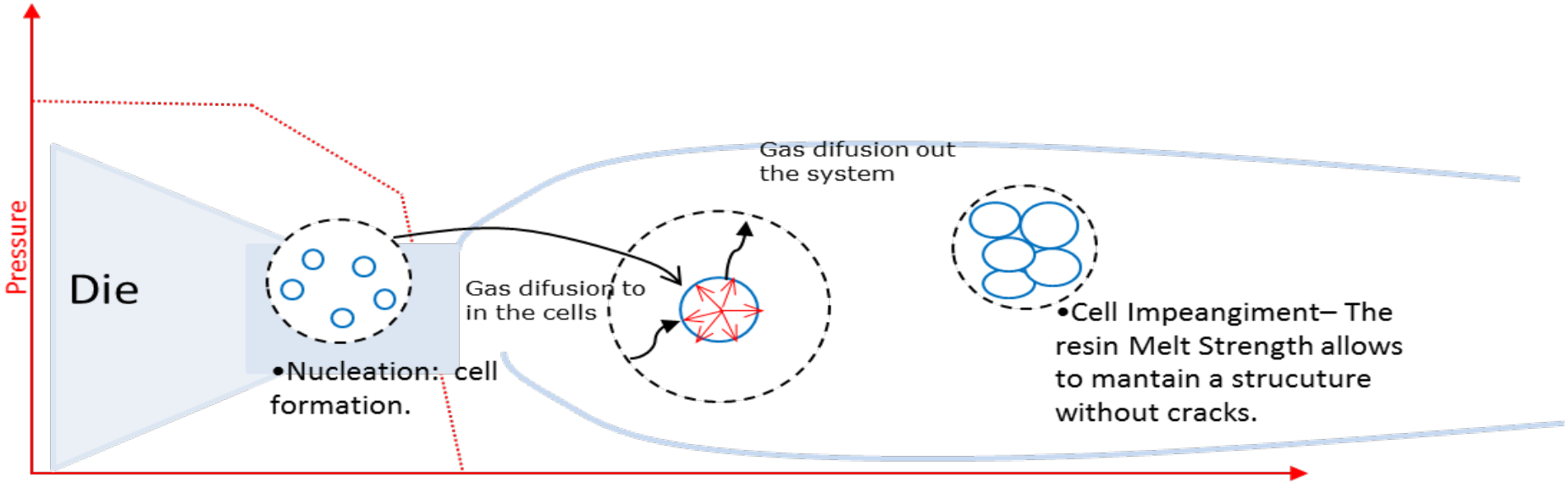
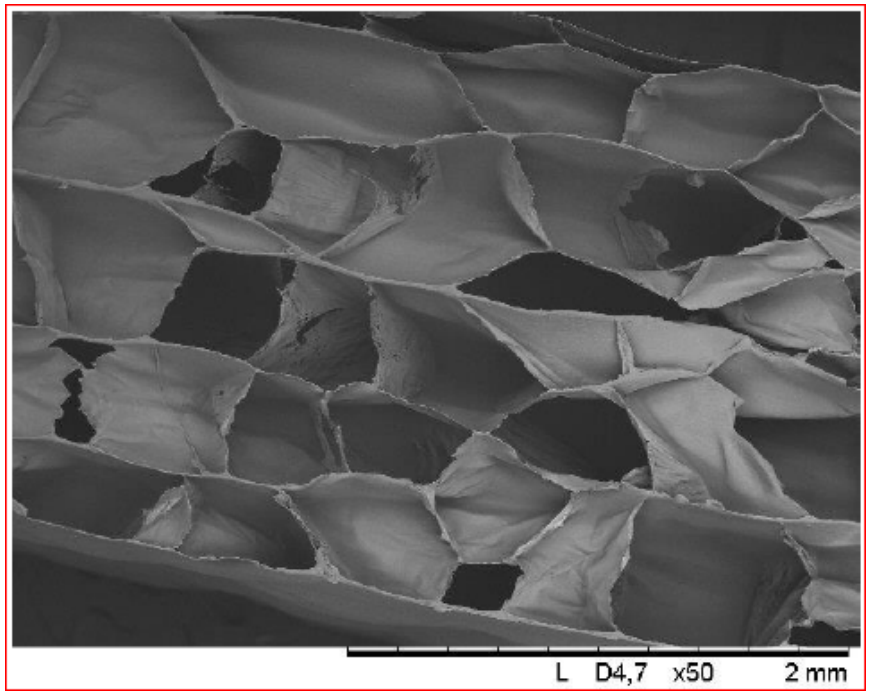
Foaming process



	Linear PP	HMS-PP
Nucleation	Control by cell nucleant agents and gas solubility.	Control by cell nucleant agents and gas solubility.
Expansion	Low melt strength, quickly expands	High melt strength control better the expansion process
Impingment	Low melt strength do not support thinner cells walls	Strain hardening increase quickly the polymer resistance and maintain closed cell even thin cell walls.
Crystallization	Highly sensitive to heterogeneities.	Lower sensibility to nucleant and heterogeneities

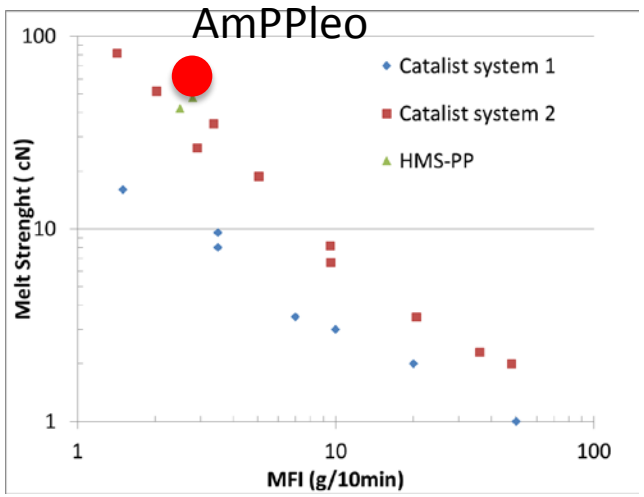
Braskem Foam Technology Overcomes the Challenges

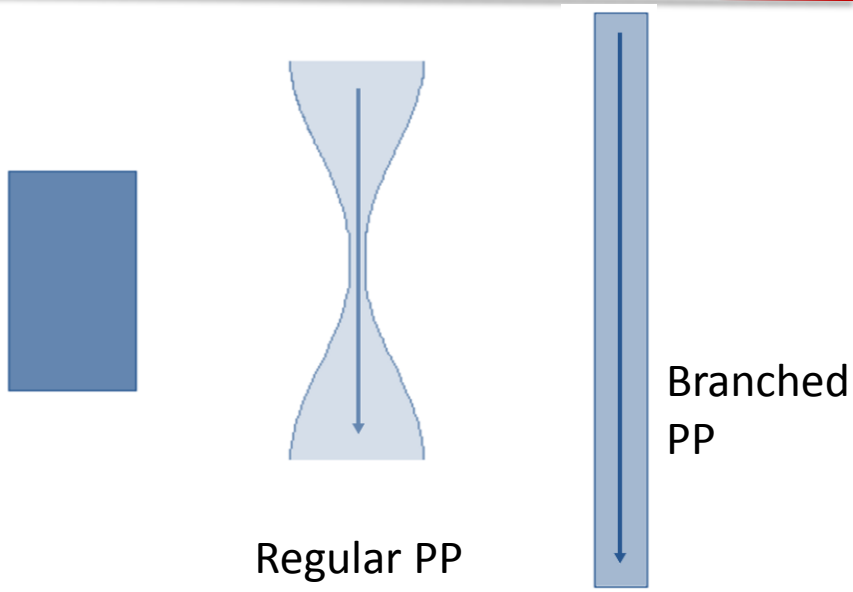
- **High melt strength PP**
  - High melt strength and high MFR
    - Branching proprietary technology.
- **Foam process strategy**
  - Balance contributions from:
    - Polymer
    - Foam process
    - Blowing agent
    - Nucleating additives

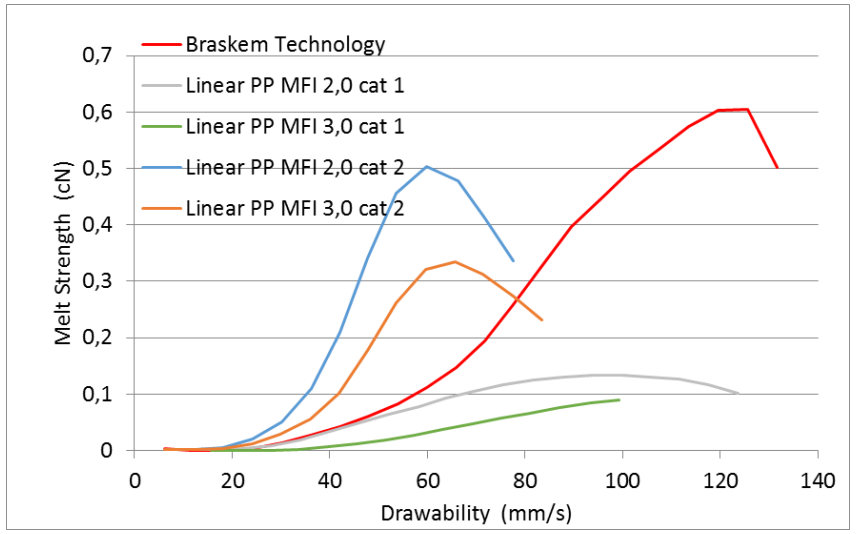


What is Melt Strength?

- **Melt Strength describes resistance to extensional flow:**
  - More specifically, increases the uniform deformation by increasing the molten elasticity.
- **But Melt Strength alone cannot disclose about the polymer foamability.**



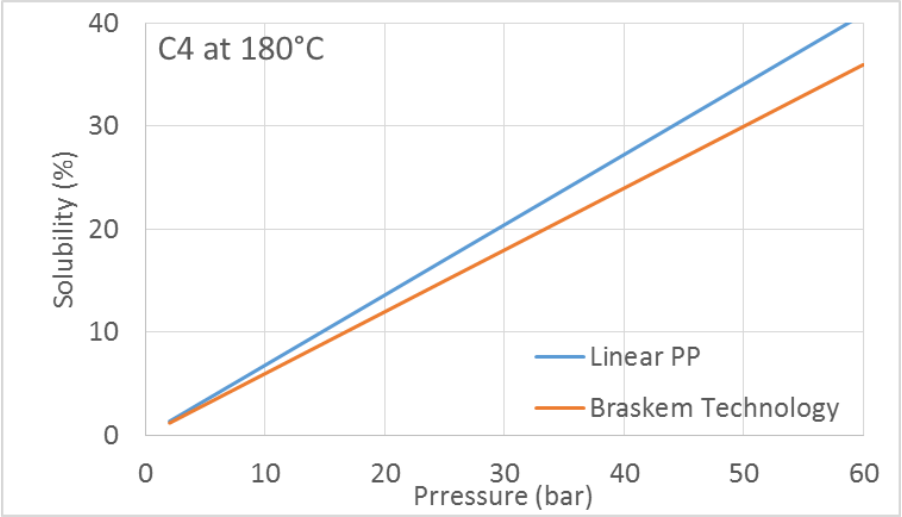


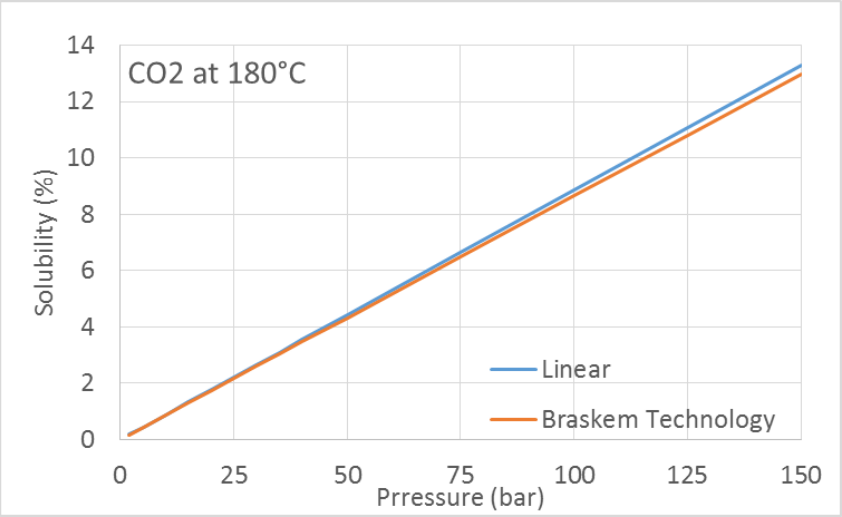


- **To low densities, the material must also to have deformability.**

HMS-PP GAS SOLUBILITY

- **BRANCHED MATERIALS normally show a lower gas solubility comparing to linear PP.**
- **However, Braskem technology isn't too far from the linear as expected due the different technological route, mainly to CO_2.**





Curves generated on Toronto University.

HMS-PP PROCESSING CHARACTERIZATION

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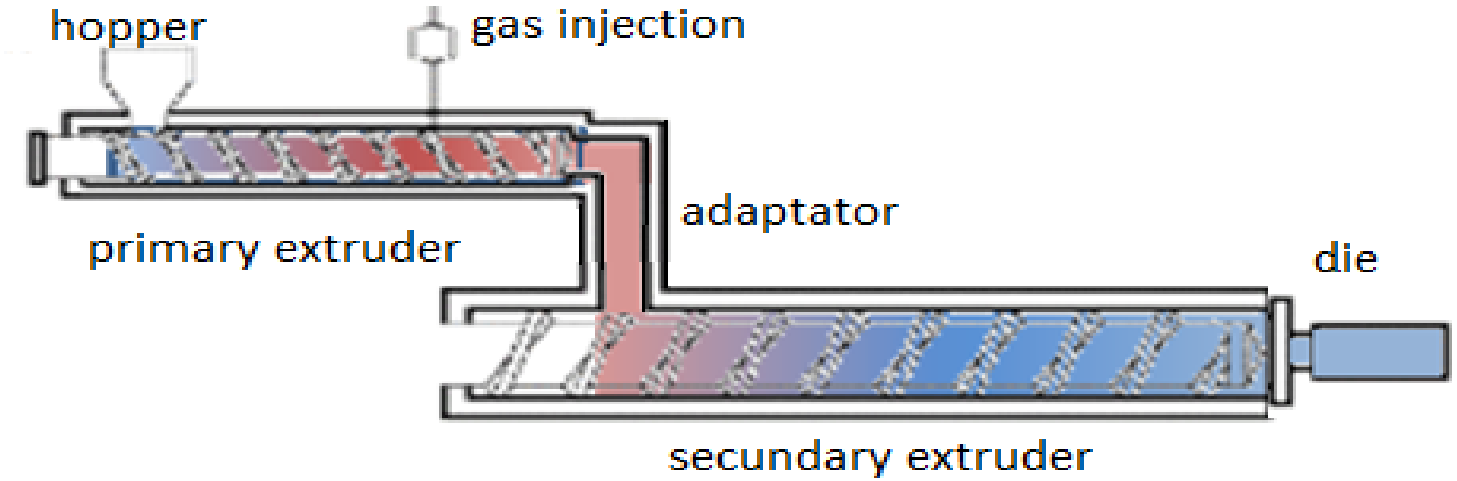
- The trials were run on Krass-Maffei Berstof on Hannover laboratory, Germany.



- 1st Extruder- ZE 40, Co-rotating twin screw extruder
- 2nd Extruder, KE 90, Single screw extruder, coupled to an annular die, operating at 100 kg/h
- Four Brabender feeders to control the final composition:
  - Resin → Amppleo 1020GA

Additive	Commercial name	Supplier
Talc	Finatalc M30	Mondo Minerals
CBA-1	Hydrocerol CF40E	Clariant
CBA-2	Ecocell 20P	PoliFil

HMS-PP PROCESSING

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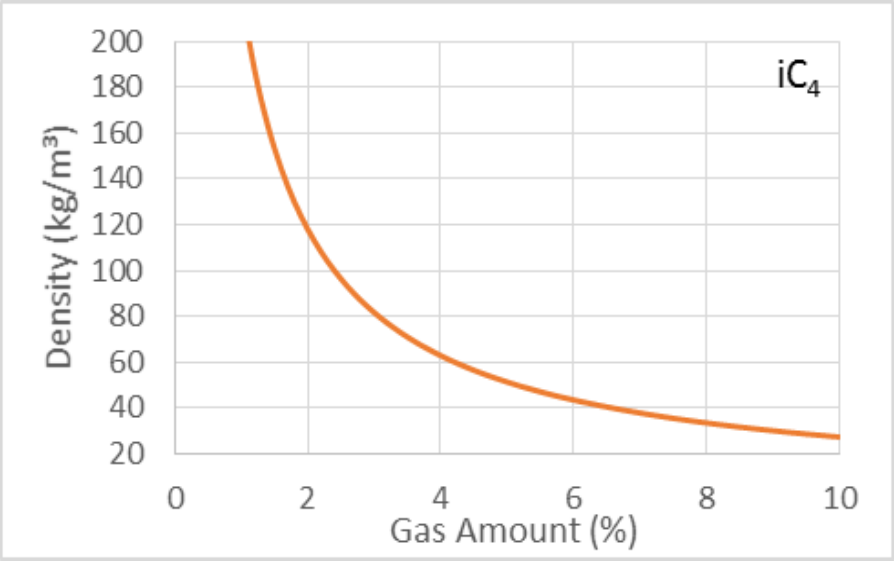
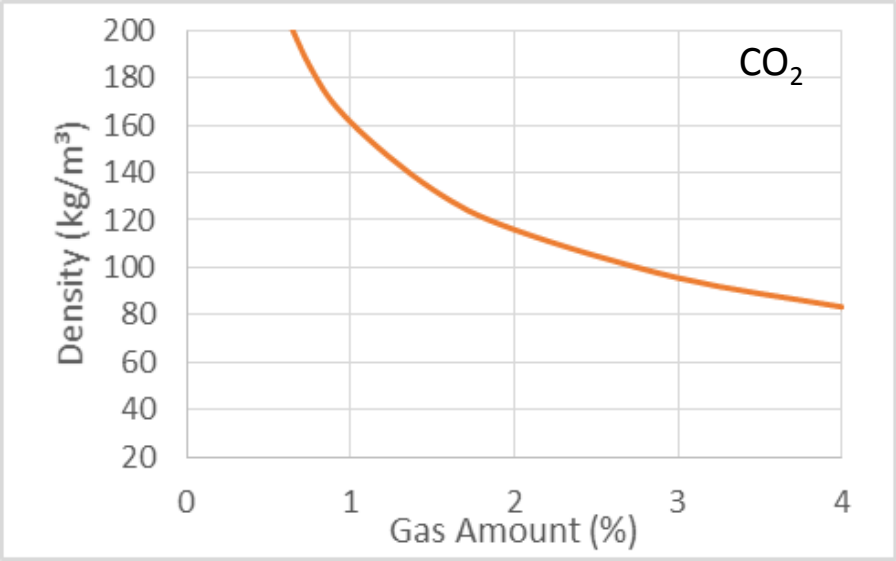
- General overview:
  - Gas against densities





  - A non-linear correlation is observed for iC_4 and to CO_2 as PBA
  - Amppleo is capable to reach very low densities.

HMS-PP PROCESSING

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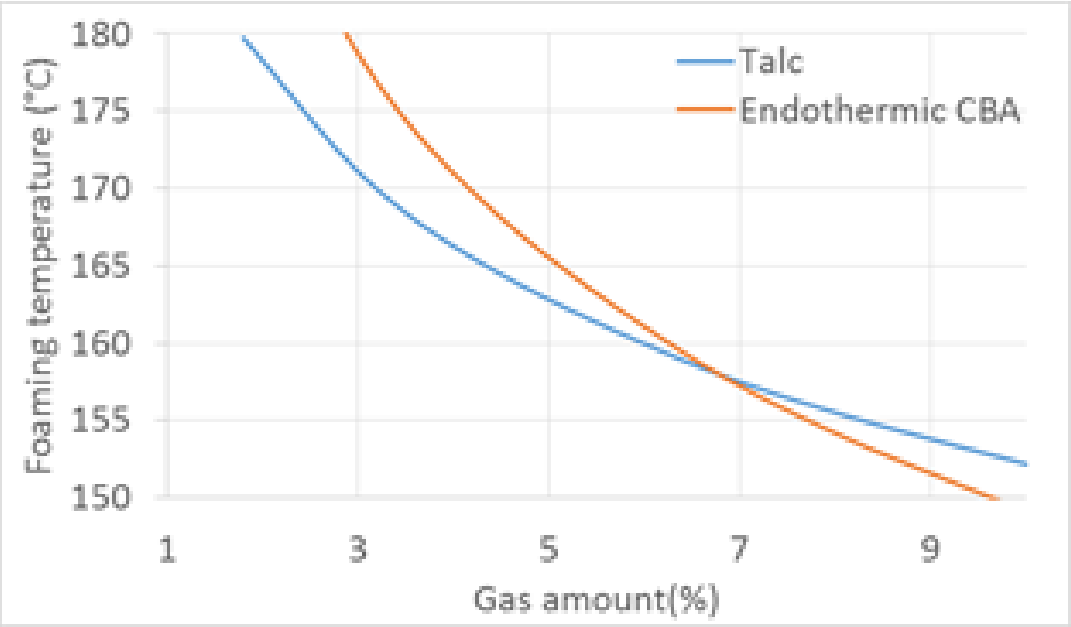
- General overview:
  - Foaming temperatures:



  - It is clear the effect of endothermic CBA.
    - The endothermic CBA absorb internally the heat to lower amount of gases.
  - To CO_2 it is much less sensible, being around 175-180°C

HMS-PP PROCESSING

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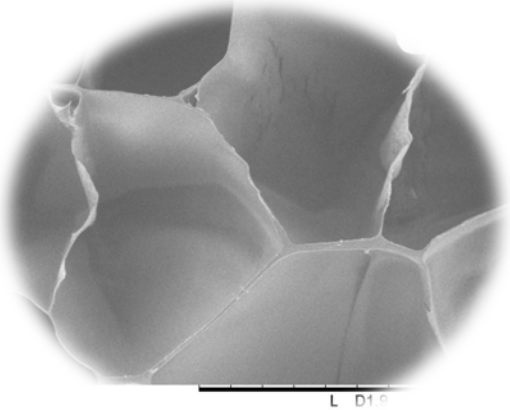
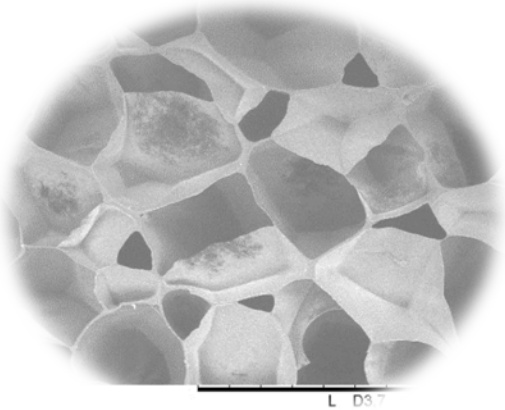
Cell Number

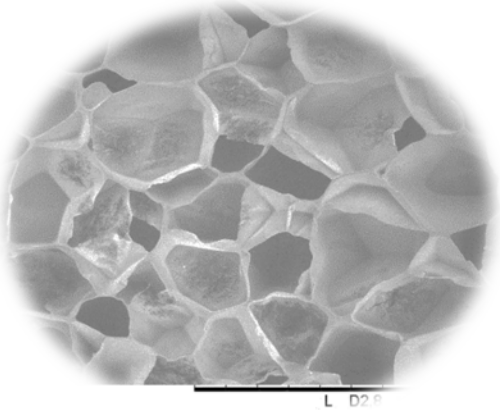
$$N_f = \left(\frac{n}{A}\right)^{3/2} \left(\frac{\rho_s}{\rho_f}\right)$$



15.000 cell/cm³

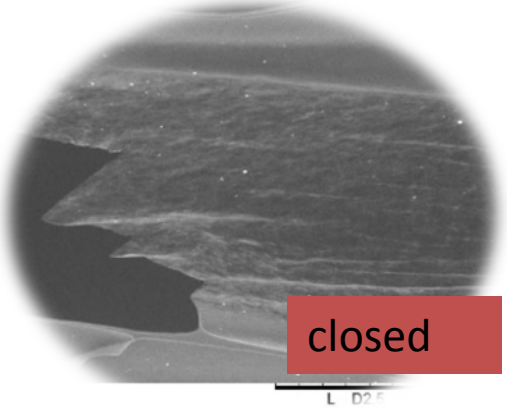


75.000 cell/cm³

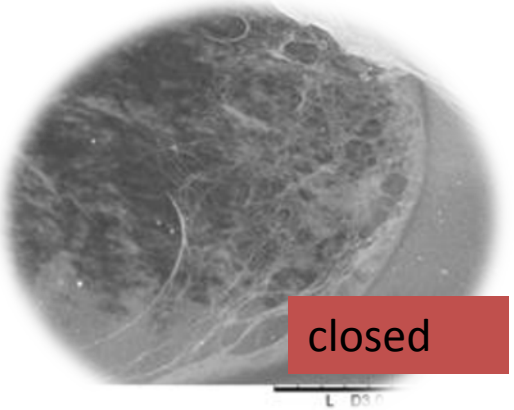


180.000 cell/cm³

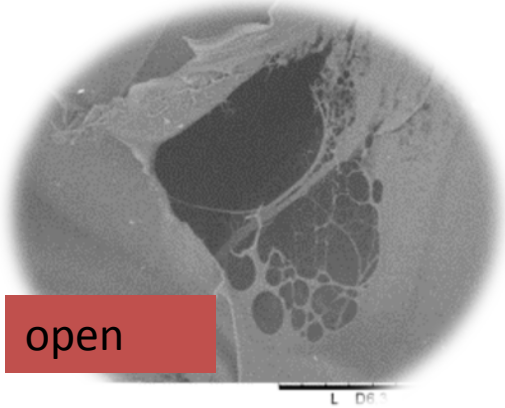
Integrity?



Well formed wall cells.



On the limit
Superficial microfibrillation



Ruptured cells
Do not supported the final impingement process.

Conversion factor from cells/cm³ to cells/in³ → 16,38

HMS-PP PROCESSING - iC4

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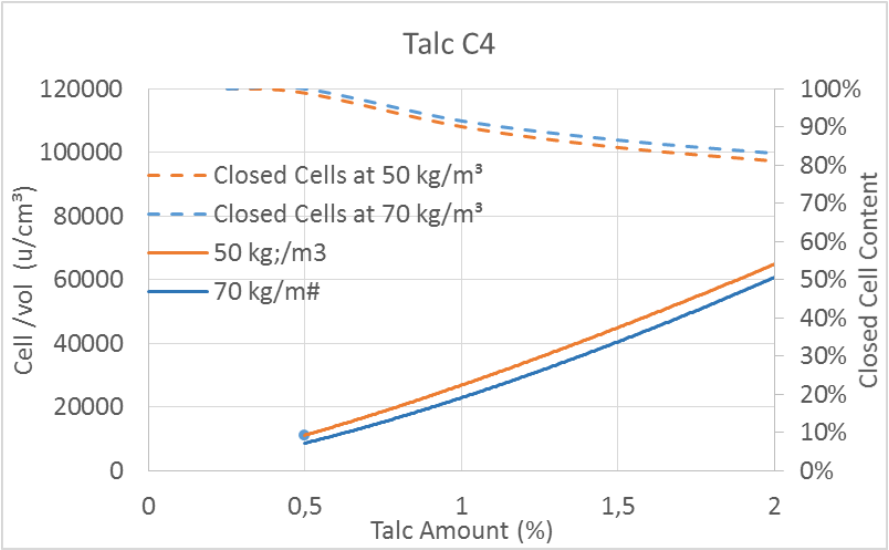
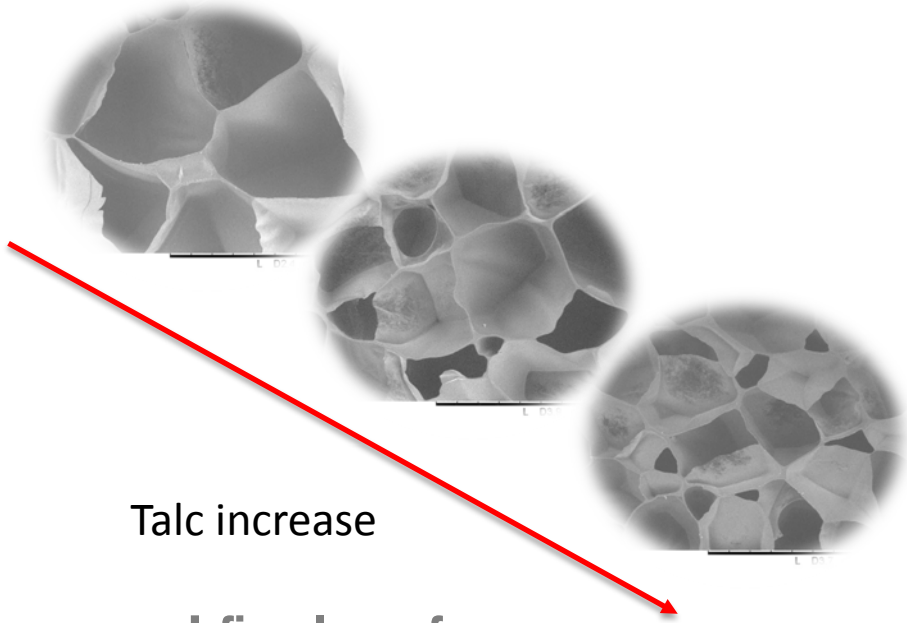
- **Nucleant effects:**
  - **A good foam is determined by the capability to control the close cell content and not by the capability to of reach vey low densities**
    - **Good materials retains high level of close cell content in all ranges of cell density→ capability to control final properties to a specified application.**
    - **TALC**





    - **The decrease in cell content is quite slow and a good final performance are achieved.**

Conversion factor from cells/cm³ to cells/in³ → 16,38

HMS-PP PROCESSING – iC4

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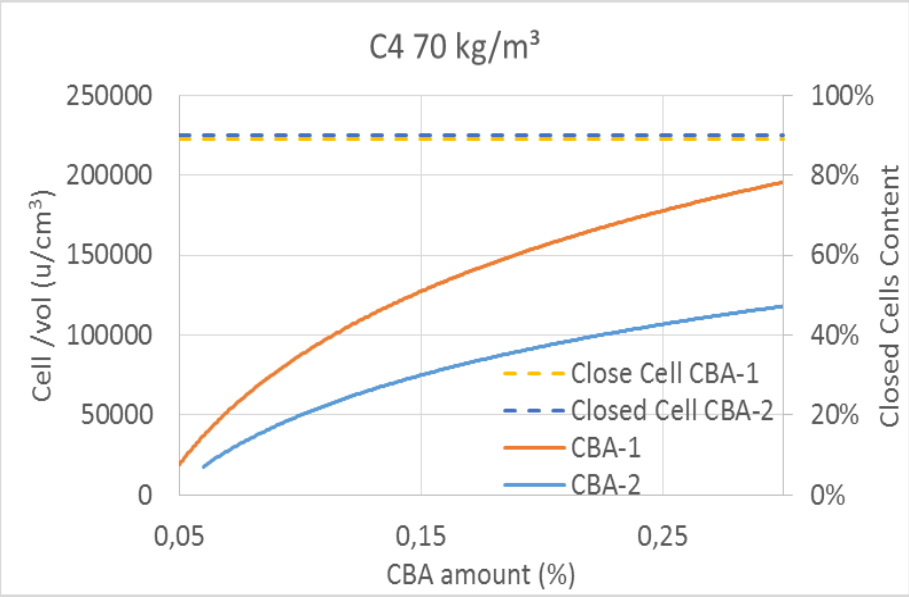
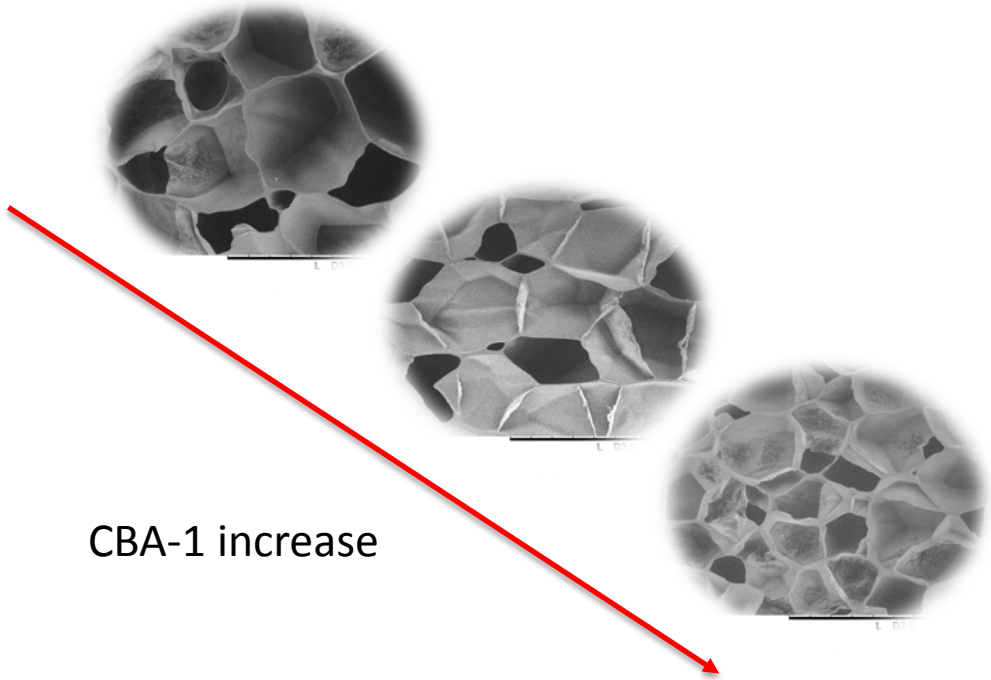
- **Nucleant effects:**
  - **CBA – Chemical Blowing Agents.**





  - **The use od CBA affects significantly cell nucleation maintaining the closed cell content.**

HMS-PP PROCESSING – iC4

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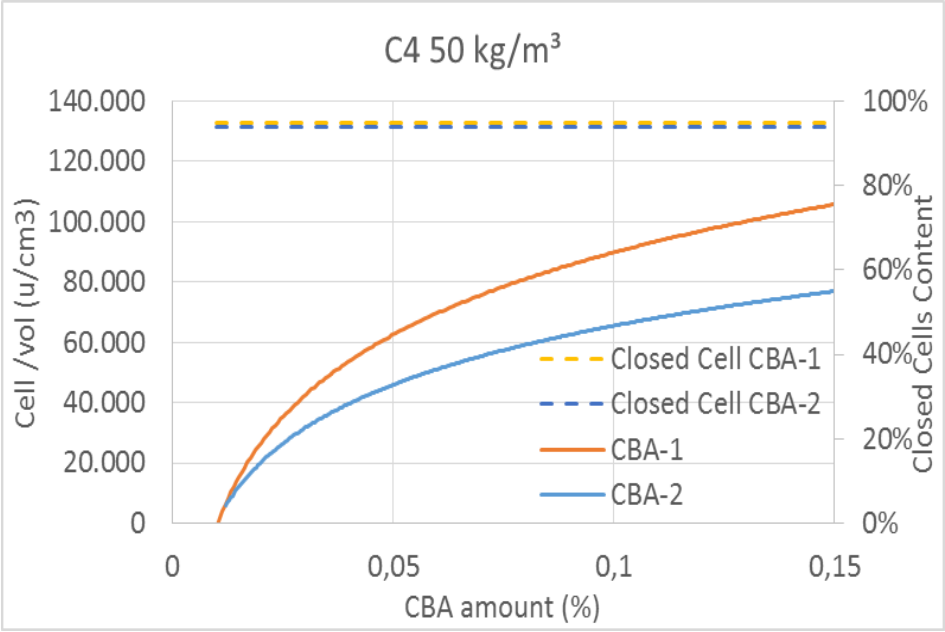
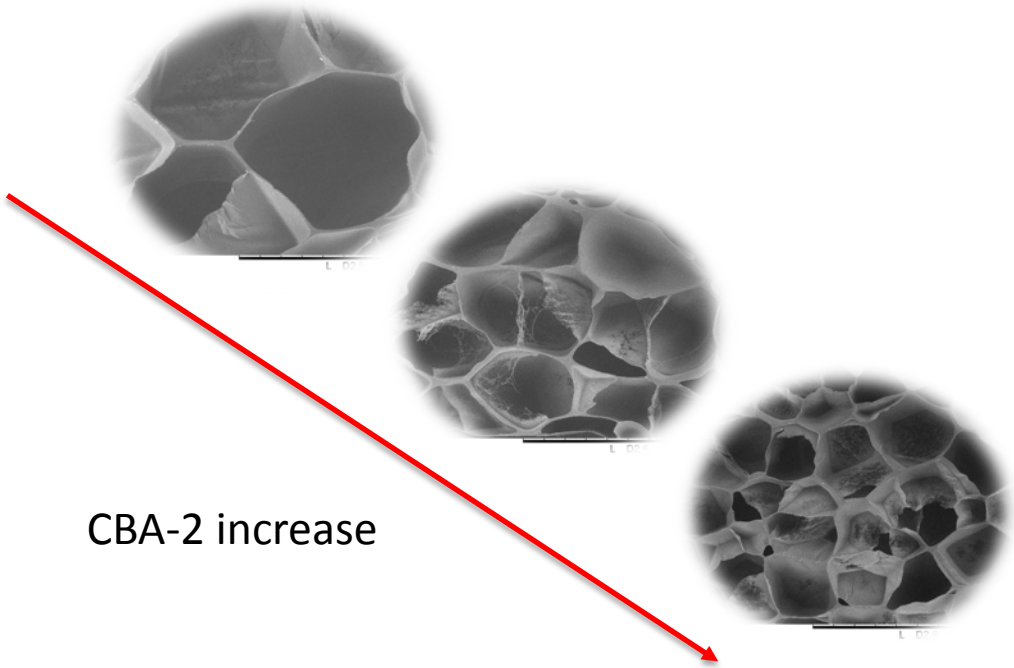
- **Nucleant effects:**
  - **CBA – Chemical Blowing Agents.**





  - **With higher gas amount, the efficiency of CBA are reduced but still much better than Talc, maintaining the cells integrity.**

HMS-PP PROCESSING – CO_2

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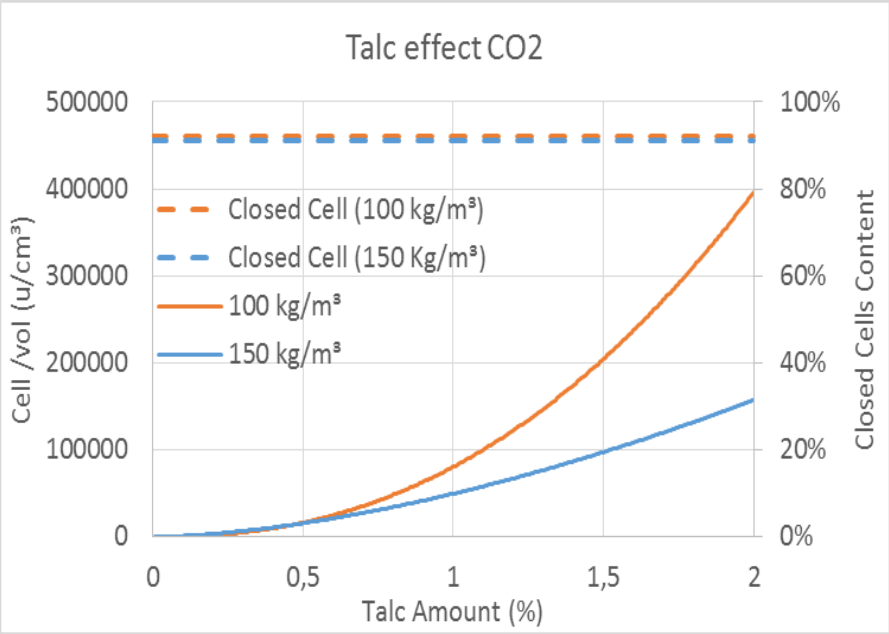
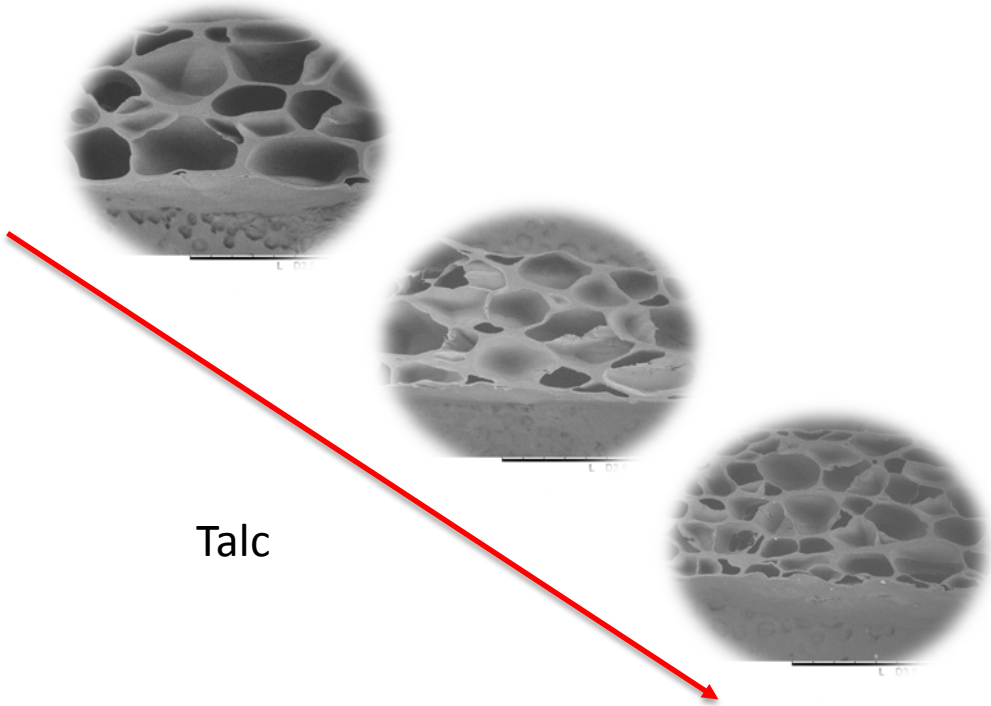
- **Nucleant effects:**
  - **Talc**





  - **Amppleo shows a suitable response to cell nucleation, avoiding change due some CBA feeding oscillation.**

HMS-PP PROCESSING – CO_2

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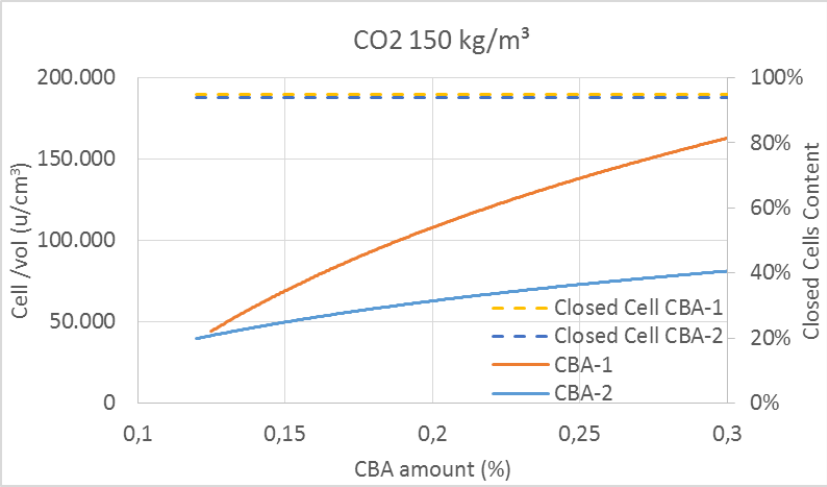
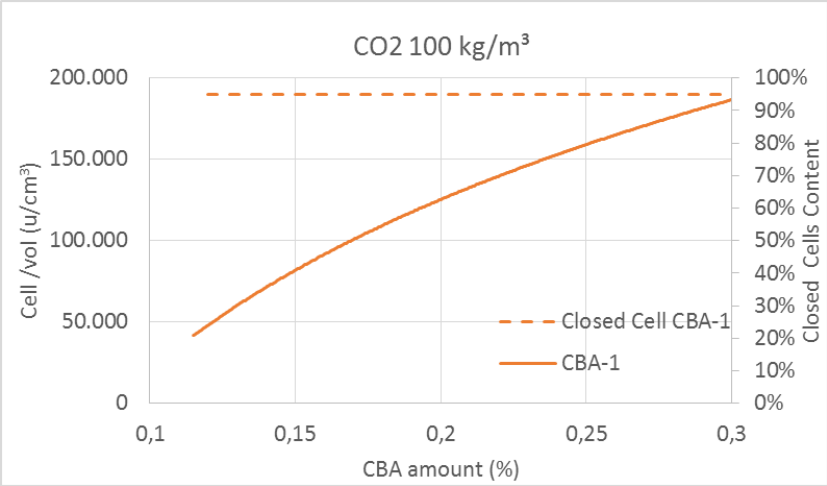
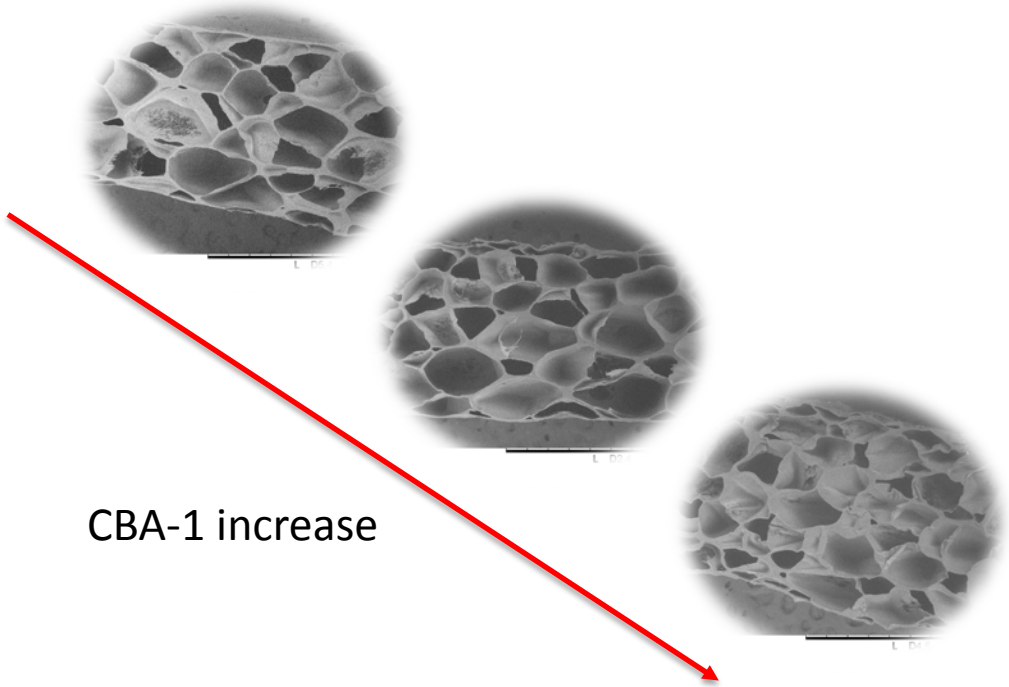
- **Nucleant effects:**
  - **CBA – Chemical Blowing Agents.**







- To CO2 the efficiency has equal to C4 but at lower degree, permitting generate sample with large cell count and high closed cells content.
- Suitable response to CBAs: easy to control final product morphology.

BRASKEM HMS-PP CONCLUSIONS

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- This paper demonstrates the melt rheological attributes and foam processing of Amppleo 1020GA;
- Performance properties of Braskem's new high melt strength PP, Amppleo 1020GA was demonstrated:
  - Broad processing window;
  - Different foaming densities;
  - Different blowing agents;
  - Different cell nucleators.
- Capability to design foams for final applications.
  - Amppleo is a new option in the market for PP foams development.

Obrigado!
Thank you!
Gracias!
Danke!

Houston, February 28th, 2017.

Braskem