



BIO4MAP - GA 606144

Workshop

19th November 2015

EMPACK (MADRID)

Development of multilayer packaging



Nuria López - AIMPLAS



Development of multilayer packaging

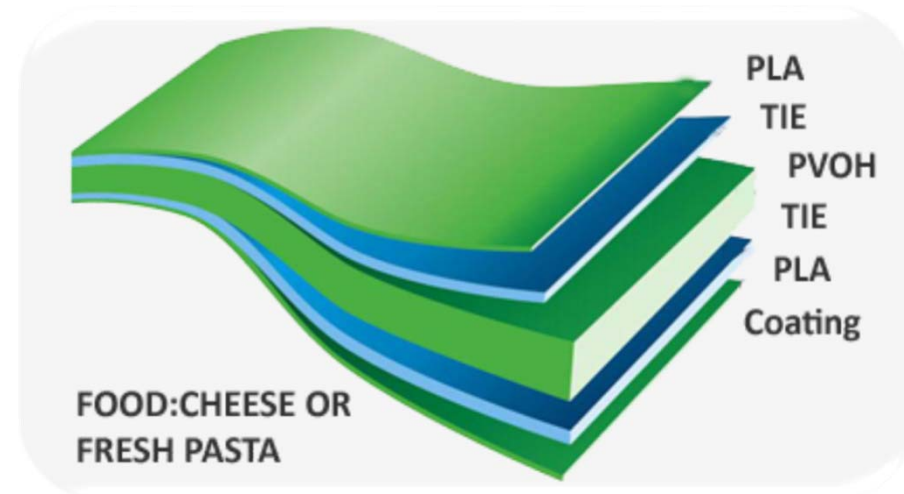
2

OBJECTIVE:

The multilayer manufacturing processes studied and optimized for the new compounds are:

- 1) **Co-extrusion cast-sheet (lid)**
- 2) **Co-extrusion cast-sheet + thermoforming (tray).**

Additional **coating** substrate for improving **the water barrier properties** of the package.

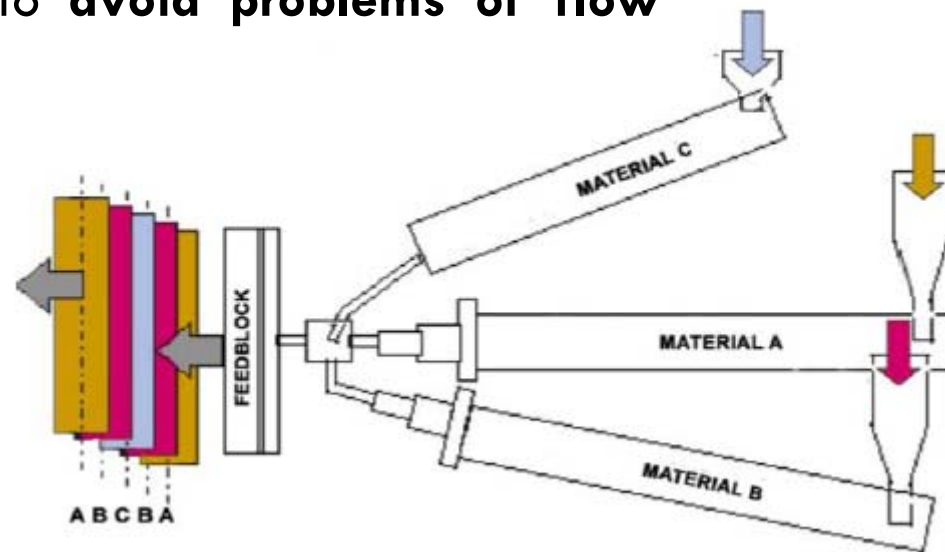


Development of multilayer packaging

3

Co-extrusion cast-sheet

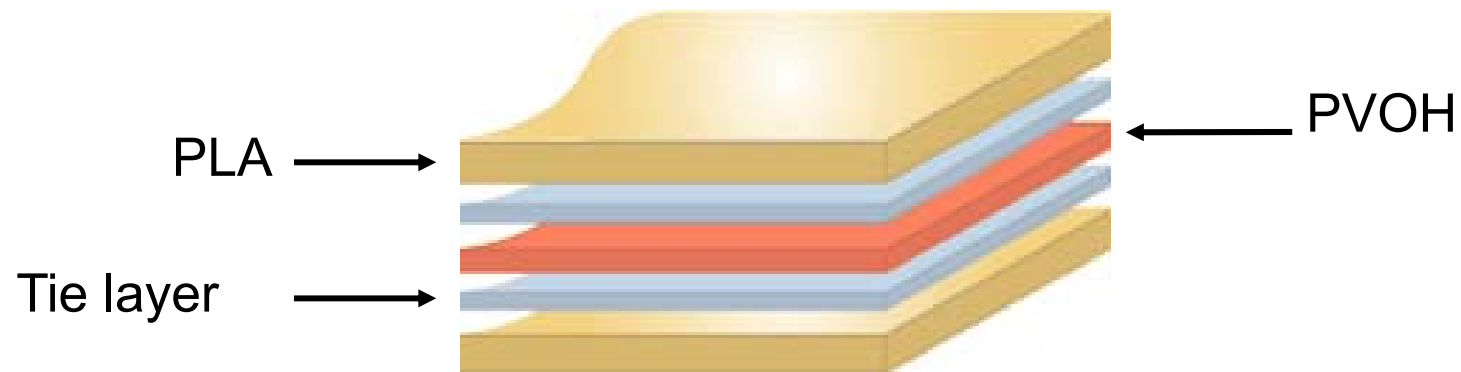
- Control of **processing temperatures'** profile of each extruder.
- **Speed** in each extruder to provide an adequate residence time (right viscosity).
- The **thickness of each layer** according to the material's properties and extruders output to **avoid problems of flow** and/or **interface instabilities**.



Development of multilayer packaging

4

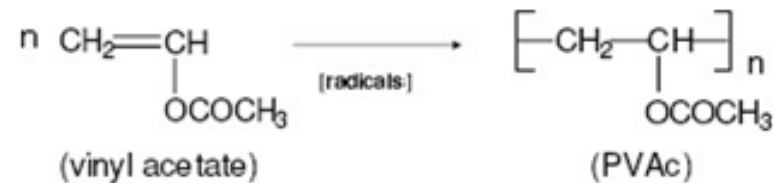
Co-extrusion cast-sheet



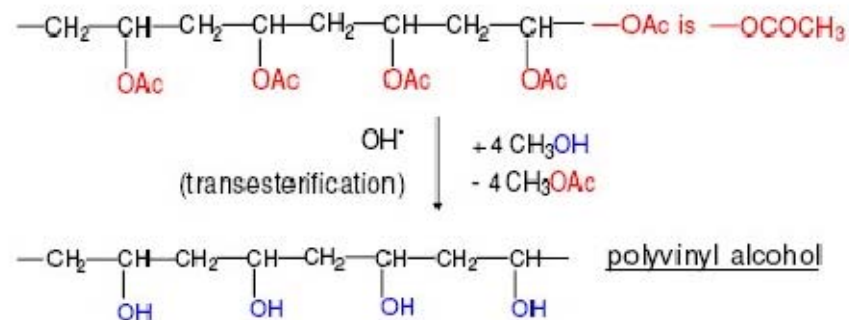
Development of multilayer packaging. PVOH new grade.

5

PVOH is a polymer that is not been obtained from a monomer polymerization.



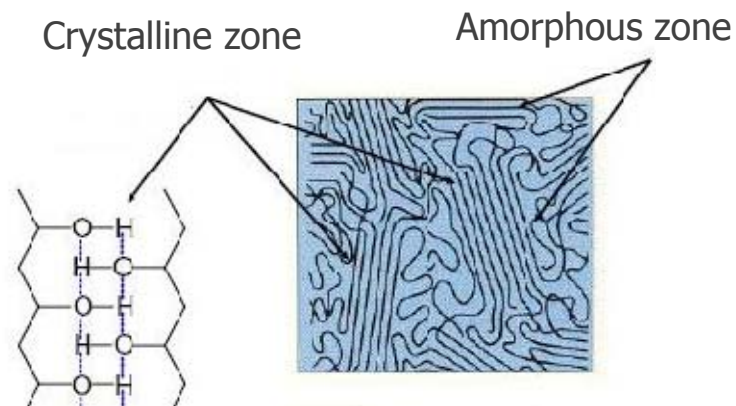
PVOH or PVA is formed by partial or complete hydrolysis of PVAc.



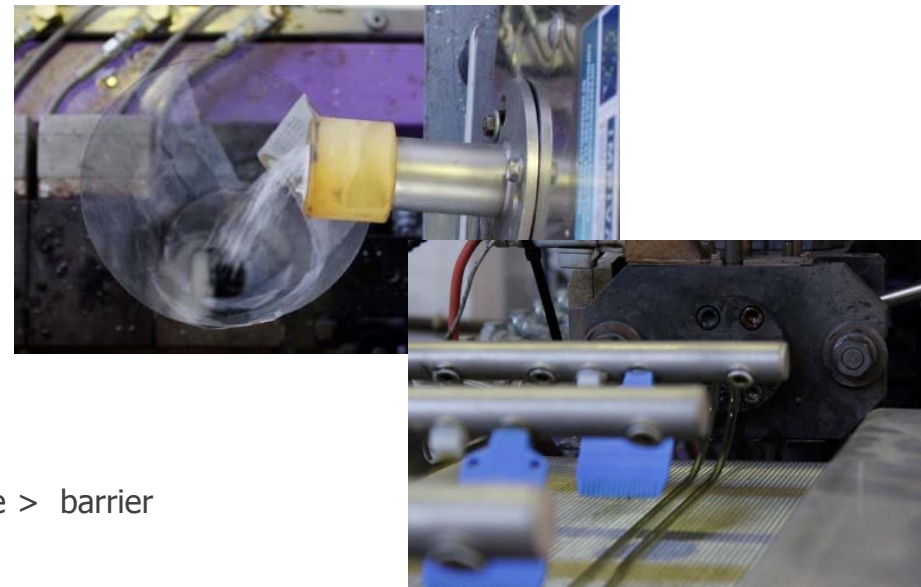
Development of multilayer packaging. PVOH new grade.

6

PVA or PVOH have different properties depending on their hydrolysis degree and their chain size (viscosity)



> Hydrolysis degree > crystallinity > tensile resistance > barrier
MELTING DIFFICULTIES.



A plasticisation is needed to be processing in a conventional extrusion line

Development of multilayer packaging. PVOH new grade.

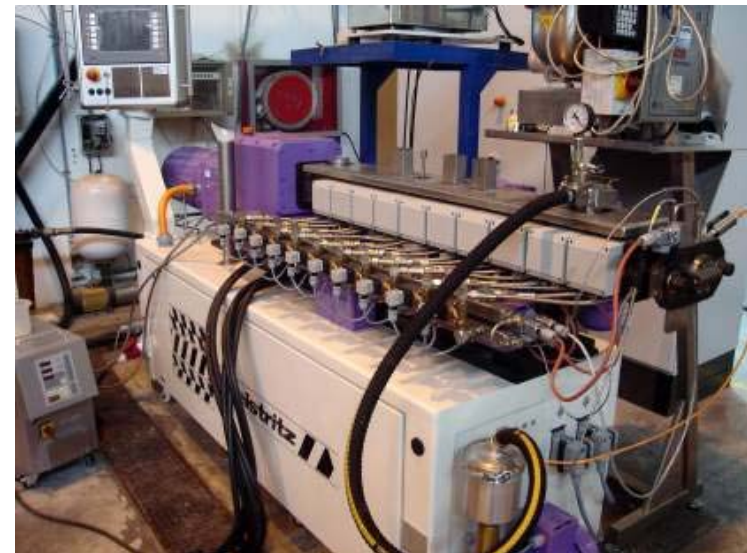
7

Improve processability of PVOH with different types of plasticizers and other processing aids additives.

Plasticiser will reduce PVOH problems in processing.

Co-rotating twin screw extruder will be used to optimize the plasticizer distribution.

- **Screw configuration** (dispersion/distribution) and barrel design.
- PVOH with different % of **hydrolysis**.
- Parameters: **temp, speed, residence time and SME**.
- **Composition:** PVOH, high compatible plasticizers, protective additives.



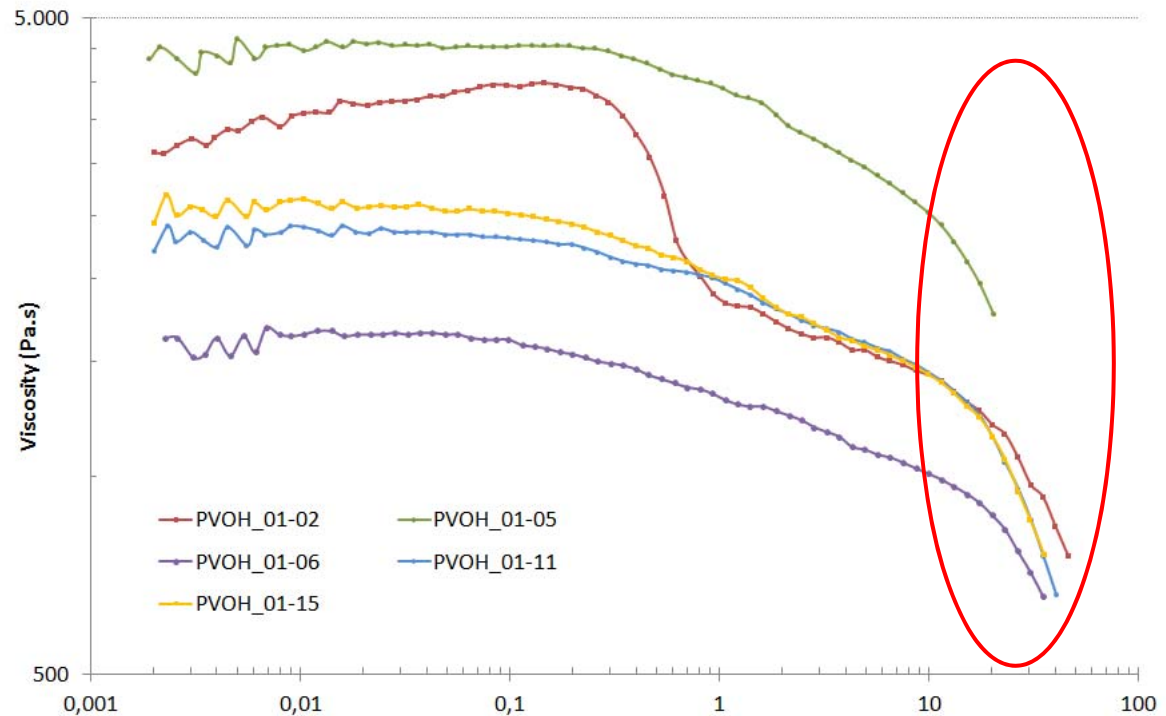
BIO4MAP 606144

Development of multilayer packaging. PVOH new grade.

8

Improve processability of PVOH with different types of plasticizers and other processing aids additives.

Rheology test results



BIO4MAP 606144

Development of multilayer packaging. PVOH new grade.

9

The commercial PVA selected has been plasticised using different percentages of plasticiser to obtain different PVOH grades with different viscosity.

PVOH selected for the Project has a viscosity of 1390 Pa.s (shear rate: 10 s⁻¹) and a permeability < 0.05 (cm³/(m²•day)) at 23 °C and 0 % R.H.

Material	Viscosity (Pa·s) (*)	Viscosity (Pa·s) (**)
1	1830	1390
2	4910	2640
3	7580	3580
4	9640	3560
5	14700	3650
6	17600	4300
7	19600	3910
8	55780	-

(*) a shear rate=1 s⁻¹

(**) a shear rate=10 s⁻¹

Development of multilayer packaging. PVOH new grade.

10

Production and characterization of the PVOH monolayer sheets.

The compounds developed were processed using a monolayer cast sheet equipment.

Parameters to be optimized: **temp, speed, screw design and stretch ratio. Also, die design and roll temperature.**



BIO4MAP 606144

Development of multilayer packaging. PVOH new grade.

11

Production and characterization of the PVOH monolayer sheets.

The better PVOH formulation has been tested according to:

- **Rheological** and **thermal** characteristics (PVOH compounds).
- **Mechanical** and **barrier** characteristics (monolayer PVOH sheets).
- The **Biodegradability** characteristics have been taken into account in material selection.

Thermal	Tensile strength (MPa)	Elongation (%)	Oxygen Permeability (cm ³ /(m ² d*bar))
T _m (°C) ≈ 185°C	21.8 ± 1.5	280 ± 17	<0.005



BIO4MAP 606144

Development of multilayer packaging. PVOH new grade.

12

Composition optimization

Screw with more dispersive and distributive elements.

Improved mixing and increased the residence time.

Processing temperature profile.

Plasticizer percentages,

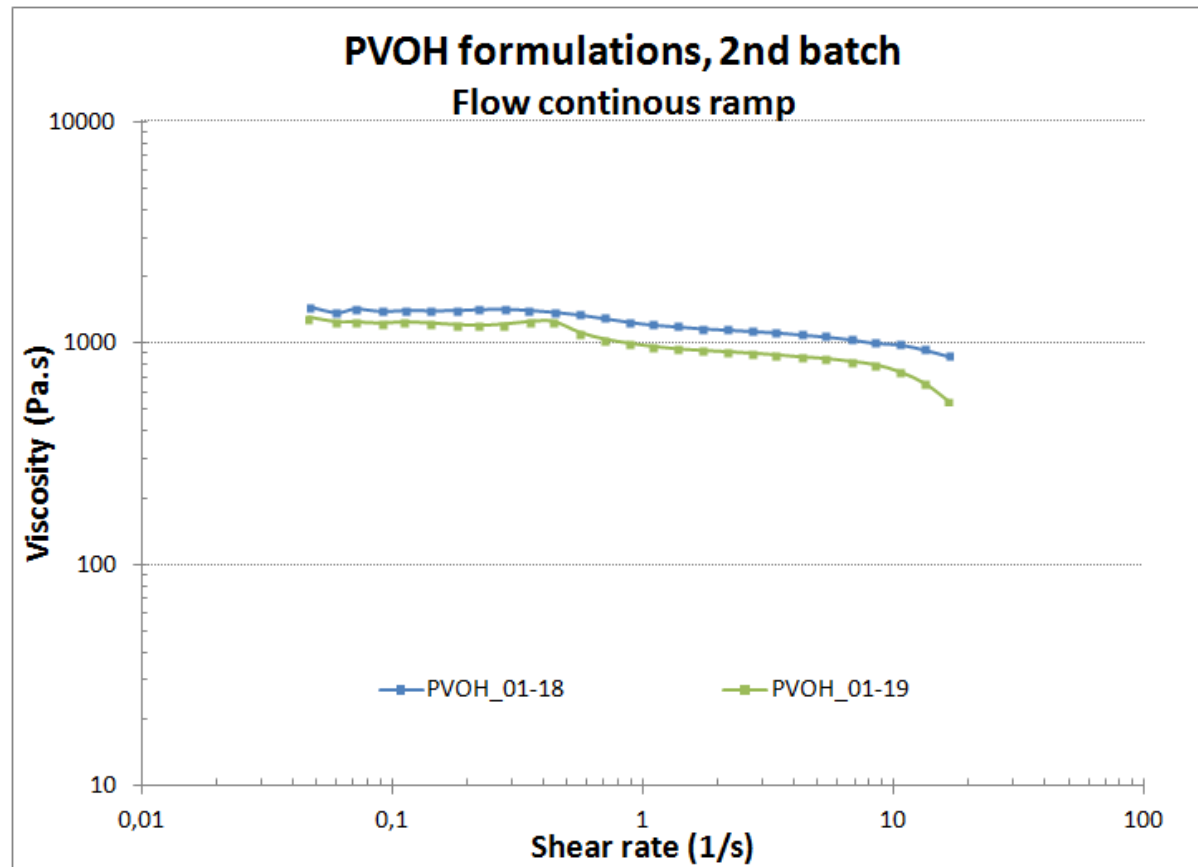


BIO4MAP 606144

Development of multilayer packaging. PVOH new grade.

13

Composition optimization



BIO4MAP 606144

Development of multilayer packaging. PVOH new grade.

14

Composition optimization

GENERAL PROPERTIES	
Melt Flow Index, ISO 1133 (g/10min)	5-6 (190°C/2,16 Kg)
MECHANICAL PROPERTIES (*)	
Tensile strength (MPa)	11-14
Elongation at break (%)	250-360
BARRIER PROPERTIES (**)	
OTR at 23°C, 0%RH (cm ³ /(m ² d*bar))	<0.05
THERMAL PROPERTIES	
Melting point (°C)	185

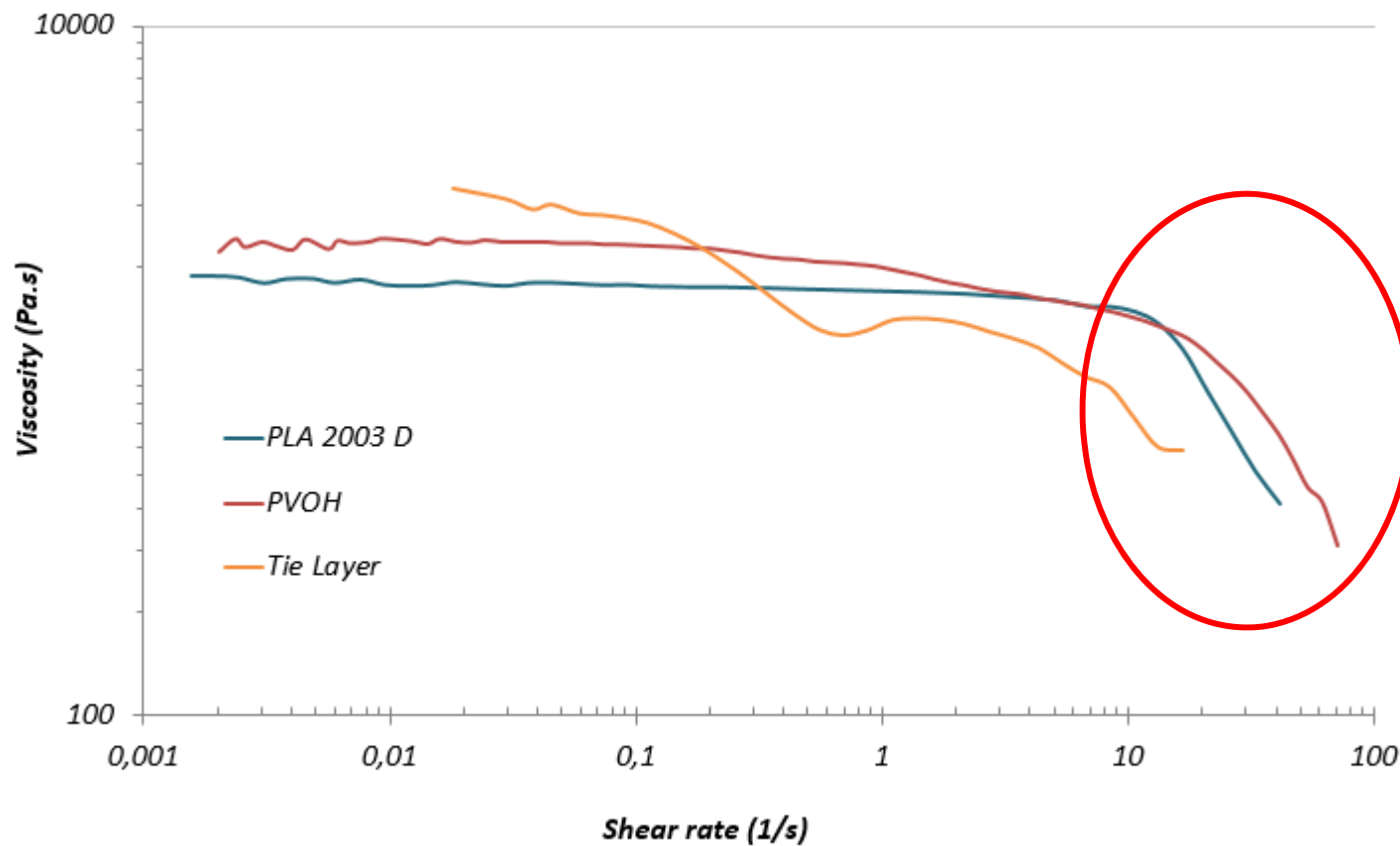


BIO4MAP 606144

Development of multilayer packaging

15

Co-extrusion cast-sheet



Development of multilayer packaging

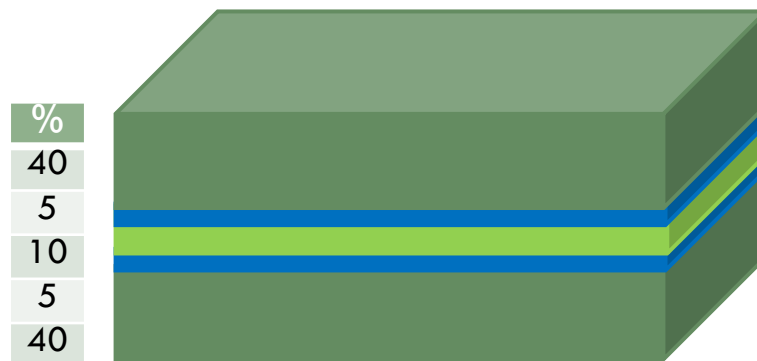
16

Co-extrusion cast-sheet

Multilayer structure definition

5 layers → 3 materials

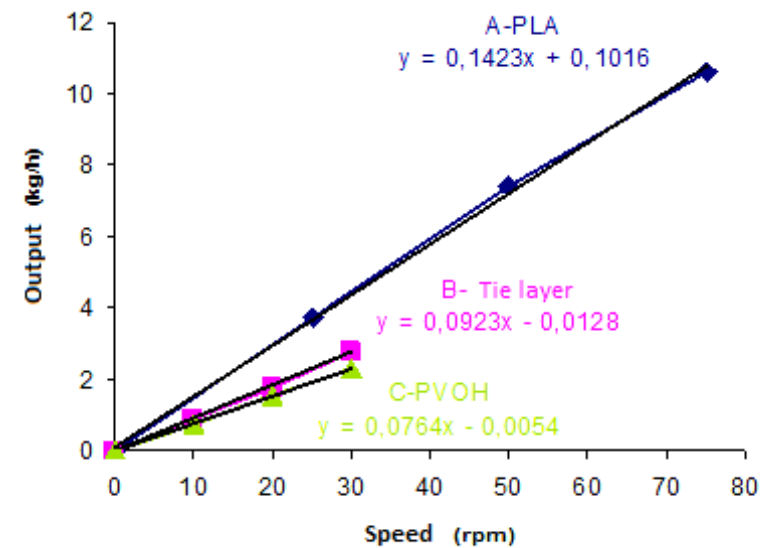
Thickness ratio



A **B** **C** **B** **A**

A PLA **B** Tie layer **C** PVOH

Output vs extrusion speed



Development of multilayer packaging

17

Co-extrusion cast-sheet

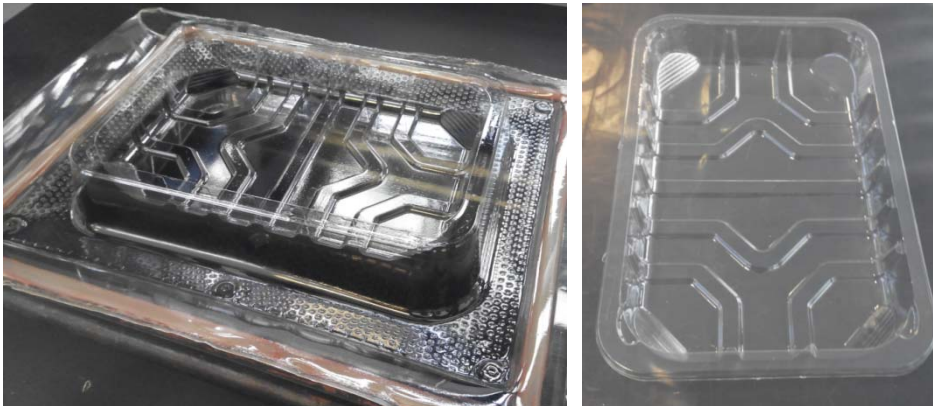
- A 300 microns-multilayer sheet was obtained.
- No defects were found in multilayer structure (uniform thickness along the sheet, good transparency and brightness, etc.)
- The process conditions were stable during the co-extrusion process.



Development of multilayer packaging

18

Semi-rigid tray production at pilot plant and characterization.



The first sheets obtained were correctly thermoformed

After that, the lid was sealed to the tray



Development of multilayer packaging

19

Full package characterization.

To analyze the influence of the different studied parameters on the film properties, laboratory results of critical performance indicators (regarding the application, and defined in task 1.1) will be used as a selection criteria:

- **Water vapor and oxygen permeability**
- Most suitable **mechanical properties** in both directions (dart impact, tear strength and tensile test film using the suitable EN-ISO standards)

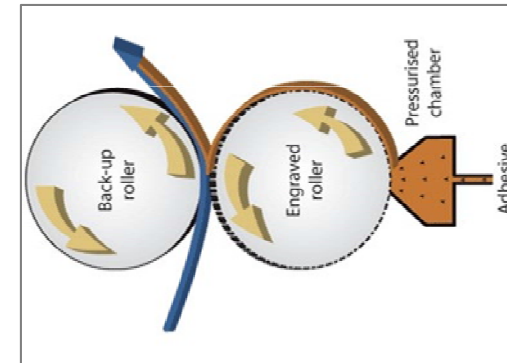
Food Contact Approval (according to the European legislation)

- Specific migration tests using a simulant (D2 UE 10/2011, EN 13130 parts or internal procedures)
- Global migration test using the simulant (D2 UE 10/2011, EN 1186).

Development of multilayer packaging

FUTURE ACTIONS IN THE PROJECT

- Development of natural wax for coating



- Development of biodegradable tie layer for PLA / Adh / PVOH.
- Multilayer processing at Industrial level
- Biodegradability and compostability study
- Technical and economical viability



Development of multilayer packaging

21

Thank you for your attention

Technical issues

Núria López

nlopez@aimplas.es

Project Management issues

Maria-José Moretó

mjmoreto@aimplas.es



AIMPLAS

INSTITUTO TECNOLÓGICO
DEL PLÁSTICO

València Parc Tecnològic

C/Gustave Eiffel, 4

**46980 Paterna – Valencia –
Spain**

Tel: + 34 96 136 60 40

Fax: + 34 96 136 60 41