Simultaneous and Sequential BOPP UHB Films with improved Gas Barrier Properties

The entire added value chain for flexible food packaging is permanently striving to further improve its packaging materials in many different aspects such as functionality, sustainability, convenience and – very important – gas barrier properties against moisture and oxygen. This paper highlights recent developments to achieve further improved barrier properties for simultaneously as well as sequentially produced BOPP ultra-high-barrier (UHB) films, metallized and transparent:

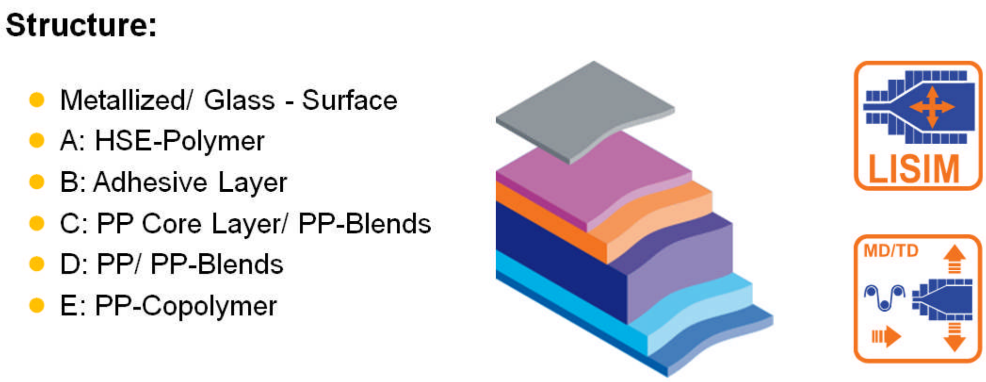

Figure 1: Typical structure of a 5-layer UHB-barrier film.

A) Metallized BOPP UHB Barrier Films:

Simultaneous and sequential UHB BOPP Barrier Films: In the past we have reported about mainly metallized simultaneous UHB BOPP barrier films e.g. for a possible aluminium foil replacement. Typical barrier values for the simultaneous stretching mode with high surface energy polymer 1 (HSE 1) and a PP-copolymer based tie-layer material are given in table 1 (column 2).

By choosing a modified high surface energy polymer (HSE 1 mod.) and a PP-homopolymer based tie-layer material also sequential UHB BOPP barrier films could be produced on our pilot line. Reasonable MDO stretching ratios of up to 4.5 have been obtained. Typical barrier values of metallized sequential UHB BOPP barrier films are also summarized in table 1 (column 1).

Table 1: Gas barrier values of different metallized BOPP UHB barrier films (OD 2.7-2.9):

Stretching Process	**Sequential**	**Simultaneous**	**Simultaneous**
HSE Base Film	HSE 1 mod	HSE 1	HSE 1/ LMWPO
Tie-Layer	Homo-PP	Copo-PP	Copo-PP
Stretching ratios λ_{MD} x λ_{TD}	4,5 x 8,8	8,0 x 9,0	8,0 x 9,0
OTR (23°C/75% r.h.) [cm³/ m² d bar]	0,071	0,080	0,115
WVTR (37,8°C/90% r.h.) [g/ m² d]	0,280	0,075	0,043
Metal Adhesion [N/15 mm]	0,63	1,72	1,66

The simultaneous metallized UHB-BOPP barrier films show a clearly improved WVTR barrier performance in comparison to the sequential webs, presumably due to different raw materials and processing conditions.

Improved barrier values by adding low molecular weight PO additives (LMW-PO):
Especially for improving the WVTR value we have analysed the influence of small amounts of low molecular weight PO additives into the UHB film. Table 1 summarizes the barrier results of a simultaneously processed UHB film with LMW-PO (column 3). The addition of PO additives clearly improves the WVTR barrier values, hardly affecting the OTR values.

Influence of tie-layer material on metal adhesion (EAA Test):
Due to the different stretching processes used in our trials, we have also tested several tie-layer adhesives. We found, that metal adhesion was much better with PP-copolymer based tie-layer materials.

B) Transparent BOPP UHB and High Barrier Films:

Transparent UHB BOPP films with SiOx vacuum coatings: A SiOx glass coating has been applied to an simultaneously oriented HSE base film, giving barrier values similiar to the metallized UHB films (table 2, column 3).

Transparent High Barrier BOPP films with AlOx vacuum coatings: Additionally we have tested transparent AlOx vacuum glass coatings applied with different new systems and treatments on simultaneously produced HSE base films. Table 2 summarizes the best results in columns 1 and 2.

Although the barrier performance of AlOx-coated webs is on a lower level, the current AlOx processes can nevertheless be of high interest due to high coating speeds – comparable to standard metallization processes – at clearly lower production costs in comparison to SiOx coatings.

Table 2: Barrier values of transparent simultaneous glass-coated BOPP barrier films:

Glass Coating	**AlOx**	**AlOx**	**SiOx**
Coating Process	1	2	-
OTR (23°C/75% r.h.) [cm^3/ m^2 d bar]	1,37	1,02	0,2
WVTR (37,8°C/90% r.h.) [g/ m^2 d]	0,25	0,69	0,3

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