Diofan® PVdC Coating On Paper Based Barrier Packing

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ABSTRACT

PVdC coating on Paper makes it suitable for food packaging application by providing moisture barrier; oxygen barrier; aroma barrier and resistance to oil & fat permeation. The selection of right grade of paper; suitable PVdC grade and also the understanding of coating process is utmost critical to make barrier Paper. In the evolution of use of green source packaging material or optimal use of polymer for packaging application; PVdC coating brings value to Paper packaging.

Introduction

Polyvinylidene Chloride (PVdC), available in dispersion; resin and solvent processable form, is a copolymer of vinylidene chloride and vinyl chloride or acrylic copolymers with unique properties. It is one of the best barrier polymers that offers moisture as well oxygen barrier together. It also offers aroma barrier and resistance to permeation to oil / fats.

Due to this property; PVdC is widely used in food and pharmaceutical packaging application. PVdC water based dispersion is coated on rigid PVC for Blister packaging; on PET or BOPP film for food packaging. The coating on paper based substrates is one of the oldest applications for the PVdC and it makes paper suitable for food packaging.

- PVdC coated Paper prevents :
  - o Moisture loss or gain
  - o Oxidation of ingredients
  - o Aroma and off-odour transfers
  - o Oil and fat permeation
- PVdC coated Paper provides:
  - o Heat Seal
  - o Gloss
  - o Print Protection
  - o Scratch resistance
- Regulatory compliance - Approvals for direct food contact.
- More than 50 years of proven performance.

With the requirements of the packagers, numerous coated papers are developed and main structures are as follow :

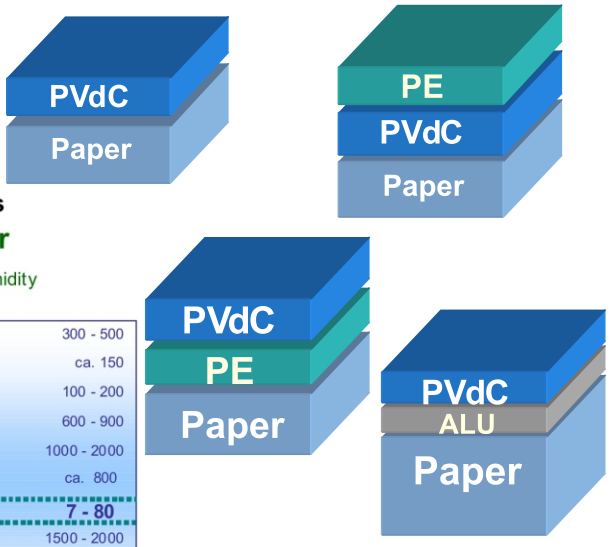
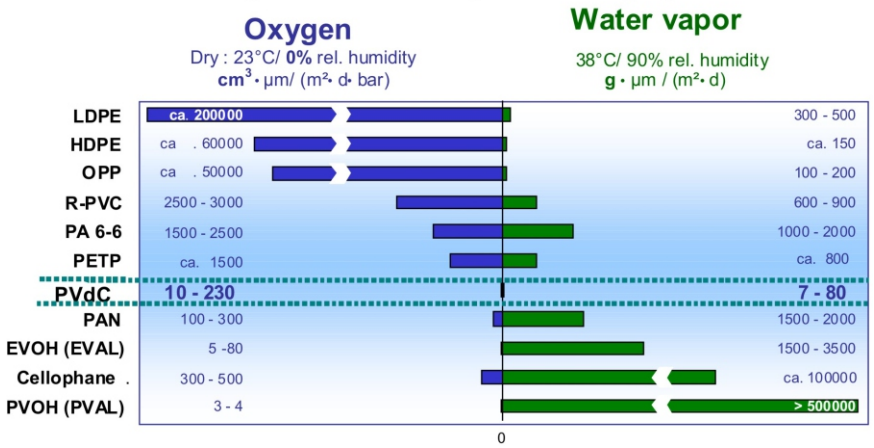


Figure 2 : Structures of PVDC coated Paper

Figure 1: Permeability of different polymers



These complexes are used for the packaging of bakery products (flour, wheat…), freeze dried products, water sensitive materials (salt, bicarbonate…). They are also used in non-food applications to protect against damages (washable cover, etc.) Generally speaking, coating is applied to only one side of the paper, the one coming in contact with the packaged product. The PVdC coating is so used for its sealing properties. The substrates currently used include calendered or supercalendered bleached Kraft paper, surfaced or not in a size-press, coated with kaolin or not, vegetable parchment or imitation parchment, and glassine (the basis weight of the papers used varies from 40 to 100 g/m²).

The Choice of The Substrate

The best results are obtained on papers most closely satisfying the following requirements:

- The papers should be calendered or satined, i.e. they should have a smooth surface.
- The papers should have a low absorbency, so that the dispersion does not penetrate to deep into the strip, but they should not be too hydrophobic, which could give rise to adhesion problems.
- The papers should be sufficiently sized to avoid rising of the fibres when the paper is wetted and to ensure good cohesion of the PVdC coated laminate.

Table 1 : Influence of The Type of Paper on Impermeability Properties

TYPE OF PAPER	PROPERTIES OF THE PAPERS					Permeability of the coatings (2 layers of DIOFAN A 050, 20 + 10 g/m², applied on face F)		
	ABSORPTION			Surface condition		Water vapour (4) g/m².24 h		CO_2 (6) Ncm^3/m^2. 24 h.atm
	Water absorption (1) g/m².30 sec		Air porosity (2) sec/100 cm^3	Micro-contour test (3)		Un-crumpled specimens	Crumpled specimens (5)	
	W	F		W	F			
A. Calendered bleached kraft 60 g/m²	12.4	11.1	545	3	3	2.0	2.1	5.8
B. Calendered bleached kraft 65 g/m²	17.2	16.3	270	2	3	2.3	3.5	5.6
C. Calendered bleached kraft 45 g/m²	13.6	12	1378	2	2	1.8	1.8	5.1
D. Non-calendered unbleached kraft 60 g/m²	26.5	19.5	19	6	6	14.3	40	2300
E. Non-calendered bleached kraft 60 g/m²	16.2	15.8	90	4	5	3.2	67.5	20.5
F.Calendered bleached kraft 60 g/m²	23.5	17.6	58460	1	1	13.2	-	217

According to our experience, paper suitable for coating with PVdC - DIOFAN copolymers should in the first place satisfy the following requirements:

- Water absorption (COBB) 10 - 20 g/m².30 s
- Micro-contour test < 3 (conventional score)

The final choice of the paper necessarily requires a trial under working conditions as close as possible to those envisaged in practice.

The nature of the Kraft paper substrate can influence the impermeability of the structure as shown in the table 1 :

1. TAPPI Standard T 441 M-60 (measurement en Cobb apparatus)
2. ASTM Standard D 726-58
3. According to "Study of the ink-paper relationships in letter-press and offset printing" by Ch. LORILLEUX (21.9.61), ink consisting of a pigment of coarse particle size in a mineral oil of medium viscosity is spread over the substrate under examination. The oil penetrates partly into the paper, carrying the pigment which is deposited in the surface irregularities. The resulting colour intensity after removal of the excess ink is proportional to the depth of these irregularities. The lowest values correspond to the smoothest surfaces (Score 0 = glassine; score 6 = non-calendered unbleached kraft).
4. ASTM Standard E 96-66, Procedure E (38°C and 90 % R.H.)
5. Crumpling on a Gelbo Tester according to Military Specification MIL-B 131 B, Class I.
6. ASTM Standard D 1434-66.

Suitable PVdC Properties :

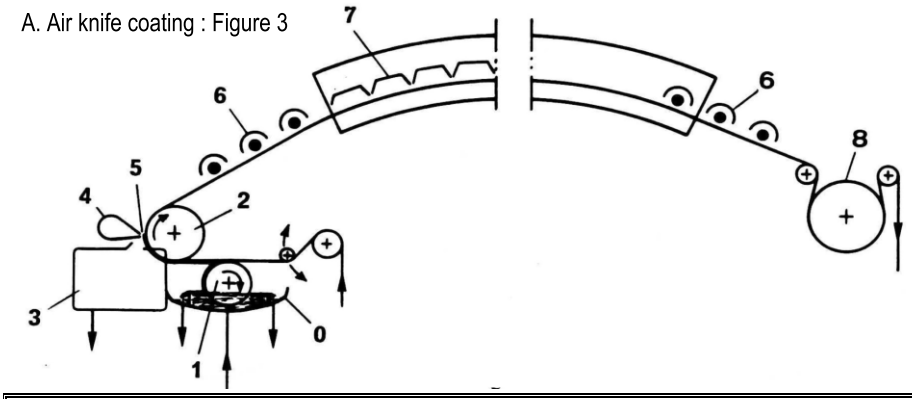
The suitable aqueous dispersions of PVdC required for coating of papers. The required properties are;

- 1st coat to fill the porosity of the paper. Low surface tension grade is preferred for high speed coating.
- 2nd coat mainly high crystalline grade that offers good slip properties and also heat saleability.
- The suitable grade is selected depending on final structure of coated paper.

Coating

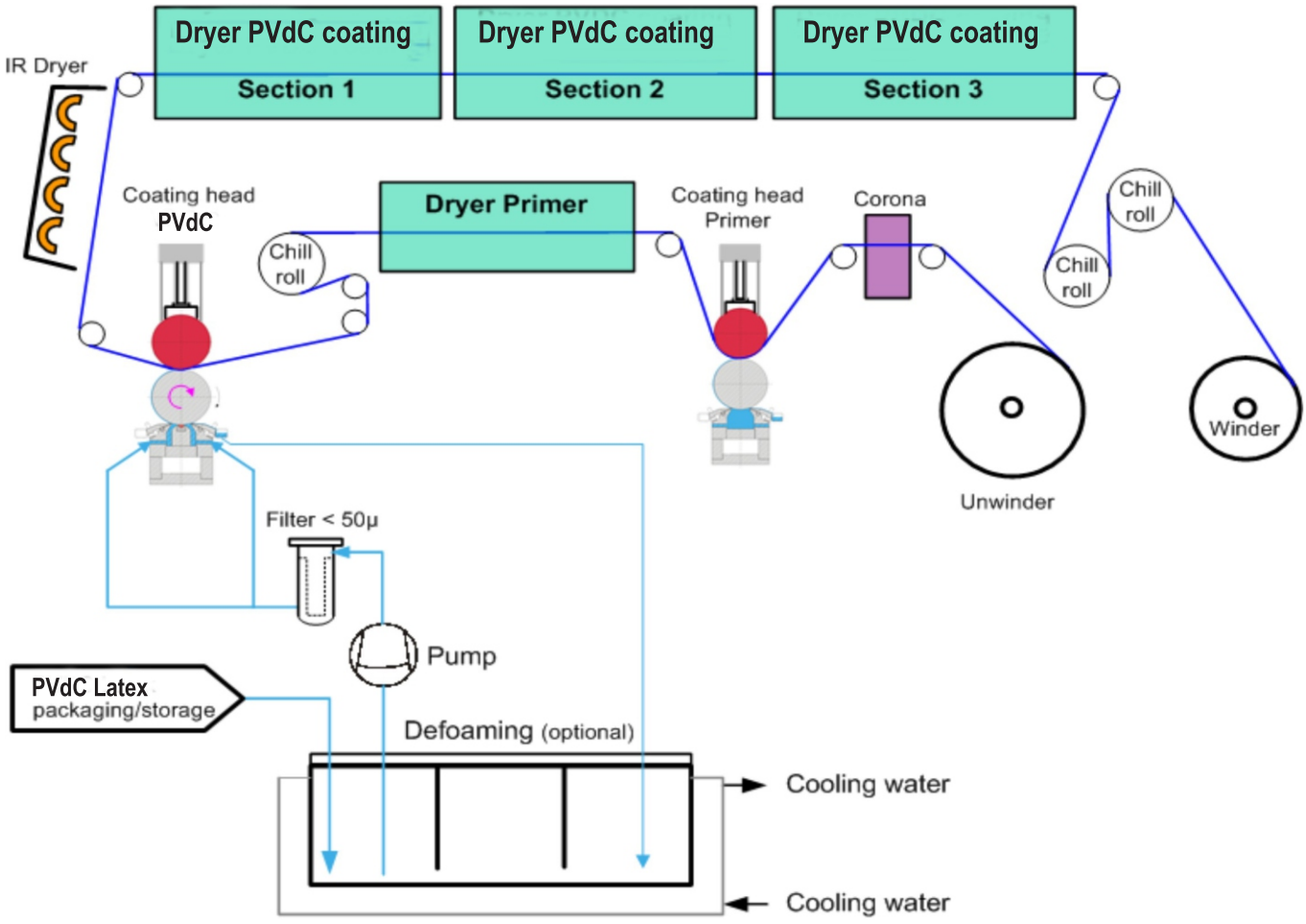
Both the reverse gravure roll and air knife coating technologies are used for paper coating even though the reverse gravure system is being more and more used.

A. Air knife coating : Figure 3



LEGEND		
0. Overflow coating pan 1. Coating roll 2. Backing roll	3.Tank for the aspiration of the flow of air and recovery of excess latex 4.Air-knife 5. Slot	6. Infrared radiation tubes 7. Nozzles of hot-air blower 8. Polished chill roll

B. Reverse Gravure Coating : Figure 4



The formulated aqueous dispersion is applied with a reverse gravure roll (ceramic or chrome plated), specially adapted to the coating of PVdC dispersions, with a helicoïdal etching and inside cooling.

The gravure roll coating process is commonly used for organic solutions of adhesives and primers, for various lacquers, and for printing. As such, existing systems may not be perfectly suitable for coating with water-based DIOFAN PVdC dispersions because of:

- progressive clogging of cells, leading to variations in the coating weight,
- cleaning problems when the PVdC dries in the cells, and
- coagulate formation on the doctor blade.

However, gravure roll coating processes have been developed by several machinery companies, which are specially adapted to PVdC aqueous dispersions.

Table 2 :Influence of The Number of Layers of Diofan A 050 Coated on Calendered Bleached Kraft 45 g/m²

Coating weight,	20 GSM in 1 Pass	20 GSM in 2 Passes	20 GSM in 3 Passes
1st layer	20 g/m²	12 g/m²	7 g/m²
2nd layer	-	8 g/m²	7 g/m²
3rd layer	-	-	6 g/m²
Permeability to water vapour (1)			
Flat	4.1 g/m².d	2.5 g/m².d	1.9 g/m².d
crumpled **(2)**	11.3 g/m².d	3.1 g/m².d	2.6 g/m².d
Permeability to gases (3) (CO_2) [$cm^3/m^2.d.b$]	3445	9.4	5.7
Permeability to fats (4) [pinholes/m²]			
Flat	765	25	0
crumpled (2)	3500	500	500

1. ASTM Standard Specification E 96-66 Procedure E (38°C - 90 % R.H.)
2. Military Specification MIL-B 131 B - Class I
3. ASTM Standard Specification D 1434-66
4. Coloured oil of turpentine - 15 min of contact

Table 3 : Influence Of The Number Of Layers And Coating Weight For Diofan A 050 on Transparent Suppled Glassine, 45 g/m² (Anchoring Treatment With An Acrylic Copolymer - 2 g/m²)

Coating weight, g/m²	Permeability to water vapour (1) g/m².d	Permeability to oxygen (2) $cm^3/m^2.d.b$	Porosity to fats, spots/m²
5 + 5	5.4	6.1	0
4 + 3 + 3	4.1	5.0	0

Table 3 : Results Obtained by Using A Flexible Underlayer in The Coating of Paper

Substrate	Calendered bleached kraft, 45 g/m²		Calendered bleached kraft, 50 g/m²	
1 - Coating weight [g/m²]	7 + 7 + 6	7 + 7 + 6	15 + 15	15 + 15
• 1st layer	Flexible Grade	Rigid Grade	Flexible Grade	Rigid Grade
• 2nd layer	Flexible Grade	Rigid Grade	Flexible Grade	Rigid Grade
• 3rd layer	Flexible Grade	Rigid Grade	-	-
2 -Characteristics of the coatings				
• *colour*	no	no	no	no
• *odour*	no	no	no	no
porosity to fats (turpentine oil) spots/m² (1)				
Flat	0	0	0	0
Crumpled (2) after				
1 day at 40°C	90	200	80	490
2 days at 40°C	150	400	340	540
4 days at 40°C	230	450	550	700
Crumpled (2) after				
1 month at 23°C	50	200	280	550
2 months at 23°C	95	230	240	560
3 months at 23°C	120	280	285	670
6 months at 23°C	-	-	310	700

C. Advantages of the Reverse Gravure Roll Coating

This coating system shows versus the air knife, the following advantages:

- Very little foam generation, enabling higher processing speeds
- Coatings with good appearance can be obtained, without defects such as microbubbles, "orange peel," etc.
- Requires only small amounts of latex for the coatings
- The quantity of wasted PVDC is reduced

Drying

To obtain the optimum properties of the PVdC coatings onto paper substrates, it is requested to reach a temperature in the coating of around 85°C. Such a temperature needs very good controls of the tensions in the machine, especially when the film passes through the drying tunnel. Better results are obtained with air flotation drying tunnel in which the film is not supported. As a guide line from our lab coating line, the following processing conditions could be used :

- Coating speed : 100 m/min
- Drying profile (air temperature): 135 °C - 110 °C - 110 °C
- Length of the drying tunnel : 6 m

Properties of The PVdC Coated Paper

Barrier To Water Vapour And Gases

The barrier properties are influenced by the coating weight and number of layers whatever the substrate which is PVdC coated (Kraft papers, glassine papers or cardboard).

A 20 g/m², PVdC coating applied in a single layer confers on the paper a level of barrier that is clearly inferior to the barrier presented by an identical coating applied in two or three layers. On a good-quality paper, after 3 layers the gain, as a rule, becomes minimal. For a given number of layers, the permeability of the laminate also depends on the coating weight.

In fact, the first layer is traversed by fibres emerging from the paper, whatever the thickness of this layer, which is, moreover, absorbed to some extent into the substrate and probably contains holes in line with the pores of the paper.

Flexibility Of PVdC Coated Papers

The high crystalline grade is suitable both for the undercoat and the topcoat. Nevertheless, for certain applications and on some slightly more rigid papers, it may be useful to have a more flexible PVdC copolymer, as the first layer(s), better capable of following all deformations of the substrate. The gain in flexibility achieved in this way may assure a better integrity of the package.

Conclusion

PVdC coated Paper offers barrier properties to the packaging structure and enhances the shelf life of the packed items. The user can customize barrier property depending on moisture / oxygen sensitivity of packed items and the expected shelf life. The sealing property and tear-ability of PVdC coated Paper makes it suitable for sachet application; aroma barrier further makes is suitable for spices and similar applications. Oil resistant property of PVdC makes it suitable for carrying or serving fresh eatables. PVdC coating brings value to paper based food packaging.