



The main printing supports for flexible packaging.

Using flexography and rotogravure printing systems it is fairly possible to print every material's surface wrapped in coil and sufficiently flexible for high speeds of printing. Flexible packaging are constituted essentially from the following supports and their combinations (in laminations):

MATERIALS THAT CONSTITUTE THE FLEXIBLE PACKAGING

- 1. PAPER AND CARDBOARD**
- 2. CELLULOSE FILMS**
- 3. THIN ALUMINIUM**
- 4. PLASTIC FILMS**

As expected, customary use of multiple materials for printing implies the necessity of a series of inks adapted to the several supports.

PAPER AND CARDBOARD

To obtain a good quality of printing on absorbent materials like paper and cardboard is essential that they come satisfied specific needs such as uniformity of the thickness and dimensional stability of the support.

Furthermore, an excellent adhesion of the coat on the paper is essential for the printing on glossy paper.

The appropriate inks have to be flexible, with a high degree of gloss, rub resistance, good adhesion properties and low solvent retention especially in case of printing on coated paper.

In addition, printing on materials laminated with plastic films requires good resistance to the high temperatures.

In order to obtain such characteristics are usually formulated nitrocellulose-based inks (also modified by the addition of resins such as acrylic, polyurethane or ketonic) (Table 1).

PAPER

- **UNIFORMITY OF THE THICKNESS**
- **DIMENSIONAL STABILITY**
- **SMOOTH AND GLOSS DEGREE**
- **GOOD ADHESION OF THE COATING**

INKS FOR PRINTING ON PAPER

- **HIGH GLOSS DEGREE**
- **GOOD THERMO RESISTANCE
(PAPER LAMINATED WITH PLASTIC FILMS)**
- **GOOD RUB AND BEND RESISTANCE**
- **LOW SOLVENT RETENTION**

SUPPORT	PRINTING INKS
PAPER	Nitrocellulose based inks and modified (acrylic, polyurethane, ketonic resins)

Table 1

CELLULOSE

The cellophane, which was widely employed in the past decades, is today in disuse, replaced from less stiff and expensive materials.

The extensive use of the cellophane as printing support was due to many advantages related to its transparency, the low thickness obtainable and the thermo-stability.

Moreover through lacquering is possible to increase remarkably the application field obtaining properties such as thermo-sealing (cellophane MS and XS), barrier-effect against moisture (cellophane MS lacquered with nitrocellulose) and atmospheric oxygen (cellophane XS lacquered with PVDC).

Cellophane is a hygroscopic material that, depending on the external conditions, easily absorbs or releases moisture.

Due to its peculiarity to maintain the torsion endured and not coming back to the stretch form, this material is still commonly used for twisting packaging (cellophane P-MF), particularly for the candies packaging.

The inks apt for printing on cellophane have to be suitable also for laminations (for the inner printing is necessary a good affinity between adhesive and ink), have a high gloss degree, good resistance to high temperatures and blocking and a low solvent retention. For this purpose, inks made up of nitrocellulose and modified (for example adding some resins such as acrylic, polyurethane or ketonic) are commonly used (Table 2).

CELLOPHANE

- **LOW THICKNESS**
- **THERMO-STABILITY**
- **TRASPARENCY**
- **BARRIER EFFECTS:**
MOISTURE: CELLOPHANE MS
OXYGEN: CELLOPHANE XS
- **TWISTING PACKAGING:**
CELLOPHANE P-MF
- **THERMO SEALING:**
CELLOPHANE MS
CELLOPHANE XS

INKS FOR PRINTING ON CELLOPHANE

- **HIGH GLOSS DEGREE**
- **GOOD THERMO RESISTANCE**
- **BLOCKING RESISTANCE**
- **LOW SOLVENT RETENTION**
- **APT FOR LAMINATIONS
(INTERNAL PRINTING)**

SUPPORT	PRINTING INKS
CELLOPHANE <ul style="list-style-type: none"> ▪ P ▪ DM-DMS ▪ MF ▪ MS 	<p style="text-align: center;">Nitrocellulose based inks and modified (acrylic, polyurethane, ketonic resins)</p>
CELLOPHANE <ul style="list-style-type: none"> ▪ XS ▪ XSAT 	<p style="text-align: center;">Nitrocellulose based inks and modified (acrylic resins)</p>

Table 2

THIN ALUMINIUM

Many qualities of metallic Aluminium are useful in packaging applications:

In fact it is a thermal conductor, flexible and resistant to the corrosion¹, which constitute a barrier to gases and light and is well suited for food packaging.

Thanks to its excellent barrier effect it is indicated above all for the packaging of products for which the aromas and fragrances preservation is essential.

The nude metal is opaque and for many applications it has to be polished by calendering. Due to the residual oily layer, the printing process in such cases could be subject to technical complications related to the ink fixing.

It is important to obviate to these inconveniences by accurately removing the oily layer or, alternatively, through a pre-treatment that consists usually in varnishing the metal before printing.

This varnishing pre-treatment presents also the considerable advantage of protecting the metal from oxidation.

¹ The oxide stratum that forms on the metal surface has the remarkable advantage of protecting the metal from further oxidation.

To the inks for printing on thin aluminium a high gloss degree is demanded together with transparency, low solvent retention, good thermal resistance and resistance to the blocking.

Currently the trend is to replace the nude metal with metallized films that are plastic films² covered by a thin aluminium layer. The metallic coating is deposited through a discontinuous process that consists in a condensation of a thin aluminium stratum on the film after evaporation under vacuum of hot metal.

In such a way the advantage of a lower weight is obtained and properties of aluminium and those of plastic film are coupled.

Unfortunately this procedure generate some inconveniences:

Actually reducing the thickness of the metallic layer cause the reduction of the thermo resistance and the gases barrier effect. Plastified nitrocellulose-based and modified (with acrylic or polyurethane resins) inks are used for printing on nude aluminium (Table 3).

THIN ALLUMINIUM

- **OPACITY**
- **DEFORMABILITY**
- **THERMO-SEALING**
- **THERMAL CONDUCTION**
- **CORROSION RESISTANCE**
- **BARRIER-EFFECT**
- **FOOD PACKAGING**

INKS FOR PRINTING ON THIN ALLUMINIUM

- **HIGH GLOSS AND TRASPARENCY DEGREE**
- **GOOD FLEXIBILITY AND THERMO RESISTANCE**
- **BLOCKING RESISTANCE**
- **LOW SOLVENT RETENTION**

² The mainly used are: PET, PA and OPP.

SUPPORT	PRINTING INKS
NUDE ALLUMINIUM	Plastified Nitrocellulose based inks and modified (acrylic resins)
COATED ALLUMINIUM (Primer NC)	Nitrocellulose based inks and modified (acrylic, polyurethane resins)

Table 3

PLASTIC FILMS

Polyethylene (PE), **Polypropylene (PP)**, **Polyester (PET)** and **Polyamide (PA)**, are the most diffuse plastic films (Table 4) that in several forms and combinations constitute the great part of flexible packaging.

<u>PLASTIC FILMS</u>
<ul style="list-style-type: none"> ▪ POLYETHYLENE (PE) ▪ POLYPROPYLENE (PP) ▪ POLYESTER (PET) ▪ POLYAMIDE (PA)

Table 4

Polyethylene (PE) is a multipurpose material with an excellent duration. It is diffused principally like **LDPE** (low density polyethylene), **HDPE** (high density polyethylene) and **LLDPE** (low density linear polyethylene). They have different properties that depend on the manner in which ethylene is polymerised and are used for diverse applications.

The main characteristics are: extensibility, rub resistance, water resistance, impermeability to oxygen and carbon dioxide, thermo-retractable.

HDPE structure is constituted by very long chains and has a molar mass average of many hundred of thousand. It is hard, tough and resilient. Its ramified structure contributes to the great chemical resistance to tensile strength and breaking strength. Moreover it provides excellent moisture barrier properties and chemical resistance.

The **LDPE** is more transparent and glossy than **HDPE** and it's characterized by some toughness, flexibility and transparency. **LDPE** has a low melting point making it popular for use in applications where heat sealing is necessary. It absolutely is the most used thermoplastic film in packaging and its huge applications go from the high resistance bags to the pre-packaging of fresh food, to the shrink-wrapping. Moreover it has higher shock resistance and rip resistance than **HDPE**.

LDPE and **LLDPE** differ for molecular weights and ramification degrees. The latter is more resistant to the breaking and the sealing.

HDPE is a too much plastic material for being used in high-speed rotogravure.

The inks apt for printing on this kind of films have to exhibit high gloss, good thermo-resistance, flexibility and resistance to the blocking.

Specific pre-treatments (as an example the electrical pre-treatment or crown treatment) are useful to improve the adhesion between the inert support surfaces and ink. In fact in these ways polar groups on surfaces are created and the adhesion characteristics enhanced.

Depending on the particular type of support, polyamide- or nitrocellulose-based inks, modified or not, are applied (Table 5).

POLYETHYLENE

**LOW DENSITY POLYETHYLENE
HIGH DENSITY POLYETHYLENE
LOW DENSITY LINEAR POLYETHYLENE**

- **THERMO-RETRACTABLE**
- **WATER RESISTANCE**
- **EXTENSIBILITY**
- **CHEMICAL RESISTANCE**

SUPPORT	PRINTING INKS
HDPE LDPE	Polyamide based inks Solvent system: alcohol-hydrocarbon Not thermo resistance Not apt for laminations
LDPE HDPE	Nitrocellulose based inks plastified and modified (polyurethane resins)
LDPE (High resistance bags)	Nitrocellulose based inks and modified (polyurethane resins + catalyst) Resistance to: light, alkalis, and water.
LDPE (Thermo extensible)	Nitrocellulose based inks and modified (polyurethane and polyamide resins)

Table 5

INKS FOR PRINTING ON POLYETHYLENE

- **HIGH GLOSS DEGREE**
- **GOOD FLEXIBILITY AND THERMO RESISTANCE**
- **BLOCKING RESISTANCE**

Polypropylene (PP) is slightly more brittle than polyethylene but it is characterized by: permeability to gases, dimensional stability, thermo-sealing (when co-extruded) and transparency. Several applications and a wide-ranging assortment of modifications can be enumerated for PP too (Table 6).

The polypropylene is thermo-sealing only when co-extruded with other materials that improve its thermo-resistance. The films of oriented polypropylene (**OPP**) are characterized by greater brilliancy, shock-resistance and higher barrier-effect than the **PP**.

High degree of gloss, good solvent release, thermo-resistance and suitability to lamination, are requirement of inks apt for printing on **PP**.

For such purpose are used inks whose composition vary depending on the specific kind of polypropylene support: nitro-modified inks with polyurethane and cellulose esters, nitro-acrylic modified with polyurethane resins without using adhesion promoters, nitro-acrylic for external printing and laminations (Table 7).

On the coated PP are used inks that do not contain adhesion promoters that could interfere with the lacquer and cause variations of the sealing temperature.

POLYPROPYLENE (PP)

**BI-ORIENTED
PLAIN**

**CO-EXTR. : TRANSPARENT, OPAQUE, WHITE
METALIZED CO-EXTRUDED
ACRYLIC DOUBLE COATED
ACRYLIC-PVDC DOUBLE COATED
PVDC DOUBLE COATED
METALIZED DOUBLE COATED**

- **TRASPARENCY**
- **DIMENSIONAL STABILITY**
- **THERMO-SEALING**
- **GAS PERMEABILITY**

Table 6

INKS FOR PRINTING ON POLYPROPYLENE

- **HIGH GLOSS DEGREE**
- **GOOD THERMO RESISTANCE**
- **GOOD SOLVENT RELEASE**
- **APT FOR LAMINATIONS**

SUPPORT	PRINTING INKS
PP: - BI ORIENTED - CO-EXTRUDED - PLAIN	Nitrocellulose based modified inks (polyurethane resins, cellulose esters)
PP: - ACRYLIC DOUBLE COATED - ACRYLIC-PVDC DOUBLE COATED	Nitro-acrylic based modified inks (polyurethane resins without catalyst)
PP: - PVDC-PVDC DOUBLE COATED - METALIZED CO- EXTRUDED - METALISED DOUBLE COATED	<ul style="list-style-type: none"> - Nitro-acrylic based inks for laminations and external printing - Nitro-modified Primer (solvent-water based) - Nitro-modified inks

Table 7

Polyester (PET) (polyethylene terephthalate) is another extremely diffused plastic film. Characteristics such as transparency, excellent thermal properties, gas and moisture barrier-effect, stiffness, shock-resistance, chemical resistance and suitability to deep-freezing and sterilization processes due to its high use temperature, make it a multipurpose plastic material. Due to the modest polarity of its surfaces and the resulting partially suitability to the inks adhesion, it does not need of a high degree pre-treatment. Like **PP**, some property of the **PET** can be increased using several treatments (Table 8).

POLYESTER (PET)

**PLAIN
CHEMICALLY TREATED
PVDC COATED
METALIZED**

- **TRANSPARENCY**
- **STIFFNESS**
- **DIMENSIONAL STABILITY**
- **CHEMICAL RESISTANCE**
- **APT TO DEEP FREEZING AND
STERILIZATION PROCESSES**
- **THERMO-SEALING**
- **BARRIER PROPERTIES**

Table 8

Further than a low solvent retention the inks that can be used on polyester materials, depending on the applications, must have suitability to lamination or to heat treatments like pasteurisation, deep-freezing and sterilization.

Inks used for bi-oriented **PET** are made up of some vinyl resins, **PVB**, polyurethane film-forming resins; for printing on chemically treated bi-oriented **PET** are used nitrocellulose inks modified with film-forming polyurethane resins.

The saraned **PET** is printed using specific inks, vinyl resins, **PVB**, nitrocellulose inks modified with film-forming polyurethane resins (Table 9).

INKS FOR PRINTING ON POLYESTER (PET)

- **LOW SOLVENT RETENTION**
- **GOOD THERMO RESISTANCE**
- **APT FOR DEEP FREEZING,
STERILIZATION, PASTEURIZATION**
- **APT FOR LAMINATIONS**

SUPPORT	PRINTING INKS
PET: BI ORIENTED	Vinyl resins based inks PVB Film-forming Polyurethane resins
PET: CHEMICALLY TREATED BI ORIENTED	Nitrocellulose based inks modified (with film-forming polyurethanes)
PET: SARANED	- Specific inks - Vinyl resins based inks - PVB - Nitrocellulose based inks modified with film-forming polyurethanes

Table 9

Polyamide (PA) is characterized by thermo-forming, transparency, barrier-effect, chemical and mechanical resistance, high punch resistance.

Corresponding inks must be suitable to sterilization and pasteurization processes, blocking resistant and have low solvent retention. It are used Inks similar to those used for printing on **PET** (Table 10).

<u>POLYAMIDE (PA)</u>	
<ul style="list-style-type: none"> ▪ TRASPARENCY ▪ THERMO-FORMING ▪ CHEMICAL AND MECH. RESISTANCE ▪ HIGH PUNCH RESISTANCE ▪ BARRIER PROPERTIES 	

SUPPORT	PRINTING INKS
PA: BI ORIENTED	Vinyl resins based inks PVB Film-forming Polyurethane resins
PA: CAST	Nitrocellulose based inks modified with film-forming polyurethanes
PA: SARANED	<ul style="list-style-type: none"> - Specific inks - Vinyl resins based inks - PVB - Nitrocellulose based inks mod. with film-form. PUR

Table 10

INKS FOR PRINTING ON POLYAMIDE (PA)

- **LOW SOLVENT RETENTION**
- **THERMO FORMING**
- **APT FOR STERILIZATION AND PASTEURIZATION**
- **BLOCKING RESISTANCE**
- **CHEMICAL RESISTANCE**
- **BARRIER PROPERTIES**

Lamination

When a single film does not satisfy all the needed requirements come useful composite films, which are materials obtained by lamination (or coupling) or co-extrusion techniques.

Laminates are thin multi-layer structures obtained through the adhesion of cast materials like paper, plastic films or aluminium. The layers adhesion is obtained by various systems (depending on the specific materials that have to be coupled) using synthetic adhesives (thermoplastic or thermo-set).

The mainly used are: polyester, polyurethane, acrylic or PVDC polymers.

Plastic polymers can be also co-extruded to obtain multi-layer structures

The laminated importance and applications are constantly increasing in the food-packaging field. Through many possibilities of combinations, it is allowed the joining together of the properties of two or more supports to obtain high-quality products as it can be noticed looking at the following examples.