7.4 Coating of plastic films – types and properties

7.4.1 Introduction to coating

Coatings are applied to the surfaces of plastic films to improve heat-sealing and barrier properties. They are also applied to rigid plastics to improve barrier. Traditionally, the most common method of application to film has been by using an etched roll, as this gives consistent and accurate coating with weights up to around 6 g m\(^{-2}\). This level of coating is commercially available from film manufacturers. If higher coating weights are required, this is normally carried out by converters.

With environmental concerns being an important factor, water-based coating systems have been developed. It is unusual to find solvent-based systems being used today. Where they are used they are mostly alcohol based, with butanol being the highest boiling point solvent used. Priming coats are applied. Where the coating is to be applied to both sides of the film, the primer is applied to both sides simultaneously using reverse driven gravure rollers. Adhesion to the base film is essential, and hence an adhesive-type coating with antistatic properties is normally used, with a coating weight of less than 1 g m\(^{-2}\).

Metallised coating using aluminium has been available for some time. This is carried out by converting the aluminium to vapour in a vacuumised chamber and depositing it on the surface of plastic film, paper and paperboard for packaging purposes. More recently, SiO\(_x\), a mixture of silicon oxides, has been deposited in thin layers on several plastic films. It is likely that other materials, e.g. DLC, diamond-like coating based on carbon which has been internally applied to PET bottles, will be developed further for both bottles and film.

Extrusion coating is also a method of applying a plastic coating, though this usually refers to the application of plastics to other materials such as aluminium foil, paper and paperboard. Coating as a technique for improving the properties of plastic film and containers is an active area for innovation.

7.4.2 Acrylic coatings

Acrylic coatings are applied to plastic film, particularly OPP. The coating is glass clear, hard, heat sealable and very glossy. It has an initial sealing temperature of around 100°C. The melting point is sharply defined. This means that the coating can easily slide over hot surfaces without sticking. A typically acceptable lower sealing strength would be 250 g m\(^{-2}\)/25 mm seal width. With a film shrinkage temperature of 150°C, this would give a sealing range of 50°C. It is necessary to have some slip and anti-blocking compounds incorporated in the coating to achieve the best packaging machine runnability. The coating thickness is generally about 1.0 g m\(^{-2}\), and with a specific gravity close to 1, this gives a thickness of 1 \(\mu\)m.
7.4.3 PVdC coatings

PVdC coatings may be modified to produce either a good heat-sealing polymer or a high-barrier polymer. There is a compromise to be made between the quality of sealing and the barrier properties required. Modification of the polymer to give a wider sealing range lowers the threshold for sealing to around 110°C at the expense of the gas barrier. PVdC coatings are applied to films and paper.

The majority of general-purpose coatings supplied will have sealing properties starting to seal at 120°C and oxygen barrier of around 25 ml m⁻²/24 h. For PET film, PVdC is normally chosen for high oxygen barrier (10 ml m⁻²/24 h) and as a result may have poor sealing properties.

The formulation needs to incorporate both silica and waxes as slip and anti-blocking agents to prevent the coatings from sticking to the hot sealing surfaces. Typically, film producers apply coating weights of 3 g m⁻² or 2 μm thickness. The specific gravity of PVdC is 1.3. Surface coatings can be applied to rigid containers such as the surface of PET beer bottles.

7.4.4 PVOH coatings

With the environmental concern that dioxins may be produced if chlorine-based compounds are incinerated, an alternative high gas barrier has been sought to replace PVdC without needing to modify coating parameters. PVOH emulsions meet this requirement, but they are sensitive to moisture, losing barrier properties if the RH increases to more than 65% RH. Films with PVOH are therefore likely to be used as part of a laminate, with the PVOH on the inside of the web. BOPP with PVOH on the outside can be used, provided it is overlacquered with a protective varnish. PVOH also has no sealing properties. It is, however, an excellent surface to receive printing inks with low absorption or retention of solvents. Coating weights are similar to PVdC, but the specific gravity is nearer to 1.0 and film yield is slightly higher.

7.4.5 Low-temperature sealing coatings (LTSCs)

LTSCs for OPP which seal at lower temperatures and have a wider sealing range are required to meet the demand for faster packaging machine speeds. These coatings, based on ionomer resins, applied in the form of emulsions are an alternative to both acrylic and PVdC coatings. As silica and waxes are likely to raise the sealing temperature threshold of any coatings, they are kept to a minimum with the consequence that friction is higher on LTSC than with the conventional coatings. The LTSC does not stick or block to PVdC or acrylic coatings and hence it is possible to have differentially coated films. The ionomer surface has good ink receptivity and does not retain printing ink solvents.
7.4.6 Metallising with aluminium

Direct vacuum metallising with aluminium on plastic films results in a significant increase in barrier properties. This is because these films are smooth and a continuous layer of even thickness can be applied. Films treated in this way are PET, PA and OPP. A major cost factor is the time taken to apply the vacuum after a reel change. This favours 12 μm PET because a large area can be contained in a reel. When applied to PET, the film can be used to metallise paper and paperboard by transfer from the film using a heated nip roll, after which the PET can be reused (Fig. 7.13).

7.4.7 SiO_x coatings

SiO_x has recently been introduced as a coating. This material has excellent barrier properties. It is applied by vacuum deposition. SiO_x coated PET film is commercially available and is used in the retort pouch laminates in Japan. It is transparent, retortable, recyclable and has excellent barrier properties. An alternative method of coating is being developed by Lawson Mardon in Switzerland which uses plasma pretreatment followed by evaporation of the silicon using an electron beam (EB) (Lohwasser, 2001).

SiO_x has also been applied to plastic bottles, giving an oxygen barrier which is 20 times greater than the barrier of an uncoated bottle (Matsuoka et al., 2002). The Glaskin process introduced by Tetrapak also vacuum coats the inside of PET beer bottles. Bottles coated in this way have been used by several leading breweries in Europe (Anon, 2000b,c). Less flavour scalping has been claimed to result in a minimum shelf life of 6 months.

![Figure 7.13 Metallising process (courtesy of The Institute of Packaging).](image-url)
European use of thermal or EB chemical vapour deposition of silicon oxide and the reactive evaporation of aluminium is discussed in Naegeli (2001).

### 7.4.8 DLC (Diamond-like coating)

A relatively new coating is known as DLC (diamond-like coating). It comprises a very thin layer of carbon. PET bottles do not give as long a shelf life as glass for the bottled beer market. A DLC coating on the inside of PET bottles has been trialled extensively in Japan. Significant improvements in barrier have been reported (Ayshford, 1998; Anon, 2000a).

### 7.4.9 Extrusion coating with PE

A heat seal coating can be applied to a heat-resistant film such as PET and PA by extrusion coating the film with PE (Fig. 7.14).