**Barrier Coatings for Flexible Substrates**

Since 1990’s the Nanoparticulates have shown promise in coating formulations and recently have shown exciting properties when made into barrier formulations. In packaging applications, they most notably improved barrier to gases, aroma and UV light. One of the more interesting applications has been in providing oxygen barrier coatings for packaging. Early problems with instabilities and poor coverage have been for the most part eliminated with improved formulations and press techniques. Functional oxygen barriers of less than .006 cm$^3$/100 inch$^2$ over 24 hours at 23° C and 50% RH on polyester are now routine.

What are Nanoparticles? Nano is a prefix meaning “dwarf” in Greek, also means one billionth. A nanometer is therefore one billionth of a meter. To provide a sense of scale, a tennis ball would be 100,000,000 nm. In practice, nanoparticles are finely dispersed nanoparticulate (intercalated/exfoliated) silicate mineral in a polymer solution/dispersion. As the Nanoparticulates stack and arrange themselves on a flexible film substrate they provide an obstacle to gases though formation of a “tortuous path”. In the example below, Nanoparticulates move from agglomerated clay to nanocomposite (exfoliated) coatings.

As long as the distance $d_2$ is greater than $d_1$, a tortuous path exists and oxygen barrier performance is improved over a unmodified polymer matrix.

The uses for oxygen barrier coatings in the packaging industry are both economic and performance related. The barrier performance of these nanocomposite barriers are much improved over typical PVdC and EVOH barrier resins typically used in packaging films. While most commercial activity today is in the area of dry foods, prototypes have been made for liquid packaging as well as chilled packaging. Application methods have varied widely with Gravure, Flexo and roller coatings all being successful.

In a typical example, a familiar three ply laminate composed of PET/mPET/PE can be replaced with a barrier coated PET/PE structure. Besides the obvious reduction of the one film layer, there are economic benefits of using less adhesive and improving the visibility of the product. Barrier coatings of this type also offer an advantage in flex cracking as they often are more flexible than mPET and oxide treated films.
The flex cracking improvement can be quite dramatic. In the following example, various coatings on typical packaging films show were subjected to a Gelbo flex tester to measure oxygen barrier before and after flexing.

Another common example is moving from commercial 2-ply laminate to a new 2-ply laminate plus printable barrier coating. In this example, a coated film, PVdC coated PET is replaced with a barrier coated corona treated PET. The film is then laminated in the usual way to a sealant web of polyethylene. The benefits of this new structure are an improved oxygen barrier of up to ten times the previous structure, no chlorine, and improved shelf life.

**Commercial 2-Ply Laminate**

- PVdC coated PET
- Ink
- Adhesive
- Polymer Film

**New 2-Ply Laminate plus printable barrier coating**

- PET Film
- Barrier Coating
- Ink
- Adhesive
- Polymer Film

Another example is the Oxygen barrier enhancement example of a commercial 3-Ply laminate to a new 3-Ply Laminate plus printable barrier coating by providing lower cost than alternative high performance barriers.

**Practical Concerns**

Application weight of barrier coatings is critical to obtaining high barrier numbers. Depending on the substrate, application weights need to be adjusted to attain the barriers desired. In the following graph the relationship between application weight and oxygen performance is detailed.
Anilox and gravure suppliers can offer advice on the best screen and line combinations for the deposition weights desired. The Nano clay coatings are often supplied in two or more parts that need to be mixed together before use. An air-powered mixer press-side is usually adequate to mix the components before use. Newer versions are available as a one-part system and they should be kept from freezing. Corona treat films before coating as it will enhance adhesion and improve lamination bond strength.

Substrates should be free of dirt and dust as much as possible and should be applied as the first down with inks and other materials applied as a second down.

In Summary

The Oxygen Transmission Rates of typical Flexible Packaging materials provide printed oxygen barrier coatings will offer an alternative to existing High Barrier options. The average oxygen transmission rate at room temperature provides better barrier properties across multiple films. (insert chart)

Gas barrier performance across multiple substrates on polyester, oriented polypropylene and OPA provide value for commercial PE-EVOH laminate at room temperature and relative humidity. (insert chart)

The clay composite coatings provide excellent barrier performance on both PET and OPP with dry film weights as low as .2 g/m² (dry).

Gas barrier coating performance on different substrates looking at the oxygen transmission rate and the number of Gelbo flexes.

High Oxygen Barrier Coatings market needs of the printers with an option that is chlorine-free, enable light weighting, improve sustainability, remove metal, transparent, and improve ability to recycle and alternative to expensive barrier films.
The values of barrier oxygen barrier coatings are excellent oxygen barrier, aroma barrier, replace PVdC and EVOH coatings and will improve flex crack resistance of oxide/metallized films and extend shelf life.

Application of High Oxygen Barrier coatings can be applied in a variety of ways:

- Can be applied at conventional film weights depending on the structure and barrier required
- Coatings can be applied on existing equipment
- Enable removal of barrier film and adhesive in 3-ply and more laminates
- Reduction in processing waste
- Reduction in energy
- Allow duplex laminates to compete with triplex

Robert O’Boyle
Product Manager - Coatings
Sun Chemical Corporation
35 Waterview Boulevard
Parsippany, NJ 07054
T +1 973-404-6288
F +1 973-404-6877
M +1 973.615.0243
robert.oboyle@sunchemical.com